

**S. P. Mandali's**  
**Ramnarain Ruia Autonomous College**



**Syllabus for Masters of Science**

**Program: M.Sc. Life Science**

**Program Code: RPSLSc**

(Choice Based Credit System for the academic year  
2022–2023)

## Graduate Attributes for Masters in Science (M.Sc.)

In the post graduate courses, S.P. Mandali's Ramnarain Ruia Autonomous College is committed to impart conceptual and procedural knowledge in specific subject areas that would build diverse creative abilities in the learner. The College also thrives to make its science post graduates research/ job ready as well as adaptable to revolutionary changes happening in this era of Industry 4.0.

GA	GA Description
	<b>A student completing Master's Degree in Science program will be able to:</b>
<b>GA 1</b>	Demonstrate in depth understanding in the relevant science discipline. Recall, explain, extrapolate, and organize conceptual scientific knowledge for execution and application and to evaluate its relevance.
<b>GA 2</b>	Critically evaluate, analyze, and comprehend a scientific problem. Think creatively, experiment and generate a solution independently, check and validate it and modify if necessary.
<b>GA 3</b>	Access, evaluate, understand, and compare digital information from various sources and apply it for scientific knowledge acquisition as well as scientific data analysis and presentation.
<b>GA 4</b>	Articulate scientific ideas, put forth a hypothesis, design and execute testing tools and draw relevant inferences. Communicate the research work in appropriate scientific language.
<b>GA 5</b>	Demonstrate initiative, competence, and tenacity at the workplace. Successfully plan and execute tasks independently as well as with team members. Effectively communicate and present complex information accurately and appropriately to diverse groups.
<b>GA 6</b>	Use an objective, unbiased and non-manipulative approach in collection and interpretation of scientific data and avoid plagiarism and violation of Intellectual Property Rights. Appreciate and be sensitive to environmental and sustainability issues and understand its scientific significance and global relevance.
<b>GA 7</b>	Translate academic research into innovation and creatively design scientific solutions to problems. Exemplify project plans, use management skills, and lead a team for planning and execution of a task.
<b>GA 8</b>	Understand cross disciplinary relevance of scientific developments and relearn and reskill to adapt to technological advancements.

## PROGRAM OUTCOMES

### Program: M.Sc. Life Science

PO	Description
	<b>A student completing Master's Degree in Science program in the subject of Life Science will be able to:</b>
PO 1	Gain a multidisciplinary understanding of science and its related fields.
PO 2	Improve their overall personality with skills like independent thinking and innovation as well as soft skills.
PO 3	Follow good laboratory etiquettes and research ethics.
PO 4	Present themselves and their research work with confidence.
PO 5	Develop problem solving and troubleshooting abilities as well as the ability to work as a team when performing laboratory experiments.
PO 6	Appear for various competitive exams like CSIR-NET, UGC-NET, SET, GATE, ICMR, etc in the subject of Life Sciences as well as Biotechnology.
PO 7	Find employment in a variety of fields ranging from biotechnology to nanotechnology or become self-sustaining bio-entrepreneur.
PO 8	Display their creativity and express their ideas in a nurturing environment.

## **MSc Life Science Program Outline**

The main objectives of the MSc Life Sciences Program curriculum involve:

- The application, attainment, and synthesis of knowledge.
- Improving written as well as spoken communication skills.
- Developing research skills, ethics, and etiquettes.
- Encouraging critical thinking and problem solving.

The MSc syllabus is also designed keeping in mind the highly competitive CSIR NET (Council of Scientific & Industrial Research – National Eligibility Test) exam which only has Life Sciences as the subject of choice for biological sciences. Qualifying this exam enables the students to receive a Junior Research Fellowship as well as eligible to apply for teaching positions at various colleges, institutes, and universities. The Life Science program also gives students the freedom of choice to branch out and pursue whatever occupation they wish in any field of biological sciences because of the diversity of the core and elective topics.

The program of the first two semesters allows BSc students of all biological science streams to have a common foundation in the basics of Life Sciences. The course of the first semester is designed so that every student begins on the same level before advancing to more specialised topics. It includes the basic and advanced concepts in Ecology, Cell biology, Biochemistry, Molecular Biology, etc. Topics that help to inculcate a scientific temperament and research acumen are also taught before the students begin their internship or dissertation projects. The second semester is a mix of basic subjects such as Animal and Plant Physiology, Microbiology, Immunology as well as advanced subjects like Cellular signalling, Cancer biology, Epigenetics, Genetic manipulation, and Genetic engineering.

The third semester is designed to further the knowledge of the students in the specialization of Biotechnology. Topics like Tissue culture, Fermentation technology and promising areas of research like Diagnostics, Microfluidics and Nano biotechnology are focused on which have a direct industrial application. Students will also get a chance to work as an intern in research institutes like ACTREC, NIRRH, BARC, etc. or in an industry and present their work at the end of the semester.

The final semester rounds off the knowledge they have gained by the introduction of diverse topics like advanced protein studies, Proteomics as well as Biomathematics. The students will also be exposed to the fundamentals of the Pharmaceutical and Medical biotechnology industries as well as Environmental biotechnology and the novel areas of research involved in it. Students will also get a chance to work on an individual research project in the college itself which may lead to research publications or presentations in conferences. The individual project work will culminate in a final presentation and thesis at the end of the fourth semester.

The teaching style encourages students to use logic and reasoning instead of rote learning. Concepts are explained through discussions, debates, presentations, and even innovative games. By the end of the program the intellectual arsenal of the students is well equipped and fortified along with the sense of responsibility and scientific temperament that will assist them in their future endeavours.

## PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	COURSE TITLE	CREDITS
2022-23	I	RPSLSc101 (Core Course)	Cell and Molecular Biology	6
	I	RPSLSc102 (Core Course)	Biochemical Studies	6
	I	RPSLSc103 (Core Course)	Bioanalytical Techniques and IPR	6
	Note: <b>Students should select ANY ONE of the following Discipline Specific Elective (DSE)</b>			
	I	RPSLSc104 (DSE)	Environmental Biology, Biodiversity and Evolution	6
	I	RPSBOT104 (DSE)	Bioprospecting for Industrial Molecules	6
	I	RPSZOO104 (DSE)	Entrepreneurship in Aquarium Management	6
	I	RPSLSc105 (AECC)	Emotional well-being through Logic-based thinking	2
	II	RPSLSc201 (Core Course)	Microbiology, Immunology and Plant Physiology	6
	II	RPSLSc202 (Core Course)	Model Organisms and Life Processes	6
	II	RPSLSc203 (Core Course)	Genetic Manipulation and Cell Signalling	6
	Note: <b>Students should select ANY ONE of the following Discipline Specific Elective (DSE)</b>			
	II	RPSLSc204 (DSE)	Genetic Engineering	6
	II	RPSBOT204 (DSE)	Immunology and Cancer Biology	6
	II	RPSZOO204 (DSE)	Wildlife Biology	6
	II	RPSLSc205 (AECC2)	Research Methodology	2

2022-23	III	RPSLSc301	Tissue Culture and Aquaculture	6
	III	RPSLSc302	Fermentation Technology and its Applications	6
	III	RPSLSc303	Bioinformatics, International Standards & Bioethics	6
	III	RPSLSc304	Project Work	6
	IV	RPSLSc401	Medical Biotechnology	6
	IV	RPSLSc402	Applied Biotechnology	6
	IV	RPSLSc403	Environmental Biotechnology	6
	IV	RPSLSc404	Protein studies, Advanced Bioinformatics and Biomathematics	6

- Ability Enhancement Compulsory Course (AECC) - For all students offered by college/department
- Discipline Specific Elective (DSE) - For biology cluster students (Botany, Life Science and Zoology)
- Skill Enhancement Courses (SEC) - For Life Science students

## M.Sc. Part - I Life Sciences Syllabus

### SEMESTER I

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Cell and Molecular Biology			
RPSLSc101 (Core Course)	I	Cell Biology	6	4
	II	Genetics		4
	III	DNA Replication, Repair & Recombination		4
	IV	Transcription and Translation		4
Paper II	Biochemical studies			
RPSLSc102 (Core Course)	I	Proteins and Lipids	6	4
	II	Carbohydrates, vitamins and minerals		4
	III	Enzymology		4
	IV	Photosynthesis, Mitochondrial and Chloroplast Electron Transport Chain		4
Paper III	Bioanalytical Techniques and IPR			
RPSLSc103 (Core Course)	I	Microscopy, Spectroscopy and PCR	6	4
	II	Chromatography and Tracer techniques		4
	III	Biostatistics		4
	IV	Traditional Knowledge and IPR		4
	Note: Students should select ANY ONE of the following Discipline Specific Elective (DSE)			
Paper IV	Environmental Biology, Biodiversity and Evolution			
RPSLSc104 (DSE)	I	Environmental biology	6	4
	II	Current Environmental Issues in India and Biodiversity Management		4
	III	Evolution and Astrobiology		4
	IV	Use of software in research		4

Paper IV	Bioprospecting for Industrial Molecules			
RPSBOT104 (DSE)	I	Bioprospecting for crop protection	6	4
	II	Bioprospecting for anti-microbial products		4
	III	Algal Biomass for high-value biomolecules		4
	IV	Bioprospecting for flavours and fragrance		4
Paper IV	Entrepreneurship in Aquarium Management			
RPSZOO104 (DSE)	I	Introduction to Aquarium Fish Keeping	6	4
	II	Aquarium Fishes		4
	III	Maintenance of Aquarium		4
	IV	Basic requirements of Aquarium Maintenance		4
Paper V	Emotional well-being through Logic-based thinking			
RPSLSc105 (AECC)	I	Relation between Emotions and Thinking	2	4
	II	Fallacies		4



## SEMESTER I

**PAPER I – Core Course**

**Course Code: RPSLSc101**

**Course Title: Cell and Molecular Biology**

### COURSE OUTCOMES:

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Describe the structure, composition, and functions of various cell organelles in detail and Explain the importance of cell cycle in growth and development of an organism with the detailed events of one of the highly coordinated processes of the cell cycle, its role, regulation, and checkpoints.
<b>CO 2</b>	Explain concepts related to Mendelian genetics, non-mendelian inheritance and quantitative genetics.
<b>CO 3</b>	Describe the concept of conjugation, transformation and transduction involved in microbial genetics.
<b>CO 4</b>	Compare the mechanisms involved in DNA replication, recombination and repair in prokaryotes and eukaryotes.
<b>CO 5</b>	Describe the concepts of the central dogma of life from DNA to RNA to proteins which serve the whole purpose of molecular biology.
<b>CO 6</b>	Compare and state differences between the transcriptional and translational process among Prokaryotes and Eukaryotes.
<b>CO 7</b>	Use gene mapping methods to find the distance between genes and solve population genetics related problems.
<b>CO 8</b>	Apply isolation methods to analyse and quantify DNA and RNA. Amplify DNA using PCR machine and perform RAPD analysis.

## DETAILED SYLLABUS - Paper I - Core Course

Course Code: RPSLSc101

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Cell Biology</u></b></p> <p><b>Plasma membrane:</b> Structure and composition, Membrane properties, Functions and Membrane models.</p> <p><b>Endoplasmic reticulum:</b> Structure and function of Rough and smooth ER.</p> <p><b>Golgi complex:</b> Structure and function, Cisternal progression theories.</p> <p><b>Nucleus:</b> Structure - Nuclear envelope, Nuclear pore complex &amp; Nuclear lamin proteins, Functions, Chromatin - Heterochromatin, Euchromatin, Packaging and models. Nucleolus - Structure and function.</p> <p><b>Other organelles:</b> Lysosomes, peroxisomes, mitochondria, chloroplasts, and vacuoles.</p> <p><b>Cytoskeleton:</b> Structure, Assembly &amp; Functions of Microtubules, Intermediate filaments (types) &amp; Microfilaments.</p> <p><b>Introduction to cell cycle:</b> Stages of the cell cycle – G<sub>0</sub>, G<sub>1</sub>, S, G<sub>2</sub> and M. Molecular events in the various cell cycle stages (Yeast / Mammalian).</p> <p><b>Checkpoints</b> (unreplicated DNA, spindle attachment, segregation of chromosomes, DNA Damage)</p> <p><b>Concept of cyclin and CDKs; activation of the cyclin-CDK complexes (Yeast / Mammalian).</b></p> <p><b>G<sub>1</sub> cyclins:</b> Cln1, Cln2 and Cln3 and its relevance in commitment to cell division.</p> <p><b>S phase and G<sub>2</sub> phase:</b> S phase cyclin, its inhibitors and pre-replication complex and its significance in DNA replication in the cell cycle.</p> <p><b>M phase:</b> Prophase, Metaphase, Anaphase and Telophase, condensins, securin, separase and the end of mitosis.</p> <p>Meiosis checkpoints (Ime2, Rec8 and monopolin)</p>	1/ 15L
II	<p><b><u>Unit II: Genetics:</u></b></p> <p><b>Extensions of Mendelian principles:</b> Codominance, incomplete dominance, Multiple alleles, Lethal and Essential Genes.</p> <p><b>Non-Mendelian Inheritance:</b> Cytoplasmic inheritance, organelle genetics, maternal inheritance.</p> <p><b>Microbial genetics:</b> transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating.</p> <p><b>Quantitative genetics:</b> Pleiotropy and epistasis, polygenic inheritance, heritability and its measurements, QTL mapping, linkage and crossing over.</p> <p><b>Population Genetics:</b> gene pool, gene frequency, Hardy Weinberg Law and its role in evolution and speciation, Pedigree analysis.</p>	1/ 15L

	<p><b>Gene mapping methods:</b> Linkage maps and lod score for linkage testing, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.</p> <p><b>Human Genome Project.</b></p>	
III	<p><b><u>Unit III: DNA Replication, Repair and Recombination</u></b></p> <p><b>DNA replication:</b> DNA structure, forms of DNA, Unit of replication and enzymes, replication origin and replication fork, fidelity and processivity of replication, extrachromosomal replicons (plasmid). Replication process in prokaryotes and eukaryotes.</p> <p><b>DNA repair mechanisms:</b> SS damage reversal repair, SS damage excision repair (BER, NER, MMR), DS damage repair (HR, NHEJ, NMEJ), Defects in DNA repair.</p>	1/ 15L
IV	<p><b><u>Unit IV: Transcription and Translation</u></b></p> <p><b>Transcription:</b> Classes of RNA molecules - structure and function.</p> <p><b>Transcription in prokaryotes:</b> E. coli RNA polymerase, transcription activators and repressors, initiation, elongation and termination, processing of tRNA and rRNA in E. coli.</p> <p><b>Transcription in Eukaryotes</b> - Types of eukaryotic RNA Polymerases, mRNA transcription - formation of initiation complex, elongation &amp; termination, Upstream activation sites and enhancers, mRNA processing and modifications - capping &amp; polyadenylation, mRNA Splicing, RNA editing, RNA Pol II &amp; Pol III promoters, Eukaryotic rRNA genes, rRNA synthesis &amp; processing, formation of eukaryotic tRNA molecules.</p> <p><b>Translation:</b> Outline of Translation.</p> <p><b>The Genetic Code:</b> The Decoding System, Codon -Anticodon interaction.</p> <p><b>Ribosomes:</b> the special properties of the prokaryotic and eukaryotic ribosomes, ribosome biogenesis.</p> <p><b>Translation process:</b> initiation, elongation and termination factors of prokaryotes and eukaryotes mechanisms to overcome premature translation termination, role of suppressor tRNAs.</p> <p><b>Inhibitors of protein synthesis:</b> Prokaryotic and eukaryotic protein synthesis inhibitors and their significance.</p>	1/ 15L

### **PRACTICALS: RPSLScP101 (2 credits)**

1. Electron Micrographs of cell organelles and cytoskeletal elements.
2. Localization of cytoskeleton elements using Fluorescence staining.
3. Isolation of chloroplasts and chlorophyll estimation from spinach or any other suitable system.
4. Study of cell stages of mitosis – Onion root tip / meiosis - *Tradescantia*.
5. Inhibition of cell division by colchicine.
6. Isolation and estimation of RNA from Yeast or a suitable system.
7. Determination of lambda max of KMnO<sub>4</sub>, CoCl<sub>2</sub>, methylene blue and Verification of Beer-lamberts law by colorimeter / UV Visible spectrophotometer.
8. Problems in Genetics:
  - a. Problem solving: Multiple alleles, Lethal genes
  - b. Problem solving: Hardy Weinberg equation, Pedigree analysis.

### **References:**

- Principles of Biochemistry- Lehninger, Nelson and Cox
- Gene VIII- Lewin
- Principles of Genetics- Tamarin
- Microbial Genetics- Freifelder
- iGenetics- Russell
- Genetics- Benjamin Pierce
- Introduction to Genetics- T.A. Brown
- Molecular Cell biology: 5<sup>th</sup> Edition and above. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell.

**PAPER II - Core Course**  
**Course Code: RPSLSc102**  
**Course Title: Biochemical Studies**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Explain the unique properties of amino acids which influences the amazing diversity of proteins and describe the structure and properties of lipids and their role in our diet.
<b>CO 2</b>	Apply the basic concepts of protein biochemistry to advanced subjects like protein engineering, vaccine formulation and drug designing.
<b>CO 3</b>	Describe the classification, structural properties of carbohydrates along with the concept of stereochemistry and biological roles.
<b>CO 4</b>	Explain the structure, and role of vitamins and minerals and their importance with respect to nutritional deficiencies.
<b>CO 5</b>	Explain the concept of Enzyme-substrate interactions, kinetics, mechanism of catalysis and regulation of enzyme activity using appropriate examples and various industrial applications of enzymes.
<b>CO 6</b>	Compare the mechanisms of the light and dark phases of photosynthesis, including the processes involved in CO <sub>2</sub> fixation by the C <sub>3</sub> , C <sub>4</sub> , and CAM pathways, and explain the significance of photorespiration.
<b>CO 7</b>	Optimize various parameters of the enzyme assays and construct the graphs depicting enzyme kinetics.
<b>CO 8</b>	Extract, Estimate, Quantify and Analyse amount of Sugars, Lipids and Proteins using respective methods and compare the sensitivity of the methods used for proteins.

## DETAILED SYLLABUS - Paper II - Core Course

Course Code: RPSLSc102

Unit	Course/ Unit Title	Credits/ Lectures
I	<b><u>Unit I: Protein and Lipids</u></b>  <b>Protein:</b> Primary structure elucidation, secondary structure structures eg. Keratin, Collagen, tertiary structure and the underlying interactions/ forces, quaternary structure (example: haemoglobin), protein folding, domains and motifs, cytoskeletal and extracellular proteins. <b>Lipids:</b> structure, nomenclature, classification and properties of lipids, lipid assembly, model membranes, formation of liposomes and drug targeting.	1/ 15L
II	<b><u>Unit II: Carbohydrates, Vitamins, Minerals</u></b>  <b>Carbohydrate:</b> Classification and stereochemistry, structure, properties and biological roles of storage and structural polysaccharides such as, starch, glycogen cellulose, pectin, hemicelluloses, chitin, mucopolysaccharides. Structure and role of N and O- linked glycoproteins and proteoglycans. <b>Vitamins:</b> Structure and biological roles of water soluble and lipid soluble vitamins, vitaminosis and deficiency. <b>Minerals:</b> Structure and biological roles of bulk and trace elements.	1/ 15L
III	<b><u>Unit III: Enzymology</u></b>  <b>Enzyme:</b> enzyme and enzyme substrate interactions, enzyme kinetics, chemical modification, and identification of active site amino acids, mechanism of enzyme catalysis with reference to chymotrypsin, lysozymes, metalloenzymes and the role of metals in catalysis with reference to carboxypeptidase. <b>Regulation of enzyme activity:</b> theory of allosterity with reference to AT case, Isozymes with reference to LDH: Coenzymes and their roles, types of enzyme inhibitors and activators and their kinetics, ribozymes and abzymes.	1/ 15L
IV	<b><u>Unit IV: Photosynthesis, Mitochondrial &amp; Chloroplast Electron Transport Chain</u></b>  <b>Photosynthesis &amp; Chloroplast ETC:</b> Significance of photosynthesis. The structure, chemical composition, function, and origin of Chloroplasts. Absorption of light, Photosynthesis pigments, Light energetics, Light harvesting complexes, Light and dark phase reaction mechanisms, Photorespiration. CO <sub>2</sub> fixation by C <sub>3</sub> , C <sub>4</sub> and CAM pathways.	1/ 15L

	<b>Mitochondrial ETC:</b> structure and function of mitochondrial ETC proteins and mechanism of oxidative phosphorylation, F <sub>0</sub> F <sub>1</sub> ATPase, theories of ATP synthesis.	
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### PRACTICALS: RPSLSCP102 (2 credits)

1. Estimation of sugar by DNSA method from a biological source.
2. Enzyme kinetics, effects of pH, temperature, time and substrate concentration, determination of K<sub>m</sub> and V<sub>max</sub> using phosphatase/Amylase.
3. Estimation of protein by Folin Lowry and Biuret methods. Compare sensitivity by using Folin Lowry method, Biuret method and UV absorbance at 280nm.
4. Lipid extraction and estimation by Bligh and Dyer method, separation of lipids by TLC and analysis by JustTLC software.
5. Estimation of ascorbic acid from vegetable source by colorimetric method.
6. Polyacrylamide Gel Electrophoresis (PAGE)
  - A. Staining techniques for molecular weight determination: Coomassie and Silver staining.
  - B. Determination of effect of acrylamide concentration on the mobility of proteins
7. Activity staining of enzymes using Native PAGE.
8. Separation of plant pigments by column chromatography.
9. Separation of amino acids by paper chromatography.

### References

- Principle of Biochemistry, Lehninger, Albert L. (III Ed. 2000 worth pub), CBs publishers and distributors.
- Biochemistry, Stryer, Lubert, W. H. Freeman.
- Biochemistry and Molecular biology, Elliott, Willam H, Elliott, Daphne C, Oxford University Press.
- Oxford dictionary of biochemistry and molecular biology, Oxford University Press.
- Proteins- Structures and molecular properties, Creighton, T. E, Freeman, and Co.
- Biochemistry of cell membranes: a compendium of selected topics, Papa S., ed. Tager, J. M., ed, Birkhauser Verlag.
- Plant Biochemistry, Hans-Walter Heldt, Birgit Piechulla, Academic press.

**PAPER III - Core Course**  
**Course Code: RPSLSc103**  
**Course Title: Bioanalytical Techniques and IPR**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> Upon successful completion of this course, learners will be able to;
<b>CO 1</b>	Explain the principles, instrumentation, and working of various microscopy and spectroscopy techniques and their applications in biological research.
<b>CO 2</b>	Explain the principle of PCR (Polymerase Chain Reaction) and its steps. Analyse the constraints and limitations of PCR and explain the modifications of PCR techniques and its wide range of applications in various fields of biological research.
<b>CO 3</b>	Illustrate the basic principles, working and applications of chromatography and tracer techniques in various fields of biological research.
<b>CO 4</b>	Describe the various blotting techniques used for biological research.
<b>CO 5</b>	Explain different forms of IPR's, procedures and the process of patent filing.
<b>CO 6</b>	Explain the protection of traditional knowledge, geographical indications, industrial designs, gene patenting, plant variety protection, and trade secrets.
<b>CO 7</b>	Determine pKa of buffers and lambda max for solutions using colorimeter / UV spectrophotometer to verify Beer-Lamberts law.
<b>CO 8</b>	Analyse amino acids and proteins using separation techniques including paper chromatography and SDS-PAGE.



## DETAILED SYLLABUS - Paper III - Core Course

Course Code: RPSLSc103

Unit	Course/ Unit Title	Credits/ Lectures
I	<b><u>Unit I: Microscopy, Spectroscopy and PCR</u></b> <b>Microscopy:</b> Principles, instrumentation, working and applications of Fluorescence microscopy, Polarization microscopy, Phase contrast microscopy, TEM, SEM. Biological sample preparation for electron microscopy. <b>Spectroscopy:</b> IR, GC MS, LC MS, AAS, ICP- AES, Plasma Emission spectroscopy, NMR, 2D NMR. <b>PCR:</b> Principle, Steps in PCR, Constraints in PCR, Modifications of PCR techniques and its applications.	1/ 15L
II	<b><u>Unit II: Chromatography and Tracer techniques</u></b> <b>Chromatography</b> - General Principle of chromatography. Techniques and applications of Ion exchange, Affinity Chromatography and HPLC Application / validation of herbal drugs using HPTLC. <b>Radioactive isotopes and autoradiography</b> - Principle, instrumentation & technique: Geiger-Muller counter, Liquid scintillation counters. Applications of isotopes in biology. Radionuclide imaging, CT scan and PET scan. <b>Blotting techniques:</b> Southern, Western and Northern.	1/ 15L
III	<b><u>Unit III: Biostatistics</u></b> Hypothesis testing: Theory of errors – Type I and Type II errors Null Hypothesis & Alternate Hypothesis Z-test Test of significance Introduction to ANOVA, One-way & two-way ANOVA Dunett's test Randomized Block Design and Latin Square. (5 problems to be solved in each category).	1/ 15L
IV	<b><u>Unit IV: Traditional Knowledge and IPR</u></b> Different property rights & IPR in India <b>IPR:</b> Objectives, process & scope <b>TRIPS &amp; Patent laws:</b> Introduction & standards for patent protection WTO, WIPO, GATT & Indian Patent Laws <b>Protection of traditional knowledge</b> – objective, concept of traditional knowledge, holders, issue concerning, bio-prospecting and biopiracy; geographical indications, industrial designs, advantages of IPR, some case studies International Depositary authority, Gene patenting, plant variety protection, trade secrets & plant breeders right.	1/ 15L

**PRACTICALS: RPSLScP103 (2 credits)**

1. Preparation of buffers (phosphate and acetate)
2. Determination of pKa
3. Density gradient centrifugation
4. Analysis of heavy metals from soil/plant sample by AAS
5. Analysis of volatile oils by GC-MS
6. Separations of proteins by ion exchange chromatography
7. Separation of phytochemicals using chromatographic techniques (HPLC/HPTLC)
8. Separation of amino acids by two dimensional chromatography
9. DNA amplification using PCR
10. Normal deviate test
11. ANOVA- one way & two way
12. Randomized block Design & Latin square
13. Patent search and patent filing.

**References:**

- Berlyn GP and Miksche JP. 1976. Botanical micro-techniques and cytochemistry
- Chang R (1971). Basic principles of spectroscopy. McGraw Hill.
- Garry D Christian, James E O'reilvy 1986. Instrumentation analysis. Alien and Bacon, Inc.
- Gordon MH and Macrae M. 1987. Instrumental analysis in the biological sciences.
- Henry B Bull (1971). An Introduction to physical biochemistry. F A Devis Co.
- Wilson K and Walker JM.1994. Principles and techniques of practical biochemistry.
- Allan Peacock, H. 1966. Elementary Microtechnique. Edward Arnold Publ.
- Duddington, C.L, 1960. Practical microscopy. Pitman publ.
- Perkampus H (1992). UV-VIS Spectroscopy and its applications. Springer-Verlag.
- Pesce A J, Rosen C G, Pasty T L. Fluorescence Spectroscopy: An introduction for Biology
- Vanholdem K.E. and W.C.Johnson, 1998. Principles of Physical Biochemistry
- Goon,A.M., Gupta,M.K. and Dasgupta,B.1986. Fundamentals of Statistics (Vol.2). The world press Private limited, Calcutta. 17. Gupta,S.C. and Kapoor,V .K.1993. Fundamentals of applied statistics. Sultan Chand and Sons, New Delhi 18.
- Gupta,S.P. 2001. Statistical methods. Sultan Chand and Sons, New Delhi.
- Khan I and Khanum (2008) Fundamentals of Biostatistics, Ukaaz Publications, Hyderabad.
- Hamilton, C.(2006) Biodiversity, Biopiracy and Benefits: What allegations of Biopiracy tell us about intellectual property. Blackwell publishing Ltd., Oxford.
- Heink, U and Kowarik,I. (2010) What criteria should be used to select biodiversity indicators . Biodiversity Conservation 19:3769-3797.
- Ram Reddy,S. Surekha ,M. and Krishna Reddy,V (2016). Biodiversity Traditional Knowledge Intellectual Property Rights .Scientific Publishers.
- Unnikrishna,P and Suneetha,M. (2012). Biodiversity ,traditional knowledge and community health : strengthening linkages .Institute for Advanced Studies, United Nations University ,Tokyo.
- Wood ,A., Pamela, S.E.and Johanna, M.(2000). The root causes of biodiversity loss. United Kingdom: Early –Scan Publications.

**PAPER IV - DSE**  
**Course Code: RPSLSc104**  
**Course Title: Environmental Biology, Biodiversity and Evolution**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Explain ecological concepts, national and international environmental issues and concepts in evolution which forms the basis of phenomena like antibiotic resistance as well as cancer progression.
<b>CO 2</b>	Apply ecological concepts to their day-to-day life to benefit the environment and use various essential software that will help them in their respective careers.
<b>CO 3</b>	Explain the magnitude and distribution of biodiversity and its economic value. Describe the concepts of bioprospecting, ecotourism, and biodiversity management approaches. Examine the biodiversity of India and the importance of its conservation.
<b>CO 4</b>	Identify the major events and dates that provide the structure for geologic time on Earth.
<b>CO 5</b>	Identify and explain features of various fossils and aquaculture specimens and analyse the age of fossils with the help of radio dating techniques.
<b>CO 6</b>	Explain the concepts of astrobiology, including the planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, and the astrobiology of Mars.
<b>CO 7</b>	Arrange data and determine diversity indices for a population study and perform probit analysis for toxicological studies.
<b>CO 8</b>	Use various online softwares for Word processing, Image editing, Referencing, Presentation & designing, Website building and making graphs & use of statistical tools.

## DETAILED SYLLABUS – Paper IV - DSE

Course Code/ Unit: RPSLSc104

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Environmental biology</u></b></p> <p><b>Ecosystems:</b> Types of ecosystems [terrestrial (Tropical evergreen forests, Tropical deciduous forests, Deserts, Chaparral, Temperate grasslands, Savannahs and thorn forests, Temperate deciduous forests, Boreal forests/ Taiga, Tundra) and aquatic (Lentic, Lotic, Oceans, Estuaries, Coral reefs)], Habitat fragmentation and niche overlap, Competitive exclusion principle, resource partitioning, character displacement and resource management and conservation.</p> <p><b>Community ecology:</b> Nature of communities; fundamental properties of biological communities (Productivity, Diversity, Complexity, Resilience, Stability, Structure); levels of species diversity and its measurement (Simpson, Shannon and Sorensen indices); edges and ecotones, Succession, disturbances and invasion. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.</p> <p><b>Population ecology:</b> Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation, demes and dispersal.</p> <p><b>Toxicology:</b> Basic principles of toxicology including LD50 and ED50, management of acute intoxication.</p>	1/ 15L
II	<p><b><u>Unit II: Current Environmental Issues in India and Biodiversity Management:</u></b></p> <p><b>Biodiversity:</b> Concept, characterization, generation, maintenance and loss, Magnitude and distribution of biodiversity, economic value, bioprospecting, ecotourism and biodiversity management approaches. Biodiversity of India.</p> <p><b>Conservation biology:</b> Principles of conservation, major approaches to management, conservation strategies.</p> <p><b>Forest Conservation</b> – Chipko movement, Appiko movement, Silent Valley movement and Gandhamardhan movement. People Biodiversity register.</p> <p><b>Wild life conservation projects:</b> Project Tiger, Project Elephant, Crocodile Conservation, GOI-UNDP Sea Turtle project, Indo-Rhino vision.</p> <p><b>Environmental issues related to water resource projects</b> - Narmada dam, Tehri dam, Almatti dam, Cauvery and Mahanadi, Hydro-power projects in Jammu &amp; Kashmir, Himachal and North-Eastern States.</p> <p><b>Water conservation-</b> Watersheds, Rain water harvesting and ground water recharge.</p> <p><b>National river conservation plan</b> – Namami Gange and Yamuna Action Plan. Eutrophication and restoration of lakes. Conservation of wetlands, Ramsar</p>	1/ 15L

	<p>sites in India.</p> <p><b>Soil erosion, desertification and Save Soil Movement.</b></p> <p><b>Climate change</b> - adaptability, energy security, food security and sustainability. Carbon sequestration and carbon credits.</p> <p><b>Environmental Disasters:</b> Minnamata Disaster, Love Canal Disaster, Bhopal Gas Tragedy, 1984, Chernobyl Disaster, 1986, Fukushima Daiichi nuclear disaster, 2011.</p> <p><b>Local environmental issues</b> – Mithi river pollution, Destruction of mangroves, Air quality index of Mumbai, Dumping grounds, Urban development projects at Aarey colony and Sanjay Gandhi National Park.</p>	
<b>III</b>	<p><b><u>Unit III: Evolution and Astrobiology</u></b></p> <p><b>Emergence of evolutionary thoughts:</b> Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Types of selection; Speciation – Punctuated equilibrium and phyletic gradualism; Modern evolutionary synthesis. Origin of cells and unicellular evolution</p> <p><b>Palaeontology and evolutionary history:</b> Introduction to time scales, origins of unicellular and multicellular organisms; major groups of plants and animals; Mass extinction events; Adaptive radiation, convergent evolution and coevolution; Primate evolution, Carbon dating, fossils.</p> <p><b>Molecular Evolution:</b> Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence, molecular taxonomy.</p> <p><b>Astrobiology:</b> Concepts, planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, astrobiology of Mars.</p>	<b>1/ 15L</b>
<b>IV</b>	<p><b><u>Unit IV: Use of Software in Research</u></b></p> <p><b>Literature Search:</b> Query formulation.</p> <p><b>Word Processing systems,</b> Microsoft Word, Google Docs, LATEX.</p> <p><b>Image Editors:</b> Guidelines for publishing images, Adobe Photoshop, Image J.</p> <p><b>Referencing:</b> Mendeley, EndNote, Zotero.</p> <p><b>Graphing &amp; Statistics:</b> Microsoft Excel, Google Sheets, GraphPad Prism, MaxStat, IBM SPSS, R.</p> <p><b>Anti Plagiarism:</b> Grammarly, TurnItIn, Online plagiarism checkers.</p> <p><b>Presentation and Design:</b> Microsoft PowerPoint, Google Slides, Microsoft Publisher.</p> <p><b>Website building</b> – Wix website design and publishing.</p> <p><b>Miscellaneous:</b> Using Cloud tools, Microsoft OneNote, Lightshot, Google lens.</p>	<b>1/ 15L</b>

**PRACTICALS: RPSLScP104 (2 credits)**

1. Study of animal interactions.
2. Analysing the floral origin of pollen grains in honey.
3. Determination of the Simpson's diversity index/ Shannon index of a given population.
4. Effect of toxicity on *Daphnia* / *C. elegans* / *Yeast* / *Pollen grains*. Biostatistical analysis using statistics software.
5. *In silico* analysis of toxicity using the ProtoxII webserver.
6. Effect of space vacuum/ cosmic radiation on bacteria.
7. Identification of fossil specimens.
8. Creation of a multi-panel vector and raster image for research paper publishing using ImageJ, Inkscape and GIMP.

**References:**

- The Cambridge Encyclopedia of Human Evolution (Cambridge Reference Book) by Steve Jones
- Evolution by Monroe W. Strickberger, CBS publishers and distributors
- Astrobiology: An Introduction by Alan Longstaff, CRC Press.
- Astrobiology: A brief introduction by Kevin W. Plaxco and Michael Gross, The Johns Hopkins University Press.
- Biodiversity, Wilson E.O. (Ed.), National Academy Press, Washington, D. C.
- Understanding Biodiversity by David Zeigler (May 30, 2007): Amazon Press
- Fundamentals of Ecology by E.P. Odum, Cengage publishers
- Ecology and environment by P.D. Sharma, Rastogi publications
- Elements of Ecology by Smith and Smith, Pearson publishers
- Environmental Biology edited by Mike Calveret *al*: Cambridge University Press
- Molecular Environmental Biology by Seymour J. Garte, Lewis Publishers (1994)
- Basic Environmental Toxicology, Lorris G. Cockerham & Barbara S. Shane, CRC Press.
- David Wright and Pamela Welbourn, Environmental Toxicology, Cambridge university press

**Paper IV - DSE****Course Code: RPSBOT104****Course Title: Bioprospecting for Industrial Molecules****COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> Upon successful completion of this course, learners will be able to;
<b>CO 1</b>	Describe the role of entomotoxic proteins in crop protection.
<b>CO 2</b>	Enumerate the different extraction methods of natural sources for flavours and fragrances.
<b>CO 3</b>	Interpret the role of algae and plant products in bioprospecting.
<b>CO 4</b>	Comment on the economic potential of biological resources for obtaining industrial molecules of pharmaceutical, bioceutical & agricultural value.
<b>CO 5</b>	Elaborate on the plant resources as antimicrobials by testing their antimicrobial activity.



**Detailed Syllabus**  
**Paper IV – DSE**  
**Course code - RPSBOT104**

<b>RPSBOT 104</b>	<b>Title: Bioprospecting for Industrial Molecules</b>	<b>Credits – 4</b>
<b>UNIT I</b>	<b>Bioprospecting for crop protection</b>	<b>15 Lectures</b>
	<ul style="list-style-type: none"> <li>➤ Introduction to Bioprospecting.</li> <li>➤ Significance of plants in bioprospecting.</li> <li>➤ Recent trends in bioprospecting.</li> <li>➤ Entomotoxic proteins to control the crop insect pests and mechanism of insecticidal activity:               <ul style="list-style-type: none"> <li>● Lectins</li> <li>● Ribosome-Inactivating Proteins (RIPs)</li> <li>● Arcelins</li> <li>● Defensins</li> <li>● Cyclotides</li> </ul> </li> </ul>	
<b>UNIT II</b>	<b>Bioprospecting for anti-microbial products</b>	<b>15 Lectures</b>
	<ul style="list-style-type: none"> <li>➤ Use of plant products as antimicrobials: Historical perspective.</li> <li>➤ Major groups of Plant-derived antimicrobial compounds:               <ul style="list-style-type: none"> <li>● Phenols and Phenolic acids</li> <li>● Terpenes and Essential oils</li> <li>● Alkaloids</li> </ul> </li> <li>➤ Mechanisms of Antimicrobial activity:               <ul style="list-style-type: none"> <li>● Plant extracts with efflux Pump Inhibitory Activity</li> <li>● Plant extracts with Bacterial Quorum Sensing Inhibitory Activity</li> <li>● Plant extracts with Biofilm Inhibitory Activity</li> </ul> </li> </ul>	
<b>UNIT III</b>	<b>Algal Biomass for high-value biomolecules</b>	<b>15 Lectures</b>
	<ul style="list-style-type: none"> <li>➤ Algae in high-value biomolecule production:               <ul style="list-style-type: none"> <li>● Polyphenols</li> <li>● Polysaccharides</li> <li>● Fatty acids</li> <li>● Pigments</li> </ul> </li> </ul>	
<b>UNIT IV</b>	<b>Bioprospecting for flavours and fragrance</b>	<b>15 Lectures</b>
	<ul style="list-style-type: none"> <li>➤ Physiological mechanism of biosynthesis of essential oils:               <ul style="list-style-type: none"> <li>● Metabolic cycles of biosynthesis of Phenolic compounds.</li> <li>● Methods of extraction of natural sources for flavours and fragrances.</li> </ul> </li> <li>● Designing of flavours and fragrance.</li> <li>● sensory evaluation.</li> </ul>	



## **PRACTICALS: RPSBOTP104 (2 credits)**

- 1 Anti-microbial activity of plant extracts by disc diffusion method/ well diffusion method/ MIC method.
- 2 Bacterial Quorum Sensing Inhibitory Activity.
- 3 Plant extracts with Biofilm Inhibitory Activity.
- 4 Extraction of seed proteins.
- 5 Protein profiling by PAGE.
- 6 Applications of proteins to control insect pests.
- 7 Fractional distillation of essential oils (mint/lemon grass/Chafa).
- 8 Creation of flavours & fragrances and practical demonstration.
- 9 Estimation of fragrance / flavours
- 10 Application of fragrances in cosmetics, food, incense stick, soap, cream, talcum powder etc.  
Application of flavours in soft drink, tooth powder, jam, ketchup etc.

## **References:**

- Ramya Krishnan, Sudhir P. Singh, and Santosh Kumar Upadhyay. 2021. An introduction to Plant Biodiversity and Bioprospecting. Wiley Publications.
- Surjeet Kumar Arya, Shatrughan Shiva, Santosh Kumar Upadhyay. 2021. Entomotoxic Proteins from Plant Biodiversity to Control the Crop Insect Pests. Wiley Publications.
- Pankaj Kumar Verma, Shikha Verma, Nalini Pandey, and Debasis Chakrabarty. 2021. Antimicrobial products from plant Biodiversity. Wiley Publications.
- Dinesh Kumar Yadav, Ananya Singh, Variyata Agrawal, Neelam Yadav. 2021. Algal Biomass: A Natural Resource of High-Value Biomolecules. Wiley Publications.
- Monica Butnariu. 2021. Plants as Source of Essential Oils and Perfumery Applications. Wiley Publications.

**Paper IV - DSE****Course Code: RPSZOO104****Course Title: Entrepreneurship in Aquarium Management****COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b>
	Upon successful completion of this course, learners will be able to;
<b>CO 1</b>	Comprehend the key skills needed to set up an aquarium
<b>CO 2</b>	Identify and differentiate the different aquarium/ornamental fishes
<b>CO 3</b>	Formulate fish food that provides with complete nutritional benefits
<b>CO 4</b>	Analyze the required budget to set up a well maintained home aquarium

**Detailed Syllabus**  
**Paper IV – DSE**  
**Course code - RPSZOO104**

<b>DSE-I RPSZOO104</b>	<b>Title: Entrepreneurship in Aquarium Management</b>	<b>Credits 4</b>
<b>UNIT-I</b>	<b>Introduction to Aquarium Fish Keeping</b> <ul style="list-style-type: none"> <li>Types of aquaria (Salinity, Temperature, Species Selection &amp; Location) Aquarium setup and accessories.</li> <li>Aquarium Filters and types of filtration methods (Mechanical, Chemical &amp; Biological – Nitrogen Cycle)</li> <li>Precautions to be taken for an ideal aquarium; Criteria of selection for aquarium fishes</li> <li>Scope of Aquarium fish Industry.</li> </ul>	<b>15 Lectures</b>
<b>UNIT-II</b>	<b>Aquarium Fishes</b> <ul style="list-style-type: none"> <li>Exotic and Endemic species of Aquarium Fishes (Exotic Aquarium Fishes – Puffer &amp; Siamese Tiger fish;</li> <li>Endemic Aquarium Fishes – Zebra Danio &amp; Honey Gourami)</li> <li>Common characters and sexual dimorphism of Fresh, brackish and Marine Aquarium fishes.</li> <li>Freshwater ornamental fishes - Guppy, Gold fish and Angel fish.</li> <li>Brackish ornamental fishes - Black Molly and Sword tail.</li> <li>Marine ornamental fishes.</li> </ul>	<b>15 Lectures</b>
<b>UNIT-III</b>	<b>Maintenance of Aquarium</b> <ul style="list-style-type: none"> <li>Anatomy and biology, Feeding, Reproduction, Health, Nomenclature, and distribution of aquarium fish.</li> <li>Freshwater invertebrates,</li> <li>Marine invertebrates.</li> <li>Aquarium Plants</li> <li>Origin and variety of plants and Caring of live plants.</li> </ul>	<b>15 Lectures</b>
<b>UNIT -IV</b>	<b>Basic requirements of Aquarium Maintenance</b> <ul style="list-style-type: none"> <li>Budget for setting up and maintenance of Aquarium /ornamental fish farm.</li> <li>Water quality requirements: Maintenance and Temperature control.</li> <li>Live fish transport - Conditioning, packing, transport and quarantine methods. Factors and principles associated with live fish transport.</li> <li>Assembling a tank, Equipment and accessories.</li> <li>Balanced aquarium: Choosing the bed, Decor and background, Final preparations.</li> </ul>	<b>15 Lectures</b>

### **PRACTICALS: RPSZOOP104 (2 credits)**

1. Setting of freshwater aquarium tank.
2. Identify and describe food and its Types.
3. Identify and describe aquarium plants (any five).
4. Identify and describe aquarium fishes (Freshwater, Marine and Brackish water).
5. Activity based learning: Preparation of different type of fish food.
6. Develop digital presence for start-ups Lab-1: Website Development.
7. Develop digital presence for start-ups Lab-2: Search engine optimization.
8. Develop digital presence for start-ups Lab-3: email campaign.
9. Entrepreneurship Lab-1: Case study on business operation processes.
10. Entrepreneurship Lab-1: Case study on Market Research

### **References:**

1. Aquarium: Fish Keeping C B L Srivastava Published by Kitab Mahal .
2. Marine Aquarium (Fish: Keeping and Breeding Them in Captivity) Boruchowitz, Davie. Published by Chelsea House Publications (1998) .
3. Aquarium Setting Up (Fish: Keeping and Breeding Them in Captivity) Axelrod, Herbert R. Published by Chelsea House Publications (1998).
4. The Tropical Freshwater Aquarium Problem Solver: Practical and Expert Advice on Keeping Fish and Plants Sand ford, Gina Published by Voyageur Press (MN) (1998).
5. Aquariums: The Complete Guide to Freshwater and Saltwater Aquariums, Jan 2009 by Thierry Maitre-alain (Author), Chrisitan Piednoir (Author).

## AECC 1

### Emotional well-being through Logic-based thinking

(30 Hours – 2 Credits Course)

**Course Description:** Much of human existence is engulfed in the emotions of anger, depression, worry, anxiety, guilt, and frustration. From dealing with issues arising in the classroom to the workplace, and the arena of social interaction, intimacy, and friendship, the prospect for happiness is often spoiled by irrational thinking possessed by the human mind. Skills like being able to manage one's emotions and thoughts are important to every student irrespective of their academic areas of interest. This course helps students to use the methodologies in philosophy to work upon these irrational thinking tendencies thereby achieving a healthier state of mind. It focuses on a prominent form of philosophical practice known as Logic-Based Therapy and Consulting (LBT) developed by American philosopher Elliot D Cohen. Upon successful completion of this course, the student will be equipped with the knowledge of overcoming their faulty thinking patterns, ways of refuting them, and skills to replace them with rational patterns. In effect, the students will be able to manage their emotions in a better way by working on their thinking process.

COURSE OUTCOMES	DESCRIPTION At the end of the course students will be able to:
CO 1	Understand the connection between thinking patterns, emotions, and behavior.
CO 2	Identify one's faulty thinking patterns (fallacies) and methods for refuting them.
CO 3	Replace faulty thinking patterns with positive and rational thinking patterns.
CO 4	Using philosophical antidotes to promote a healthy state of mind.

**Detailed Syllabus Paper V – AECC 1****Course Code: RPSLSc105**

<b>Unit</b>	<b>Course/ Unit Title</b>	<b>Credits / Lectures</b>
<b>Unit 1</b>	<b>Relation between Emotions and Thinking</b> <ol style="list-style-type: none"> <li>Fundamentals of emotional well-being.</li> <li>Tracing the thoughts behind an emotional problem.</li> <li>Some prominent faulty thinking patterns/fallacies causing harm to oneself and others:               <ul style="list-style-type: none"> <li>○ Demanding perfection</li> <li>○ World Revolves Around Me</li> <li>○ Damnation</li> <li>○ Awfulizing</li> <li>○ Can'tstipation.</li> </ul> </li> </ol>	<b>1/15 L</b>
<b>Unit 2</b>	<ul style="list-style-type: none"> <li>● How to refute the fallacies               <ul style="list-style-type: none"> <li>○ Fallacy-Antidotes-Virtues framework</li> </ul> </li> <li>● Some uplifting Antidotal reasoning to overcome the fallacies</li> <li>● Corresponding Guiding virtues for the fallacies:               <ul style="list-style-type: none"> <li>○ Demanding perfection - Metaphysical security</li> <li>○ World Revolves Around Me - Empathy</li> <li>○ Damnation - Respect</li> <li>○ Awfulizing - Courage</li> <li>○ Can'tstipation - Temperance.</li> </ul> </li> </ul>	<b>1/15 L</b>

**References:**

- Elliot D Cohen, *What Would Aristotle Do: Self-Control through the Power of Reason*, Prometheus Books, 2003.

## Assessment Modalities

### Theory Examination Pattern:

- Assessment of theory is divided as Internal and External where internals are given weightage of 40 marks and external theory written exams are given 60 marks.

#### A) Internal Assessment: 40 Marks

- Assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / meme making assignment / video assignment / survey / debate pertaining to syllabus topics chosen or allotted.
- Students are informed at least a month in advance about the portions for topics of the assignments or presentations via emails or on google classroom and marking scheme in the form of rubrics are known to them and hard copies depicting the names of students with topics and rubrics are maintained as proofs with their signatures with date.
- Below is an example of the rubrics.

**Rubrics chart for presentations**

	<b>Total</b>	<b>80-100%</b>	<b>60-80%</b>	<b>40-60%</b>	<b>20-40%</b>	<b>0-20%</b>
Content	05	5	4	3	2	1
Presentation skills	05	5	4	3	2	1
Questions answered	05	5	4	3	2	1
Questions asked	03	3	2.4	1.8	1.2	0.6
Time management	02	2	1.6	1.2	0.8	0.4
<b>Total</b>	<b>20</b>	<b>20</b>	<b>16</b>	<b>12</b>	<b>08</b>	<b>04</b>

## B) External Examination- 60 Marks

Duration - The examinations shall be of **2 ½ hrs duration**. Theory question paper pattern is for 60 marks with 60% choice as shown below.

Semester	Papers	Units covered	Question numbers and choice	Marks for each question	Total marks
I	I, II, III, IV	1	Q1 - A, B, C (any two out of three)	06	12
		2	Q2 - A, B, C (any two out of three)	06	12
		3	Q3 - A, B, C (any two out of three)	06	12
		4	Q4 - A, B, C (any two out of three)	06	12
		1 question each from all 4 units	Q5 - i, ii, iii, iv (any three out of four)	04	12
Total marks					60

## Practical Examination Pattern: 50 Marks

- Assessment of practicals only consists of External evaluation with a weightage of 50 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
I	1, 2, 3, 4	Q1. Major experiment	30
		Q2. Identification	10
		Q3. <i>Viva voce</i>	5
		Q4. Journal	5
Total marks			50



## Overall Examination & Marks Distribution Pattern

### Semester I

PAPER	EXAM	MARKS	GRAND TOTAL
AECC1 (50 marks)	Theory	50	<b>650 marks</b>
I (150 marks)	Theory	60	
	Internal	40	
	Practical	50	
II (150 marks)	Theory	60	
	Internal	40	
	Practical	50	
III (150 marks)	Theory	60	
	Internal	40	
	Practical	50	
IV (150 marks)	Theory	60	
	Internal	40	
	Practical	50	

## SEMESTER II

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Microbiology, Immunology and Plant Physiology			
RPSLSc201 (Core Course)	I	Microbiology	6	4
	II	Immunology		4
	III	Plant physiology I		4
	IV	Plant physiology II		4
Paper II	Model organisms and life processes			
RPSLSc202 (Core Course)	I	Animal Physiology	6	4
	II	Developmental Biology		4
	III	Neurobiology		4
	IV	Model Organisms		4
Paper III	Genetic manipulation and Cell signalling			
RPSLSc203 (Core Course)	I	Gene and Epigenetics	6	4
	II	Gene Expression Regulation		4
	III	Gene cloning		4
	IV	Cell communication and signaling in normal cells and cancer cells		4
	Note: Students should select ANY ONE of the following Discipline Specific Electives (DSE)			
Paper IV	Genetic Engineering			
RPSLSc204 (DSE)	I	Recombinant Techniques	6	4
	II	Microbial Expression Systems		4
	III	Engineering Lower eukaryotes I		4
	IV	Engineering Lower eukaryotes II		4
Paper IV	Immunology and Cancer Biology			
RPSBOT204	I	Immune system and Immunotechniques	6	4

(DSE)	II	Cancer Biology		4
	III	Cancer genetics		4
	IV	Genetic disorders		4
Paper IV	Wildlife Biology			
RPSZOO204 (DSE)	I	Wildlife Management	6	4
	II	GIS and its interpretation-I		4
	III	GIS and its interpretation-II		4
	IV	Wild life Photography and Ecotourism		4
Paper V	Research Methodology			
RPSLSc205 (AECC)	I	Research Methodology-I	2	4
	II	Research Methodology-II		4

## SEMESTER II

### PAPER I – Core Course

**Course Code: RPSLSc201**

**Course Title: Microbiology, Immunology and Plant Physiology**

#### COURSE OUTCOMES:

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Describe the unique characteristics and types of bacteria, archaea, and eukaryotic microbes, including their cell structures, motility mechanisms, growth curves, and the effects of environmental factors on microbial growth.
<b>CO 2</b>	Enlist antibiotics classification and elaborate on mode of action, and resistance mechanisms and Brief the host-parasite interaction, including the mechanisms of microbial pathogenicity and disease establishment by different pathogens in animal hosts.
<b>CO 3</b>	Explain the lymphatic system, spleen, and lymph node structures and functions, as well as the importance of major histocompatibility complexes (MHC I and II) in immune responses.
<b>CO 4</b>	Explain how plants see the world through photoreceptors and their responses to abiotic and biotic stresses and describe plant development and plant cell death.
<b>CO 5</b>	Explain the responses of plants to abiotic stress, such as water, salt, and temperature, and explore the mechanisms of plant defence against biotic stress, including viral, fungal, and insect attacks.
<b>CO 6</b>	Describe the different biochemical and signalling pathways for plant hormones.
<b>CO 7</b>	Perform Diauxic growth curve, anti-microbial assay and radial immunodiffusion assay.
<b>CO 8</b>	Analyse the effects of hormones and salinity on plant growth.

## DETAILED SYLLABUS - Paper I - Core Course

Course Code: RPSLSc201

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Microbiology</u></b>  <b>Microbial diversity:</b> Bacteria, Archaea, and their Outline of classification; Eukaryotic microbes: Yeasts, molds, and protozoa; Viruses and their classification; Molecular approaches to microbial taxonomy. Bacteria: Purple and green bacteria, budding bacteria rods, Spirochaetes, Sheathed bacteria, Endospore forming rods and cocci.  <b>Archaea:</b> Archaea as earliest life forms; halophiles, Methanogens  <b>Eukarya:</b> Algae, Fungi, Slime molds- Typical characteristics and types.  <b>Prokaryotic Cell Structure-</b> Differences between eukaryotic and prokaryotic cells. Cell wall, cell membrane synthesis and nucleoid; Flagella and motility; cell inclusions like endospores, gas vesicles.  <b>Microbial Growth:</b> Growth curve; Mathematical expression of exponential growth phase; Measurement of growth and growth yields; Synchronous growth; Continuous culture; Effect of environmental factors on growth; diauxic growth.  <b>Antibiotics:</b> Typical characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.  <b>Host Parasite Interaction:</b> Recognition, mechanism of microbial pathogenicity and establishment of disease by different pathogens like viruses, bacteria, and parasites into animal hosts (one example each). Nosocomial infection; Emerging infectious diseases; alteration of host cell behavior by pathogens.</p>	1/ 15L
II	<p><b><u>Unit II: Immunology:</u></b>  <b>Lymphatic system,</b> structure and function of spleen and lymph node.  <b>Major Histocompatibility Complex I and II</b> and their importance.  <b>B cells:</b> Development, generation of antibody diversity, activation somatic hypermutation and class switch. Primary and secondary immune modulation  <b>T cells:</b> Development, TCR diversity, selection and types of T cells and activation.  <b>The Complement and its regulation.</b>  <b>Immune response to infectious diseases:</b> Viral, Bacterial, Parasitic, AIDS.  <b>Congenital immunodeficiencies:</b> SCID.  <b>Autoimmune diseases -</b> Myasthenia gravis, Rheumatoid arthritis.  <b>Disease and application:</b> Monoclonal antibodies, SCFV, Chimeric antibodies, bispecific antibodies, phage display, Recombinant, and polyvalent vaccines.</p>	1/ 16L
III	<p><b><u>Unit III: Plant Physiology I</u></b>  <b>Plant model systems:</b> <i>Arabidopsis thaliana</i>, <i>Zea mays</i>, <i>Physcomitrella patens</i>, <i>Medicago truncatula</i>, <i>Populus trichocarpa</i>, <i>Oryza sativa</i>.  <b>Material transportation:</b> through xylem, phloem and plasmodesmata.  <b>Nitrogen metabolism:</b> Symbiotic nitrogen fixation, Ammonia and nitrate uptake and metabolism, amino acid biosynthesis.</p>	1/ 15L

	<p><b>Plant Hormones:</b> Biosynthesis, signalling pathways and biological activity of Auxins, Cytokinins, Gibberellins, Ethylene, Abscissic acid, Salicylic acid, Jasmonates and Brassinosteroids.</p> <p><b>Stress response:</b> Plant response to abiotic stress- Water, salt, and temperature. Response and resistance to biotic stress (viral, fungal and insects): Host recognition and establishment of disease, overview of plant defence methods (anatomical, secondary metabolites, hypersensitive reactions, hormonal signals, and the R - avr system).</p>	
IV	<p><b>Unit IV: Plant physiology II</b></p> <p><b>Plant Development:</b> Gametogenesis, germination of pollen and self-incompatibility, Double fertilization, and seed formation (one typical example of each).</p> <p><b>Seed germination:</b> The hormonal and nutritional aspect of seed germination.</p> <p><b>Root and Shoot:</b> Development, organization of root and shoot apical meristems.</p> <p><b>Leaf development:</b> Development and phyllotaxy, stomatal movement.</p> <p><b>Flower development:</b> Flower induction, Floral organogenesis and the genes involved: Examples <i>Arabidopsis</i> and <i>Antirrhinum</i>.</p> <p><b>Sensory Photobiology:</b> Cryptochromes, phytochromes and phototropins. Photoperiodism and biological clocks. Role of Phytochromes in plant development.</p> <p><b>Programmed Cell Death and Senescence in plants:</b> Concept, effect on pigments in plants, environmental factors, and hormonal factors.</p>	1/ 15L

#### PRACTICALS: RPSLScP201 (2 credits)

1. Diauxic growth curve of bacteria.
2. Antimicrobial activity by agar cup/ disc method.
3. Isolation of Protease producers from soil and estimation of the protease activity.
4. Sandwich ELISA. (Demonstration), HepElisa/ HCG Kit.
5. Radial immunodiffusion (Mancini test).
6. Effect of salinity on seed viability and comparison of proline content in normal and salt stressed plants.
7. Differential staining of pollen grains using fluorescent dyes.
8. Estimation of Indole Acetic Acid in plants.

#### References:

- Text book of microbiology: Ananthanarayan and Paniker; Orient blackswan
- Microbiology: Prescott and Dunn
- Biochemistry and Molecular Biology of Plants: Bob Buchanan (Editor), Wilhelm Gruissem (Editor) and Russel Jones.
- Plant Physiology: Taiz and Zeiger.
- Maria Duca (auth.) - Plant Physiology-Springer International Publishing (2015)
- Heldt - Plant Biochemistry 3rd ed
- Immunology 5th Edition, Janis Kuby; OR Kuby Immunology 7th Edition
- Pollen biology - A laboratory manual, K.R. Shivanna and N.S. Rangaswamy

**PAPER II - Core Course**  
**Course Code: RPSLSc202**  
**Course Title: Model organisms and life processes**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Compare the anatomy of various life processes like digestion, respiration, circulation, and excretion across organisms.
<b>CO 2</b>	Enlist the disorders arising from defects in physiological processes in humans.
<b>CO 3</b>	Correlate various developmental processes in an organism by explaining the important fundamental concepts of development like commitment, specifications, determination, and differentiations with appropriate examples.
<b>CO 4</b>	Describe the concepts of gametogenesis, fertilization, and formation of germ layers during early development processes.
<b>CO 5</b>	Outline the basics of neuroanatomy and neuro-cellular mechanisms like electrical & chemical signalling and neurotransmission as well as the advanced functions of the nervous system.
<b>CO 6</b>	Compare and state the difference between neural and chemical regulation in controlling and maintaining homeostasis within animals.
<b>CO 7</b>	Explain the life-cycle, stages, culturing and maintenance of certain animal model organisms and choose an appropriate plant model system depending on a research objective.
<b>CO 8</b>	Demonstrate temporary mounting and microtomical techniques for animal tissues and culturing and maintenance of animal model organisms like <i>C. elegans</i> and <i>Drosophila</i> sps.

## DETAILED SYLLABUS - Paper II - Core Course

Course Code: RPSLSc202

Unit	Course/ Unit Title	Credits/ Lectures
I	<b><u>Unit I: Animal Physiology:</u></b> <b>Vascular system:</b> Blood corpuscles, haematopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis. <b>Cardiovascular System:</b> Comparative anatomy of heart structure, cardiac tissue, cardiac cycle, blood pressure, neural and chemical regulation. <b>Respiratory system:</b> Comparative anatomy, transport and exchange of gases, neural and chemical regulation. <b>Digestive system:</b> Comparative anatomy, human digestive system, Diet and BMR. <b>Excretory system:</b> Comparative physiology, human excretory system, osmoregulation. <b>Endocrine system:</b> Structure and functions of Endocrine glands (Pituitary, Thyroid, Parathyroid, Adrenal, Pancreas – islets of Langerhans, Sex glands, Pineal, Thymus), Biological roles and mechanism of actions of hormones (protein, glycoprotein, and steroid hormones), hormonal disorders. <b>Thermoregulation:</b> Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. <b>Stress and adaptation</b>	1/ 15L
II	<b><u>Unit II: Developmental biology</u></b> <b>Concepts of development:</b> Brief history of developmental biology, Potency, commitment, specification, induction, competence, determination, and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development. <b>Gametogenesis, fertilization, and early development:</b> Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation, and formation of germ layers in animals. <b>Morphogenesis and organogenesis:</b> Dictyostelium - Cell aggregation, differentiation and culmination, Drosophila - axes and pattern formation, Vertebrates - eye lens induction and limb development; Differentiation of neurons; metamorphosis; environmental regulation of normal development; sex determination.	1/ 15L
III	<b><u>Unit III: Neurobiology</u></b> <b>Overview: central nervous system (CNS) and peripheral nervous system (PNS)-</b> structure, organization, and function <b>Cellular perspective:</b> types of cells and function <b>Impulse generation and conduction of nerve impulse</b>	1/ 15L



	<p><b>Synaptic transmission:</b> Electrical and Chemical with examples of two neurotransmitters and their receptors; cAMP as messenger, Neuromuscular junctions – structure and function.</p> <p><b>Sensory systems:</b> Visual, Auditory, Chemosensory, Somatosensory</p> <p><b>Motor systems</b> – Overview of motor circuits and neural control.</p> <p><b>Behaviour</b>– Reflexive behaviour and homeostasis, Associative and non-associative memory.</p>	
IV	<p><b>Unit IV: Model Systems</b></p> <p><b>Nematode worm (<i>Caenorhabditis elegans</i>)</b> - History and description of the model. Culturing and maintenance. Research tools – Wormbase, Wombatlas, Validation of target molecules in <i>C. elegans</i> (genome-wide RNAi, knockouts, compound libraries, HTPS and the MOA strategy)</p> <p><b>Fruit fly (<i>Drosophila melanogaster</i>)</b> - History and description of the invertebrate model. Culturing and maintenance. Research tools: Flybase, Mutant collection (Gene disruption project), Genome-wide application of genetic tools.</p> <p><b>Western clawed frog (<i>Xenopus tropicalis</i>)</b> - Trans-NIH Xenopus Initiative, Xenbase</p> <p><b>Mouse (<i>Mus musculus</i>)</b> - Model organism for mammalian physiology, Types used for research, The Mouse Knockout &amp; Mutation database.</p> <p><b>Zebrafish (<i>Danio rerio</i>)</b> - Model organism to study vertebrate physiology and development. Culturing and maintenance. Research tools- Genetic screens with morpholino's. Zebra fish assays. ZFIN database</p>	1/ 15L

#### PRACTICALS: RPSLScP202 (2 credits)

1. Mounting of cornea and statocyst of prawn.
2. Chick embryology- Fresh mounting and preparation of permanent slides of distinct stages.
3. Microtomy- block preparation and histopathological study.
4. Permanent slides of tissues.
5. Study of ECG/EEG in humans.
6. H&E staining
7. Culturing and imaging *C. elegans*.
8. Culturing of *Drosophila* sps.

## References:

- Principles of Development: L. Wolpert, R. Beddington, J. Brockes, T. Jesell and P. Lawrence. Oxford University Press
- Developmental Biology: W.A. Miller, Springer – Verlag.
- Developmental Biology: S.F. Gilbert. Sinauer Associates Inc. Publishers (4th edition).
- An Introduction to Embryology: B. I. Ballinsky' Saunders, College Publishing Co. 4th Ed.
- Molecular Biology of the Cell: Bruce Alberts. Pub: Garland Science
- Neuroscience: D. Purves, G. Augustine, D Fitzpatrick, W. Hall, A. LaMantia, L. White. Sinauer Associate Inc (2012) 5th edition
- Principles of Neural Science: E. R. Kandel, J.H.Schwartz and T.M. Jessel. Prentice Hall International. (2012)
- Neuroscience: Exploring the brain M. F. Baer, B.W.Connors & M. A. Paradiso, William & Wilkins, Baltimore
- TextBook of Medical Physiology: A. C. Guyton and J.E.Hall, Saunders College Publishers.
- Principles of Anatomy and Physiology: G. Tortora and S.Grabowski John Wiley & Sons, Inc. 10th edition.
- Fundamentals of Neurobiology: Shepherd G M 3<sup>rd</sup> Edition, Oxford University Press.
- Elements of Molecular Neurobiology: C.U.M. Smith, Wiley, and sons Publication.
- TextBook of Biochemistry and Human Biology: Talwar and Srivastava (3<sup>rd</sup> Edition)
- Developmental Biology: Mohan and Arora.
- Model organisms in Drug Discovery (edited by Pamela M. Carroll and Kevin Fitzgerald). ISBN 0-470-84893-6, John Wiley & Sons Ltd
- A Guinea Pig's History of Biology, Jim Endersby, Harvard University Press.

**PAPER III - Core Course**  
**Course Code: RPSLSc203**  
**Course Title: Genetic Manipulation and Cell signalling.**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Explain the structure of gene and summarize various genomic mutations associated.
<b>CO 2</b>	Illustrate DNA cloning techniques using suitable restriction enzyme systems and vectors.
<b>CO 3</b>	Compare and elaborate on prokaryotic and eukaryotic regulation of gene expression.
<b>CO 4</b>	Summarize the concepts of Epigenetics related to gene expression and role of histone proteins.
<b>CO 5</b>	Classify the distinct types of cellular signalling, receptors and signalling pathways as well as apoptosis pathways.
<b>CO 6</b>	Explain the concept of apoptosis, all cancer related mechanisms and its diagnosis.
<b>CO 7</b>	Isolation and analysis of plasmid DNA, histone proteins from suitable organism.
<b>CO 8</b>	Demonstration of DNA ligation and Gene cloning methods.

## DETAILED SYLLABUS - Paper III - Core Course

Course Code: RPSLSc203

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Gene and Epigenetics:</u></b></p> <p><b>Structure of Gene:</b> Monocistronic and Polycistronic, Promoter, Operator, ORF, Terminator, Gene families, Pseudogenes, Split Gene.</p> <p><b>Other elements of Eukaryotic Genome:</b> Satellite DNA, Tandem repeat array, Transposons: LINE and SINE.</p> <p><b>Genomic Mutations:</b> Introduction, Deletions, Addition, Insertion, Inversions and Translocations.</p> <p><b>Chromatin Structure:</b> Histones, Non-Histones, Scaffolding proteins.</p> <p><b>Epigenetics:</b> Hypothesis, Imprinting, Mechanism (Methylation and Acetylation), Cancer epigenetics, Anticipation, Penetrance and Expressivity.</p>	1/ 15L
II	<p><b><u>Unit II: Gene Expression Regulation:</u></b></p> <p><b>Regulation of Gene expression in Prokaryotes:</b> General aspects of Regulation, transcriptional regulation - inducible and repressible system, positive regulation and negative regulation; Operon concept – lac, trp, Ara operons, the galactose operon, relative positions of Promoters and Operators, Regulons, Master switches, Regulation of Translation, Regulation of the synthesis of Ribosomes, Unregulated changes in gene expression, Feedback Inhibition, RNA interference, mRNA half-life, riboswitches, ribozymes.</p> <p><b>Regulation of Gene expression in Eukaryotes:</b> Regulatory strategies in Eukaryotes, Transcriptional Control by hormones, signalling factors and environmental factors, Role of transcription factors, enhancers, silencers, chromatin remodelling in regulation of gene expression, role of post-translational modifications of transcription factors, Regulation of processing, Regulation through RNA splicing, RNA degradation and RNA interference, Translational control. Diseases associated with defects in regulation.</p>	1/ 15L
III	<p><b><u>Unit III: Gene cloning</u></b></p> <p><b>DNA Cloning:</b> Importance of DNA Cloning, Cloning methods - Principles of Cell-based DNA Cloning and cell independent DNA cloning, Cutting of DNA - Restriction &amp; modification systems types and functions, Non-R-M systems, and Joining DNA methods - DNA Ligase mechanism, Linkers, Adaptors &amp; Homopolymer tailing.</p> <p><b>Vectors:</b> Essential components of vectors and their significance, Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, expression vectors, YACs and BACs. Genomic and cDNA libraries. Embryonic Stem cells to produce genetically modified transgenic mice and knockout mice.</p>	1/ 15L

IV	<p><b><u>Unit IV: Cell communication and signalling in normal cells and cancer cells</u></b></p> <p>Receptor ligand dynamics, nuclear receptors, Cell surface receptors, second messengers and regulation of the signalling pathway.</p> <p><b>Signalling pathways:</b> (a) G protein coupled receptors (cAMP-PKA pathway, iP3-DAG pathway, Rhodopsin signalling); (b). Receptor tyrosine kinases - EGFR and Insulin signalling; (c) Guanylyl cyclase receptors; (d) TGF-<math>\beta</math> serine threonine kinase receptors; (e) JAK-STAT pathway - Erythropoietin signalling; (f) Toll-like receptors; (g) Wnt, Hedgehog and Notch pathways.</p> <p><b>Extracellular matrix:</b> Fibres, cell adhesion molecules and their functions, gap junctions.</p> <p><b>Apoptosis:</b> Concept of programmed cell death, Comparison with necrosis, Extrinsic and intrinsic pathways of apoptosis, detection of apoptotic cells.</p> <p><b>Cancer:</b> Hallmarks of cancer, Cancer progression and metastasis, oncogenes, and tumour suppressor genes; Mechanisms to activate oncogenes, Diagnosis, and treatment of cancer. Breast cancer: classification, types, and therapies.</p>	1/ 15L

#### PRACTICALS: RPSLScP203 (2 credits)

1. Isolation of plasmid from *E. coli*.
2. Induction of the Lac operon and assessment of enzyme activity using a suitable system (e.g., *E. coli*).
3. Isolation of histone from yeast cells.
4. FISH (Demonstration). Visit NIRRH/ ACTREC / any other institute.
5. Flow cytometry to distinguish between normal and cancer cells based on markers. (Demonstration)
6. Ligation of digested Lambda DNA using T4 DNA Ligase.
7. Western Blotting to detect proteins of interest in cancer research (Demonstration).
8. Gene Cloning using Blue-white screening method.

#### References:

- Principles of Biochemistry- Lehninger, Nelson and Cox
- Gene VIII- Lewin, Principles of Genetics- Tamarin
- Microbial Genetics- Freifelder, iGenetics- Russell, Genetics- Benjamin Pierce, Introduction to Genetics- T.A. Brown
- Molecular Cell biology: 5th Edition and above. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell.

**Paper IV - DSE**  
**Course Code: RPSLSc204**  
**Course Title: Genetic Engineering**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Explain the mechanisms of various recombinant techniques & latest gene editing tools such as CRISPR/Cas.
<b>CO 2</b>	Summarize the use novel reporter systems, metabolic engineering aspects, in-silico modelling, and Omics analysis.
<b>CO 3</b>	Evaluate the importance of cloning any desired gene using suitable host and appropriate expression system.
<b>CO 4</b>	Compare and analyse various gene expression systems for variety of hosts including both prokaryotes and eukaryotes.
<b>CO 5</b>	Optimize various components and essential parameters involved in developing a gene expression system.
<b>CO 6</b>	Design an expression system for a suitable host organism to obtain recombinant protein product.
<b>CO 7</b>	Demonstrate bacterial and yeast transformation method.
<b>CO 8</b>	Perform replica plating, slide culture and RFLP techniques.

## DETAILED SYLLABUS Paper IV - DSE

Course Code: RPSLSc204

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Recombinant Techniques</u></b>  <b>Introduction to recombinant proteins.</b>  <b>Modifying genes/regulating sequences/proteins:</b> Site-directed Mutagenesis            Methods: Error prone PCR, Cassette mutagenesis, Site Saturation mutagenesis, Overlap PCR, DNA/Domain/Exon shuffling, ICTHY, SCRATCHY, RACHITT.  <b>Expression:</b> phage, cell, DNA, RNA, ribosome and IVC display,  <b>Genome editing:</b> Homologous recombination, zinc finger nuclease, TALENS, CRISPR/Cas9, Modified nucleases – meganuclease.  <b>Application of RNAi in strain improvement:</b> use of siRNA, shRNA, miRNA, ribozymes and riboswitches to regulate and optimize gene expression.  <b>Metabolic Engineering:</b> Metabolic pathway analysis and modelling – approaches, Methods for metabolic engineering, Model organisms – <i>E. coli</i>, <i>B. subtilis</i>, <i>Saccharomyces</i>, Industrial applications.</p>	1/ 15L
II	<p><b><u>Unit II: Microbial Expression Systems</u></b>  <b>Prokaryotic: <i>E. coli</i>:</b> Expression systems – pET, pBAD, <math>\lambda</math>PL, prhaBAD systems, Expression of Foreign Genes in Bacteria – Problems, optimization of expression: host, transcriptional, translational, post translational compatibility, solubility and purification, transport and localization (use of Promoters, Ribosome Binding Site, Fusion Proteins, signal sequences, Tags and cleavage sites), Modification of gene – codon optimization, host strain modification Expression of Native Proteins, Detecting Expression of Foreign Genes.  <b>Gram Positive Bacteria:</b> <i>Bacillus subtilis</i>, <i>Lactobacilli</i>, <i>Streptomyces</i> – Expression systems, optimization of expression and applications.</p>	1/ 15L
III	<p><b><u>Unit III: Engineering Lower eukaryotes I</u></b>  <b>Algae:</b> Types, Culture systems, Genetic modification - transformation strategies, selection markers, promoters, terminators, translational regulation of protein production, strategies for efficient protein production, applications – increasing photosynthetic efficiency, yield of commercial and therapeutic products, Risks of GM algae.  <b>Filamentous fungi</b> – Host strains, transformation strategies, selection markers, promoters, terminators, translational regulation of protein production, strategies for efficient production, signal sequences, gene fusion approach, overproduction of foldases and chaperones, role of glycosylation, heterologous and homologous gene expression, humanization of filamentous fungi (<i>Aspergillus</i>, etc.), applications - pharmaceutically important secondary metabolites, medicinal mushrooms</p>	1/ 15L

	( <i>Ganoderma</i> , etc.), polysaccharides from basidiomycetes for immunostimulatory and anticancer activity.	
IV	<b><u>Unit IV: Engineering Lower eukaryotes II</u></b> <b>Yeasts:</b> Yeast Selectable Markers and Vector Systems, commercially used yeast strains ( <i>S. cerevisiae</i> and <i>Pichia</i> ) and their expression systems <b>Heterologous Protein Production</b> - Design parameters: Source of DNA, Heterologous mRNA and protein levels and downstream applications, humanization of yeast for post translational compatibility. <b>Uses:</b> YAC Technology, Constructing Gene Knockouts and Novel Reporter Systems, synthesis of commercially important compounds. <b>Protozoa:</b> Advantages of protozoan expression systems, cultivation and applications of protozoan biotechnology.	1/ 15L

#### PRACTICALS: RPSLScP204 (2 credits)

1. Transformation of *E. coli*.
2. Preparation and regeneration of fungal protoplast.
3. Detection and estimation of gene copy number by real time PCR (demonstration).
4. Transformation of Yeast.
5. Slide culture of filamentous fungi with nuclei staining using DAPI stain.
6. Replica Plating.
7. Restriction Fragment Length Polymorphism (RFLP).
8. Identification and culture of algae / filamentous fungi / yeast.

#### References:

- Molecular Biology and Biotechnology, 5th and 4th edition by J. M. Walker and R. Rapley
- Biotechnology, Concepts and Applications by R. R. Vittal and R. Bhat
- Biotechnology, Principles and Applications by S. C. Rastogi More Gene Manipulations in Fungi by J. W. Bennette and Linda L. Lasure
- Microbial Metabolism and biotechnology, ebook by Horst Doelle
- The Metabolic Pathway Engineering Handbook- Fundamentals Christina D Somlke
- Systems Biotechnology for strain improvement. Trends in Biotechnology. Volume 3 (7), 2006.
- Molecular Biology: A laboratory Manual, 2<sup>nd</sup> edition, 1989: Maniatis, Fritsch and Sambrook
- Molecular Biology: A laboratory Manual, 4<sup>th</sup> edition, 2012: M. Green and J. Sambrook



**Paper IV - DSE**  
**Course Code: RPSBOT204**  
**Course Title: Immunology and Cancer Biology**

**COURSE OUTCOMES:**

COURSE OUTCOME	DESCRIPTION
	Upon successful completion of this course, learners will be able to;
CO 1	Recall the various genes involved in oncogenesis.
CO 2	Enumerate various genetic disorders for genetic counseling and therapy.
CO 3	Enlist the different cancer diagnostic tools and imaging techniques in the field of research.
CO 4	Comment on the various components of immune system and their applications in health care.
CO 5	Elaborate on the nature, development and causes of cancer.

**DETAILED SYLLABUS Paper IV - DSE**  
**Course Code: RPSBOT204**

<b>RPSBOT 204</b>	<b>Title: Immunology and Cancer Biology</b>	<b>Credits – 4</b>
<b>Unit I</b>	<b>Immune system and Immunotechniques</b>	<b>15 Lectures</b>
	<ul style="list-style-type: none"> <li>➤ Phylogeny of immune system, innate and acquired immunity, nature and biology of antigens, major histocompatibility complex cells of immune system, regulation of immune responses.</li> <li>➤ Production of antibodies by plant cells and organs.</li> <li>➤ Immunity in Health and Disease: Immunodeficiency and AIDS</li> <li>➤ Immunotechniques- Antigen-antibody reactions: agglutination, precipitation, Immuno-electrophoresis, Coomb's test, ELISA, Radioimmunoassay.</li> </ul>	
<b>UNIT II</b>	<b>Cancer Biology</b>	<b>15 Lectures</b>
	<p>Cancer cells: Characteristics, division, spread, treatment.</p> <ul style="list-style-type: none"> <li>➤ Characteristics of Cancer: Course of Cancer formation, Division and Spread (Metastasis)</li> <li>➤ Causes of cancer: What are carcinogens? (classification and latency period)</li> <li>➤ Types of carcinogens: chemical, radiation, Internal factors (hormonal and genetic factors), Biological carcinogens (Bacteria, Helminths, Oncovirus); Other factors (Dietary and Lifestyle, Pollution, Occupational, Medical Carcinogens)</li> <li>➤ Diagnosis and Treatments: Diagnostic tools and Imaging techniques; Staging of Cancers; Treatments (Neoadjuvant and Adjuvant Therapies; Surgery, Radiation, Chemotherapy, Hormonal Therapy, Targeted Therapy, Immunotherapy, Stem cell and Regenerative Therapy)</li> </ul>	
<b>UNIT III</b>	<b>Cancer genetics</b>	<b>15 Lectures</b>
	<ul style="list-style-type: none"> <li>➤ Characteristics of Cancer cells: Telomerase activity, Genome Instability, Anaplasia, Cell surface proteins and Immune reaction</li> <li>➤ Mutations and Cancers</li> <li>➤ Two-hit mutation theory; Familial and Sporadic Cancers</li> <li>➤ Genes involved in Oncogenesis: Proto-oncogenes/Oncogenes, Tumor suppressor genes, MicroRNA (miRNA) genes, and Mutator genes.</li> <li>➤ Oncogenes and Growth Factors</li> </ul>	
<b>UNIT IV</b>	<b>Genetic disorders</b>	<b>15 Lectures</b>

	<ul style="list-style-type: none"> <li>➤ X linked Dominant disorders: X-linked hypophosphatemia, Focal dermal hypoplasia, Coffin-Lowry syndrome (CLS), Alport syndrome</li> <li>➤ X linked Recessive disorders: Red Green Color Blindness, Royal Hemophilia, Duchenne Muscular Dystrophy (DMD), Barr bodies in Klinefelter syndrome</li> <li>➤ Autosomal Dominant disorders: Familial hypercholesteremia, Huntington's disorder, Neurofibromatosis, Marfan Syndrome</li> <li>➤ Autosomal Recessive disorders: Lysosomal Diseases, Peroxisomal Diseases, Cytoskeletal Diseases, Diseases due to Protein misfolding</li> <li>➤ Biochemical disorders: Albinism, Phenylketonuria, Alkaptonuria</li> <li>➤ Cardiovascular disorders: Coronary heart disease, Strokes and TIAs, Peripheral arterial disease, Aortic disease</li> <li>➤ Need for Genetic counseling and its applications</li> </ul>	
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### Practicals: RPSBOTP204 (2 credits)

- 1 ELISA.
- 2 Western Blotting.
- 3 Human karyotyping.
- 4 Karyotypes of genetic disorder- Acute Myeloid Leukemia.
- 5 Karyotypes of genetic disorder- B-cell Acute Lymphoblastic Leukemia.
- 6 Karyotypes of genetic disorder- Chronic Myeloid Leukemia.
- 7 Identification of genetic diseases by chemical tests.
- 8 Cytogenetic Diagnostic techniques: FISH and SKY (Demonstration).
- 9 Demonstrate the presence of Barr body from the oral mucosa of a human male and female students.

### References:

- R. A. Goldsby, T. J. Kindt and B. A. Osborne. 2000. Kuby's Immunology, W. H. Freeman & Co. 6th Edition.
- K. Murphy, P. Travers and M. Walport. 2008. Janeway's Immunology. Taylor and Francis Publishers. 7th Edition.
- Swanson. M. & Young. 1982. Cytogenetics. Prentice Hall, India.
- Snustad. P & Simmons. M.J. 2003. Principles of Genetics. 3rd Ed. John Wiley & Sons Inc., USA
- Verma P.S and Agarwal V.K 2006 Cell Biology, Genetics, Molecular Biology, Evolution, Ecology. S.Chand and Company, New Delhi.
- Gerald Karp 1999 Cell and Molecular Biology- Concept and Expts. John Wiley and Sons Inc., USA.
- De Robertis and De Robertis 2005 (Eight edition) (Indian) Cell and Molecular Biology, Lippincott Williams, Philadelphia. [B.I Publications Pvt. Ltd. New Delhi].

- Lodish Et. al. 2004 (Fifth Edition). Molecular Cell Biology, W H Freeman and company, New York.
- Powar C.B 2005 (Third Edition). Cell Biology, Himalaya Publishing, Mumbai.
- Roy S.C and KKDe 2005 (Second Edition). Cell Biology, New central Book Agency Private Ltd., Kolkata.
- Verma P.S and Agarwal V.K 2006 Cell Biology, Genetics, Molecular Biology, Evolution, Ecology. S.Chand and Company, New Delhi.
- Russel, P. J. 1998 Genetics (5th Edi.) The Benjamin/ Cummings Publishing Com. Inc., USA.
- Tamarin, R. H. 2001 Principles of Genetics 7th Edi.The McGraw-Hill Companies.
- Wolf, S.L. 1993. Molecular and Cellular Biology, Wadsworth Publishing Co., California, USA.
- Gupta P K 2007 Genetics: Classical to Modern. Rastogi Publications, Meerut.
- Hexter W and Yost Jr. H T 1977 The Science of Genetics. Prentice Hall of India Pvt. Ltd., New Delhi.
- Hartl D L and Jones E W 1998 Genetics: Principles and Analysis (4thed.). Jones and Barflett Publishers, USA.
- F Bunz. 2008. Principles of Cancer Genetics, Springer.

**Paper IV - DSE**  
**Course Code: RPSZOO204**  
**Course Title: Wildlife Biology**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b>
	Upon successful completion of this course, learners will be able to;
<b>CO 1</b>	Explore the career opportunities in GIS
<b>CO 2</b>	Summarize the concepts of GIS related technologies like Global Positioning System, Aerial Photography, Remote Sensing, LiDAR
<b>CO 3</b>	Explore and visualize Geo-database
<b>CO 4</b>	Evaluate the broad concepts in wildlife photography
<b>CO 5</b>	Explain the ethical aspects in the field of tourism

**DETAILED SYLLABUS Paper IV - DSE****Course Code: RPSZOO204**

<b>DSE-II RPSZOO204</b>	<b>Title: Wildlife Biology</b>	<b>Credits 4</b>
<b>UNIT –I</b>	<b>Wildlife Management</b> <ul style="list-style-type: none"> <li>On field computation and usage of portal computing devices. Still Cameras for wild life tracking and path mapping.</li> <li>Radio telemetry and Mobile Satellite systems, Multi frequency echo sounders and acoustic tags for fishery.</li> <li>Sonogram and its analytics. e.g. (Bird songs, Insect calls, Habitat usage by Bats)</li> </ul>	<b>15 Lectures</b>
<b>UNIT –II</b>	<b>GIS and its interpretation-I</b> <ul style="list-style-type: none"> <li>Geographical Information Systems: Brief introduction, working of GIS, Geo referenced GIS data and its significance, GIS related domain.</li> <li>Use of in decision support system and real world applications.</li> <li>Basic concepts of geography related to the use GIS technology.</li> <li>Study of data display and cartographical methods.</li> <li>Explore and visualize geo-database.</li> </ul>	<b>15 Lectures</b>
<b>UNIT –III</b>	<b>GIS and its interpretation-II</b> <ul style="list-style-type: none"> <li>Definitions: Datum and geographic, projected coordinate system and their types.</li> <li>Introduction to various source for data and data acquisition terminologies in GIS.</li> <li>Study of the topological relationship of spatial data.</li> <li>Concepts of GIS related technologies like Global Positioning System, Arial Photography, Remote Sensing, LiDAR etc.</li> <li>Scope and carrier opportunities of GIS in India..</li> </ul>	
<b>UNIT –IV</b>	<b>Wild life Photography and Ecotourism</b> <ul style="list-style-type: none"> <li>Introduction to wildlife photography: Scope, opportunity, Best equipment for photography, Basics of DSLR camera. Macro and Micro Photography. Rules of Wildlife Photography.</li> <li>Tourism and visitors management: Nature and scope, Definition and concept. Types of Tourism: Responsible Tourism, Eco Tourism and Humane tourism (Brief Introduction)</li> <li>Wildlife Tourism.</li> <li>Scope of Wildlife Tourism.</li> <li>Stakeholders in Sustainable Tourism: Role of Government, Non-government bodies, Local communities and International organisation (Global Sustainable Tourism Council)</li> </ul>	

	<ul style="list-style-type: none"> <li>Sustainable Development Goals (SDG): SDG 8, SDG12 and SDG 14</li> </ul>	
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### Practicals: RPSZOO204 (2 credits)

1. Perform the GIS operations like geo-database creation, visualization, digitization, map clean up, topology, geo-referencing, data linking, symbology, geo-processing, overlay analysis and map composition in most popular GIS packages like QGIS .
2. Using a hand held GPS instrument locate coordinates of a demarcated field site (Eg. College campus).
3. Using a suitable insect model, apply the capture – recapture technique for enumeration of population size (e.g. rice weevil using - marker pen).
4. On campus visit and learning macro photography using DSLR camera/mobile camera.
5. Make an audio recording of a song bird. e.g., bulbul, magpie robin, sunbird. Observe and note the activity of the bird while recording the call. Make a sonogram of the recording. Analyze the call and correlate with the behavioral observations. Classify the call as advertisement call, territorial call, alarm call, courtship call etc.
6. Activity based learning: To communicate conservation and sustainable awareness amongst the youth & general public.

### References:

- Wildlife management. Robert, G.H. W.H. Freeman and Co., San Francisco, U.S.A.1978.
- Aerial Photography and Image Interpretation for Resource Management. Paine, D.P. John Wiley and Sons.
- Remote Sensing: Principles and Applications Sabbins, F.E., Freeman.
- Manual of wildlife techniques, for India. Sale, J.B. and Berkmuller, K. WII, FAO, Dehra Dun, India 1988.
- A New Approach to Linear Programming Sharma, S.D. Kedarnath, Ramnath and Co. Meerut 1975.
- Text Book of Wildlife Management. Singh, S.K. IBDC, Lucknow. 2005.
- Guide for Planning Wildlife Management in Protected Areas and Managed Landscapes VishwasSawarkar Natraj Publisher. Dehradun.

**AECC 2****Research Methodology****Paper code: RPSLSc205****(30 Hours – 2 Credits Course)****Course Description:**

Research is a field that requires the ability to plan and conduct experiments, deduce results and document the outcomes. It also involves exhaustive troubleshooting, dissemination of the results, managing interpersonal relationships and following several ethical norms. This paper aims to inculcate these abilities in the students so that they may successfully conduct their project work/ internship / future careers in the field of scientific research.

**Course Outcomes:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>Upon successful completion of this course, learners will be able to;</b>
<b>CO 1</b>	Enlist the resources for accessing scholarly articles, published papers, abstract writing and bibliographic management.
<b>CO 2</b>	Illustrate the skills to design good research hypotheses and select an appropriate data analysis method.
<b>CO 3</b>	Make use of methods of data collection, tools for data analysis and ethical issues in educational research.
<b>CO 4</b>	Apply basic computer skills and required numerical skills necessary for the conduct of research.



**Detailed Syllabus Paper V – AECC 2****Course code: RPSLSc205**

<b>Unit</b>	<b>Course/ Unit Title</b>	<b>Credits / Lectures</b>
<b>Unit 1</b>	<b><u>Research Methodology-I</u></b>  <b>Introduction:</b> Research design principles, execution of work, interpretation of results. Review of literature <b>Library:</b> Structure of a scientific library, journals, books, Digital library and E books <b>Catalogue:</b> Classification of books (Universal Decimal System). <b>Journals:</b> Indexing journals, H-index, abstracting journals, research journals, review journals, e-journals. Impact factor of journals, NCBI-Pub Med. Reprints, Secondary storage devices, Internet, open access initiative, INFLIBNET, INSDOC. Google Scholar <b>Preparation of index cards:</b> Author index and subject index; Open source, bibliography management system <b>Interpersonal abilities:</b> Networking, Conflict resolution. <b>Scientific misconduct:</b> Plagiarism, Fabrication, Authorship conflicts, Salami and imalas publication.	<b>1/ 15L</b>
<b>Unit 2</b>	<b><u>Research Methodology-II</u></b>  <b>Introduction to scientific writing:</b> Meaning of Scientific and non-scientific writing; Scientific Vocabulary and grammar. Synopsis, Dissertations, Thesis, Posters. <b>Correspondence:</b> Formal letters, cover letters, drafting emails, replying to reviewers. <b>Writing a Research paper:</b> Title, Abstract, Introduction, Review of literature, Methodology, Observations, Results, Discussions, Summary, Conclusion, and Bibliography (Referencing and citation styles). Supplementary data. <b>Writing a Research Grant Proposal:</b> Funding agencies, guidelines, structure of research proposals – Setting a budget (Manpower, Consumables, Equipment, Travel, Contingencies, Overheads) with justifications, Expected outcomes, Cost benefit analysis, Work plan, and Time schedule of activities. <b>Presentations:</b> Presenting numerical data - Graphical, Tabular, Animations, Slides, etc. <b>Data analysis – SPSS and MS Excel</b> <b>Ethics in research.</b>	<b>1/ 15L</b>

**References:**

- Anderson J, Durston B H, Poole 1970. Thesis and assignment writing. Wiley eastern.
- Bedekar V. H.1982. How to write assignment and research papers, dissertations and thesis. Kanak publications.
- Kothari– C.R. 2004. Research Methodology –Methods and Techniques, New Age International LTd. Publishers, New Delhi.

## Assessment Modalities

### Theory Examination Pattern:

- Assessment of theory is divided as Internal and External where internals are given weightage of 40 marks and external theory written exams are given 60 marks.

#### A) Internal Assessment: 40 Marks

- Assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / mock interview/ subjective tests / meme making assignment / video assignment / survey / debate pertaining to syllabus topics chosen or allotted.
- Students are informed at least a month in advance about the portions for topics of the assignments or presentations via emails or on google classroom and marking scheme in the form of rubrics are known to them and hard copies depicting the names of students with topics and rubrics are maintained as proofs with their signatures with date.
- Below is an example of the rubrics.

#### Rubrics chart for presentations

	Total	80-100%	60-80%	40-60%	20-40%	0-20%
Content	05	5	4	3	2	1
Presentation skills	05	5	4	3	2	1
Questions answered	05	5	4	3	2	1
Questions asked	03	3	2.4	1.8	1.2	0.6
Time management	02	2	1.6	1.2	0.8	0.4
<b>Total</b>	<b>20</b>	<b>20</b>	<b>16</b>	<b>12</b>	<b>08</b>	<b>04</b>

**B) External Examination- 60 Marks**

Duration - The examinations shall be of **2 ½ hrs duration**. Theory question paper pattern is for 60 marks with 60% choice as shown below.

Semester	Papers	Units covered	Question numbers and choice	Marks for each question	Total marks
II	I, II, III, IV	1	Q1 - A, B, C (any two out of three)	06	12
		2	Q2 - A, B, C (any two out of three)	06	12
		3	Q3 - A, B, C (any two out of three)	06	12
		4	Q4 - A, B, C (any two out of three)	06	12
		1 question each from all 4 units	Q5 - i, ii, iii, iv (any three out of four)	04	12
Total marks					60

**Practical Examination Pattern: 50 Marks**

- Assessment of practicals only consists of External evaluation with a weightage of 50 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
II	1, 2, 3, 4	Q1. Major experiment	30
		Q2. Identification	10
		Q3. <i>Viva voce</i>	5
		Q4. Journal	5
Total marks			50

## Overall Examination & Marks Distribution Pattern

### Semester II

PAPER	EXAM	MARKS	GRAND TOTAL
AECC2 (50 marks)	Theory	50	<b>650 marks</b>
I (150 marks)	Theory	60	
	Internal	40	
	Practical	50	
II (150 marks)	Theory	60	
	Internal	40	
	Practical	50	
III (150 marks)	Theory	60	
	Internal	40	
	Practical	50	
IV (150 marks)	Theory	60	
	Internal	40	
	Practical	50	

## M.Sc. Part - II Life Sciences Syllabus Specialization - Biotechnology

### SEMESTER III

COURSE CODE	UNIT	TOPIC HEADINGS	CREDIT S	L / WEEK
Paper I	Tissue culture and Aquaculture			
RPSLSc3 01	I	Plant Tissue Culture	4	4
	II	Transgenic Plants		4
	III	Animal Tissue Culture		4
	IV	Aquaculture		4
Paper II	Fermentation Technology and its Applications			
RPSLSc3 02	I	Upstream and Downstream Processes	4	4
	II	Fermentation process I		4
	III	Fermentation process II		4
	IV	Enzymes in Industry		4
Paper III	Bioinformatics, International Standards & Bioethics			
RPSLSc3 03	I	Bioinformatics	4	4
	II	Alignment problem and solutions		4
	III	ISO, GMP & GLP		4
	IV	Bioethics and Entrepreneurship		4
Paper IV RPSLSc3 04	Project Work			6

## SEMESTER III

### PAPER I

**Course Code: RPSLSc301**

**Course Title: Tissue culture and Aquaculture**

#### COURSE OUTCOMES:

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Elaborate on basics of plant tissue culture and micropropagation technique and enlisting ways to deal with contamination and conservation.
<b>CO 2</b>	Classify plant secondary metabolites and explain the industrial production of some important metabolites.
<b>CO 3</b>	Enlist applications of transgenic plants and give importance of genetically modified organisms.
<b>CO 4</b>	Explain the basics of animal tissue culture, preservation, production and analysis.
<b>CO 5</b>	Discuss various aquaculture techniques for fish, prawn, pearl, and seedweed.
<b>CO 6</b>	Demonstrate micropropagation of ex-plants, production of artificial seeds and establishment of primary ATC culture.
<b>CO 7</b>	Perform transformation of agrobacterium and RAPD analysis.
<b>CO 8</b>	Identify various species used for fish, prawn, oyster and seedweed culturing.

## DETAILED SYLLABUS - Paper I

Course Code : RPSLSc301

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit 1 - Plant Tissue Culture</u></b></p> <p><b>Basics of plant tissue culture:</b> Laboratory set up and requirements, totipotency, macro and micro nutrients, media components and types.</p> <p><b>Micropropagation:</b> Steps involved, Culturing woody plants, Advantages, Somaclonal variation</p> <p><b>Culture:</b> Somatic embryogenesis and synthetic seed production. Callus culture and growth curves, Suspension cell culture. Protoplast culture, Somatic hybridization, Cybrids.</p> <p><b>Haploid Production:</b> Androgenesis, Gynogenesis, Applications</p> <p><b>Contamination:</b> Explant source, contamination types, disinfecting agents, control of microbial contaminants.</p> <p><b>Conservation:</b> Improvement, exploitation and conservation of genetic resources, Cryopreservation of genetic resources.</p>	1/ 15L
II	<p><b><u>Unit II: Transgenic Plants</u></b></p> <p><b>Recombinant technology:</b> Plant transformation by <i>Agrobacterium tumefaciens</i> [including mechanism of T DNA transfer in wild type <i>Agrobacterium</i>], <i>A. rhizogenes</i> its plasmid, Biolistic: factors that influence transformation success,</p> <p><b>Applications of transgenic:</b> Overview, Recombinant proteins of pharmaceutical importance in plants including vaccine subunits, edible vaccines, from hairy root cultures.</p> <p><b>Transgenic plants:</b> Strategies for virus resistance, Herbicide resistance, Insect resistance, nematode infections and resistance, stress resistance [salt, water and temperature], Improved nutrition [carbohydrate, protein], improved shelf life; Novel applications: change in lipid profile for industrial purpose, biodegradable plastics, novel horticultural traits [flower colour, variegation].</p>	1/ 15L
III	<p><b><u>Unit III: Animal Tissue culture</u></b></p> <p><b>Basics of animal tissue culture:</b> Methods of cell dissociation/separation and preparation of primary cell culture, characteristics of cells <i>in vitro</i>, cell culture growth parameters, detection, prevention and determination of contamination in tissue culture.</p> <p><b>Culture:</b> Primary cell culture, immortalized cell culture, stem cell culture and transformed cell culture. Specialized cells: bone marrow, skin cell culture, myogenesis, erythropoiesis and chondrogenesis- <i>in vitro</i>,</p> <p><b>Preservation:</b> Cryopreservation of tissues and cell lines.</p>	1/ 15L



	<b>Analysis and Production:</b> cell synchronization, cell transformation <i>in vitro</i> , Mass cultivation- cytodex and bio fermenters. <b>Applications:</b> Stem cells & therapeutic cloning, Tissue engineering and 3D printing.	
IV	<b><u>Unit IV: Aquaculture</u></b>  <b>Aqua culture technology:</b> definition, history and scope, constraints and recent development, criteria for selection of species, aquafarm engineering. <b>Pisciculture:</b> cultivable fish species, seed production technology of carps, carp culture, mono and poly culture. <b>Prawn culture:</b> cultivable prawn species, spawning techniques, culture methods in India. <b>Pearl oyster culture:</b> pearl producing species, pearl culture technology, composition of pearl quality and prospects. <b>Seaweed culture:</b> economically important species culture and post-harvest technology.	1/ 15L

#### PRACTICALS: RPSLScP301 (2 credits)

1. Micropropagation of selected ex-plants.
2. Production of artificial seeds.
3. Transformation using Agrobacterium species.
4. RAPD analysis (plants/ bacteria).
5. Establishment of Primary Culture (ATC) using a suitable source.
6. Identification of cultivable fish species.
7. Identification of cultivable prawn species.
8. Identification of cultivable pearl bivalves and oyster species.
9. Identification of cultivable seaweed species.
10. Isolation and determination of colony characteristics of marine organisms.

#### References:

1. Aquaculture by Ujwala Jadhav
2. Principles of Biochemistry by Lehninger, Nelson and Cox
3. Introduction to plant tissue culture by M. K. Razdan
4. Animal Cell Culture by Ian Freshney
5. Basic Cell Culture by J. M. Davis.

**PAPER II****Course Code: RPSLSc302****Course Title: Fermentation Technology and its Applications****COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Summarize the fundamental concepts of fermentation techniques, methods used for product recovery and explain the importance of effluent treatment.
<b>CO 2</b>	Differentiate between several types of fermenters and design the components and optimize various essential parameters required in a fermenter.
<b>CO 3</b>	Derive microbial growth kinetics for fermentation processes and optimize the culture conditions to scale up the production.
<b>CO 4</b>	Explain the concept of biotransformation with secondary metabolite production from plants using appropriate examples.
<b>CO 5</b>	Describe various industrial applications of enzymes.
<b>CO 6</b>	Isolate, extract and estimate enzyme activity using suitable assay methods and demonstrate immobilisation technique.
<b>CO 7</b>	Isolate and Estimate alcohol content, tannins and lycopene using respective suitable methods.

## DETAILED SYLLABUS - Paper II

Course Code: RPSLSc302

Unit	Course/ Unit Title	Credits/ Lectures
I	<b><u>Unit I: Upstream and Downstream Processes</u></b>  <b>Fermenter design:</b> Components of the fermenter, sterilization, aeration and agitation. <b>Types of Fermenters:</b> batch, continuous, air lift, fluidized bed, stirred tank. <b>Isolation and Screening of microorganisms:</b> Isolation of microorganisms from various sources, Preservation, Primary and Secondary Screening of microorganisms. <b>Fermentation Media:</b> Definition, Criteria, Various components, Types: crude and synthetic, sterilization, rheology of various components of media. <b>Microbial growth:</b> General parameters, growth kinetics for various fermentation and types of stock culture, scaling up of culture for fermentation. <b>Product recovery:</b> Product: internal, external, cell disruption methods: physical, chemical and biological, precipitation, filtration, centrifugation, extraction and purification, drying. <b>Product Economics:</b> Microbial culture, Fermentation: Upstream and Downstream processes, recovery process, product processing. <b>Effluent Treatment:</b> Need, Traditional methods disposal and disadvantage, physical, chemical and biological methods.	1/ 15L
II	<b><u>Unit II: Fermentation process I</u></b>  <b>Single Cell Protein, Biomass and Immobilization:</b> Need of single cell production, production of bacteria, yeast, algae, fungi. Immobilization: cells and enzymes, methods of immobilization, applications. <b>Commercial Fermentations: Cheese:</b> Culture, Fermentation process, Applications. <b>Alcohol:</b> Wine, Commercial Ethanol (by-product fusel oils): Culture, Process and Applications. <b>Acids:</b> Lactic acid industrial production and applications. <b>Carbohydrate:</b> High fructose corn syrup. <b>Flavour/fragrance production</b> with example.	1/ 15L
III	<b><u>Unit III: Fermentation Process II</u></b>  <b>Secondary metabolites production from plants:</b> Secondary metabolite types (alkaloids, terpenes [include IPP synthesis: Classic pathway and Alternate pathway for IPP synthesis in plastids], tannins, lignans pigments, lipids); Selection of callus cultures. <b>Examples of secondary metabolite production</b> (industrial scale): [shikonin, taxol (biosynthesis and bioreactor production) capsaicin/ berberine].	1/ 15L

	<b>From microbes:</b> Polymers [dextrans, xanthan gums, alginate], antibiotics [peptide, lantibiotics, aminoglycosides, beta lactam], cyclosporins, biosurfactants.	
<b>IV</b>	<b><u>Unit IV: Enzymes in Industry</u></b>  <b>Biotransformations:</b> Classification and characteristics of enzymes – OTHLIL, applications of enzymes: (chiral synthesis of enantiomerically pure compounds, resolution of isomers). Examples of biotransformations. <b>Industries:</b> Textile Processing, Leather Processing, Paper & Pulp Processing, Detergents and laundry. <b>Food biotechnology:</b> Fruit and vegetable processing: juices, nectars, purees; syrup and glucose isomerases, enzymatic synthesis of aspartame. <b>Other industrial uses:</b> Vinegar, Baking, Cocoa fermentation, Olive oil production, fish processing industries. <b>Nutraceuticals:</b> Probiotics: lycopene, isoflavonoids, glucosamine, phytosterol. <b>Feed Biotechnology:</b> lignocelluloses into feed using cellulases, silage. <b>Bio preservation:</b> chemical preservatives and their safety concerns, LAB Bacteriocins. Types of bacteriocins, mode of action, applications and regulations.	<b>1/ 15L</b>

#### PRACTICALS: RPSLScP302 (2 credits)

1. Immobilization of cells.
2. Demonstration of fermenter/ chemostat.
3. Estimation of alcohol production: Sucrose/ fruit (s)/ sugarcane juice.
4. Isolation of cellulase producing microorganisms from natural source(s).
5. Determination of cellulose activity using Filter paper assay/ carboxy-methyl cellulose assay.
6. Secondary metabolite production using plant tissue culture (dye/ drug Alkaloids etc.)
7. Effect of elicitor(s) on the production of the plant secondary metabolite.
8. Estimation of tannins using the Vanillin Hydrochloride method.
9. Preparation of plant protoplasts.
10. Isolation and estimation of Nutraceuticals (lycopene/ isoflavonoids) by TLC.

#### References:

1. Principles of Fermentation Technology by Stanbury and Whitaker
2. Industrial Microbiology by Casida
3. Industrial Microbiology by Prescott and Dunn
4. Role of Biotechnology in Medicinal and Aromatics Plants by Khan and Khanum Vol.1
5. Plant Tissue Culture by M. K. Razdan.

**PAPER III****Course Code: RPSLSc303****Course Title: Bioinformatics, International Standards and Bioethics.****COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> At the end of the course students will be able to:
<b>CO 1</b>	Classify the biological databases that are used in bioinformatics and select and use the appropriate biological database according to the query.
<b>CO 2</b>	Construct phylogenetic trees manually as well as computationally after understanding the concepts, terminologies, types and properties of phylogenetic trees and the various methods of building it.
<b>CO 3</b>	Explain the concept of multiple or pairwise sequence alignment and select the appropriate software to carry out the alignment.
<b>CO 4</b>	Audit biotechnology/pharmaceutical industries as per ISO standards as well as the GMP and GLP guidelines by knowing the requirements and procedure of these certifications which may provide a basis for a future career in quality assurance or quality management.
<b>CO 5</b>	Write a successful business plan and investment proposal, understand how to set up their own businesses and take inspiration from successful Indian bio-entrepreneurs.
<b>CO 6</b>	Debate on various topics involving bioethics and understand the relevance of bioethics in regulating exciting developments in biology and medicine.
<b>CO 7</b>	Perform BLAST of various DNA and Protein sequences, restriction digestion, sequence alignment and phylogenetic tree construction using softwares like NCBI, MEGA, KEGG, Biocyc and NEB cutter.

## DETAILED SYLLABUS - Paper III

Course Code : RPSLSc303

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Bioinformatics</u></b></p> <p><b>Introduction to Bioinformatics:</b> Definition and History of Bioinformatics, Different Omics and its application and Current status.</p> <p><b>Computers:</b> Operating systems, Internet and its components, Internet sources for Bioinformatics, Flat file.</p> <p><b>Introduction to Data Mining:</b> Types of Data (Text formats, sequence data, protein structures, links), Data mining and warehousing, Process of knowledge discovery through data mining.</p> <p><b>Biological databases:</b> Classification, Primary DNA Databases, Primary and Secondary Protein Databases, Composite Structure Databases, UniProt, Protein Data Bank (PDB), Metabolism Database (KEGG).</p>	1/ 15L
II	<p><b><u>Unit II: Alignment problem and solutions</u></b></p> <p><b>Multiple Sequence Alignment (MSA):</b> Definition, Objective, Consensus, Methods for MSA: Heuristic approach, Dynamic programming approach and their combinations.</p> <p><b>Pairwise Alignment:</b> Introduction, PAM Matrix, BLOSUM Matrix, The Dot Plot, Global alignment, Local alignment, FASTA and BLAST. Statistics: P and E value.</p> <p><b>Phylogenetic Analysis:</b> Molecular-Phylogenetics, Phylogenetic-trees, Terminology of tree-reconstruction, rooted and un-rooted trees, gene vs species trees and their properties, Methods: UPGMA, Neighbour-Joining Method, Maximum Parsimony.</p>	1/ 15L
III	<p><b><u>Unit III: ISO, GMP, GLP</u></b></p> <p><b>Introduction:</b> Overview of standards in ISO9000 Family</p> <p><b>Key principles:</b> Key principles of ISO 9000- Quality Management System</p> <p><b>ISO 9001:</b> Detailed study on ISO 9001:2015 standard, based on a seven principles of quality management, including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement</p> <p><b>Application:</b> Sector specific Application of ISO 9001- Quality Management System adapted by various industries</p> <p><b>Introduction to GMP</b> (Good Manufacturing Practices) and GLP (good Laboratory Practices) in Pharmaceutical Industries.</p> <p><b>Overview:</b> GMPs and enforcement by the U.S. Food Drug Administration (US FDA) under Title 21 CFR. Documentation requirement related to GMP and GLP.</p>	1/ 15L

	<b>Case studies</b> for SOP preparation and CAPA (Corrective action Preventive Action).	
<b>IV</b>	<p><b><u>Unit IV: Bioethics and Entrepreneurship</u></b></p> <p><b>Bioethics:</b> Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; Legal and regulatory issues; Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare &amp; right / animals in research, wildlife conservation and management, commercialism in scientific research.</p> <p><b>Entrepreneurship:</b></p> <p><b>Biotechnology industry</b> - Emerging trends in biotechnology industry, organizational structure.</p> <p><b>Setting up a Biotechnology industry</b> - Writing a business plan, Funding and investment sources (Government funding, angel investors, venture capitalists, strategic investors, crowdfunding, self-funding, bank loans, IPO), Government schemes for women. Exit strategy.</p> <p><b>Licensing</b> - Motivations for licencing, scope, types and fees.</p> <p><b>Technology transfer</b> – University technology transfer and issues involved. Government policies (National biotechnology development strategy, Maharashtra biotechnology policy, National policy on skill development and entrepreneurship).</p> <p><b>Business ethics and CSR.</b></p> <p><b>Bioentrepreneurs</b> – Bio-entrepreneurship in Rural and Urban India, examples of Indian Bioentrepreneurs.</p>	<b>1/ 15L</b>

### Practicals for RPSLScP303: (2 credits)

1. Retrieving protein / nucleotide sequence information from databases – UniProt, NCBI.
2. Pathway analysis using KEGG and BioCyc.
3. Performing BLASTn, BLASTp, tBLASTn and PSI-BLAST using NCBI.
4. Multiple sequence alignment using MEGA.
5. Phylogenetic tree construction using MEGA.
6. Primer designing for a gene in the human genome using NCBI.
7. Restriction mapping using NEB cutter.

### References:

1. Introduction to Bioinformatics- Attwood, Parry-Smith and Phukan
2. Bioinformatics: Sequence and Genome Analysis- David W. Mount
3. Bioinformatics and Functional Genomics- Jonathan Pevsner
4. Bioinformatics: Harshwardhan Pal
5. Economics of Biotechnology by T.V.S Rama Mohan Rao
6. Entrepreneurship and Business of Biotechnology by S. N. Jogdand
7. Economic dynamics of Modern Biotechnology by Maureen D. McKelvey, Annika Rickne, Jens Laage-Hellman
8. ISO 9000 quality systems handbook fourth edition by David Hoyle
9. International standard ISO 9001: quality management systems requirements 5<sup>th</sup> edition 2015-09-15.

10. Jürg P. Seiler - Good Laboratory Practice - the Why and the How (2005, Springer)
11. Good Manufacturing Practices and Inspection -Volume 2 (2007, World Health Organization)
12. GLP Essentials - A Concise Guide to Good Laboratory Practice by Milton A. Anderson - (2002, CRC Press).

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**PAPER IV**  
**Course Code: RPSLSc304**  
**Course Title: Project Work**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Follow and develop the strict norms of Good Laboratory Practices in their respective laboratories.
<b>CO 2</b>	Design and perform experiments, document results, perform statistical analyses and write their observations and conclusions independently.
<b>CO 3</b>	Organise their time and resources, and be resourceful in the absence of certain instruments or reagents.
<b>CO 4</b>	Learn to troubleshoot failed experiments and gain the ability to interpret both positive and negative results.
<b>CO 5</b>	Work independently as well as in pairs or groups by adopting the culture of inclusivity.
<b>CO 6</b>	Present their work in the form of oral or poster presentations at the national or international conferences or publish their work in research journals approved by the new UGC CARE list if deemed suitable by their research guides.

## Assessment Modalities

### **Online Examination:** (Deviation from the usual modality)

Owing to the pandemic situation prevailing in 2020 and continuing in 2021, the external examinations (Semester End) may be conducted online as per the instructions/circulars received from the University of Mumbai and Maharashtra State notifications from time to time. The conventional mode of external examination will commence again only after the declaration of normalcy by the Government authorities.

### **Theory Examination Pattern:**

- Assessment of theory is divided as Internal and External where internals are given weightage of 40 marks and external theory written exams are given 60 marks.

#### **A) Internal Assessment: 40 Marks**

- Assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / preparation of business plan/ creative writing / mock audit / meme making assignment / video assignment / survey / debate pertaining to syllabus topics chosen or allotted.
- Students are informed at least a month in advance about the portions for topics of the assignments or presentations via emails or on google classroom and marking scheme in the form of rubrics are known to them and hard copies depicting the names of students with topics and rubrics are maintained as proofs with their signatures with date.
- Below is an example of the rubrics.

#### **Rubrics chart for presentations**

	<b>Total</b>	<b>80-100%</b>	<b>60-80%</b>	<b>40-60%</b>	<b>20-40%</b>	<b>0-20%</b>
Content	05	5	4	3	2	1
Presentation skills	05	5	4	3	2	1
Questions answered	05	5	4	3	2	1
Questions asked	03	3	2.4	1.8	1.2	0.6
Time management	02	2	1.6	1.2	0.8	0.4
<b>Total</b>	<b>20</b>	<b>20</b>	<b>16</b>	<b>12</b>	<b>08</b>	<b>04</b>

## B) External Examination- 60 Marks

Duration - The examinations shall be of **2 ½ hrs duration**. Theory question paper pattern is for 60 marks with 60% choice as shown below.

Semester	Papers	Units covered	Question numbers and choice	Marks for each question	Total marks
III	1, 2, 3	1	Q1 - A, B, C (any two out of three)	06	12
		2	Q2 - A, B, C (any two out of three)	06	12
		3	Q3 - A, B, C (any two out of three)	06	12
		4	Q4 - A, B, C (any two out of three)	06	12
		1 question each from all 4 units	Q5 - i, ii, iii, iv (any three out of four)	04	12
Total marks					60

## Practical Examination Pattern: 50 Marks

- Assessment of practicals only consists of External evaluation with a weightage of 50 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
III	1, 2 and 3	Q1. Major experiment	30
		Q2. Identification	10
		Q3. <i>Viva voce</i>	5
		Q4. Journal	5
Total marks			50

**Paper IV Examination Pattern: 150 Marks**

Semester	Paper	Question	Total marks
III	4	Q1. Project work thesis	60
		Q2. Project work presentation	40
		Q3. Viva voce on project	50
Total marks			150

**Overall Examination & Marks Distribution Pattern****Semester III**

PAPER	EXAM	MARKS	GRAND TOTAL
I (150 marks)	Theory	60	600 marks
	Internals	40	
	Practicals	50	
II (150 marks)	Theory	60	
	Internals	40	
	Practicals	50	
III (150 marks)	Theory	60	
	Internals	40	
	Practicals	50	
IV (150 marks)	Project thesis and presentation	100	
	Project viva	50	

## M.Sc. Part - II Life Sciences Syllabus Specialization - Biotechnology

### SEMESTER IV

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Medical Biotechnology			
RPSLSc401	I	Therapeutics I	4	4
	II	Therapeutics II		4
	III	Activity Guided Drug Development		4
	IV	Pharmacogenomics and Drug design		4
Paper II	Applied Biotechnology			
RPSLSc402	I	Assisted reproductive technology	4	4
	II	Nanotechnology		4
	III	New Emergent Technologies		4
	IV	Diagnostics and Forensics		4
Paper III	Environmental Biotechnology			
RPSLSc403	I	Biological Controls and Biopesticides	4	4
	II	Nitrogen Fixation and Biofertilizers		4
	III	Bioremediation		4
	IV	Phytoremediation and phytomining		4
Paper IV	Protein studies, Advanced Bioinformatics and Biomathematics			
RPSLSc404	I	Protein Trafficking and Targeting	4	4
	II	Protein folding and Biomolecular interactions		4
	III	Advanced Bioinformatics		4
	IV	Biomathematics		4

**SEMESTER IV****PAPER I****Course Code: RPSLSc401****Course Title: Medical Biotechnology****COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Describe the principles, classification, production and examples of therapeutic proteins.
<b>CO 2</b>	Summarize the various strategies and applications of antisense and gene therapy.
<b>CO 3</b>	Explain the important concepts in engineering of vaccines and peptibodies and their applications for various diseases.
<b>CO 4</b>	Evaluate disease models used for developing new therapeutics, and computational models for rational drug design.
<b>CO 5</b>	Describe the steps involved in drug designing right from identification of the API in activity guided drug development to its metabolism and action.
<b>CO 6</b>	Outline the pharmacogenomics of various illnesses like cancer syndromes, neuropsychotic and cardiovascular disorders.
<b>CO 7</b>	Analyse residual DNA in the given therapeutic protein samples.
<b>CO 8</b>	Compare phytochemical extraction methods, separation and visualisation using HPTLC technique and perform bioautography of plant extract and analyse its antimicrobial, antioxidant, anti-inflammatory and anti-larvicidal activity.

## DETAILED SYLLABUS - Paper I

Course Code : RPSLSc401

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Therapeutics I</u></b></p> <p><b>Therapeutic Proteins:</b> Group I, II, III and IV and their applications in humans and animals, mode of action, stability, processing and formulation. Examples of each class - Monoclonal Antibodies, vitamins, blood proteins, human hormones – Growth hormones, insulin, somatostatin, steroid hormones, immune modulators – factors VIII, IX, interferons and interleukins, erythropoietin, relaxin, epinephrine, TNF, tissue plasminogen activator protein and vaccines, glucagon, secretin and antigens.</p> <p><b>Antisense therapy:</b> Introduction, strategies. oligodeoxyribonucleotide, catalytic antisense RNA, triple - helix forming oligonucleotides (TFOs), production, and limitations, first generation antisense drugs, second generation antisense drugs. Applications: cancer therapy, viral diseases, gene function analysis and in agriculture.</p> <p><b>Gene therapy:</b> Overview, Vectors for somatic cell gene therapy, Gene therapy for inherited immunodeficiency syndromes, Cancer gene therapy, Cystic fibrosis gene therapy, HIV-1 gene therapy. Safety issues.</p>	1/ 15L
II	<p><b><u>Unit II: Therapeutics II</u></b></p> <p><b>Genetic Engineering of Vaccines:</b> Identification and Cloning of Antigens with Vaccine Potential - DNA/Oligonucleotide Hybridization, Hybrid Selection and Cell-free Translation, Expression cloning and Genomic Sequencing, Analysis of Vaccine Antigens - B-cell Epitopes and T-cell Epitopes. Generation of Subunit Vaccines, Improvement and Generation of New Live Attenuated Vaccines - <i>Pseudorabies</i> Virus, <i>Vibrio</i> and <i>Poliovirus</i>, Recombinant Live Vectors - <i>Vaccinia</i> Virus, Recombinant BCG Vaccines, Attenuated <i>Salmonella</i> Strains, Poliovirus Chimaeras, Cross-species Vaccination, 'Live- dead' Vaccines, Other Virus Vectors and Recombinant <i>E. coli</i> Strains, DNA, RNA and peptide Vaccines, Anti-idiotypes, Enhancing Immunogenicity and modifying Immune Responses - Adjuvants, Carriers and Vehicles, Carriers, Mucosal Immunity, Modulation of Cytokine Profile, Modulation by Antigen Targeting and Modulation of Signaling.</p> <p><b>Peptibodies:</b> Definition, peptide-Fc fusion, advantages over monoclonal antibodies, production in <i>E. coli</i> using recombinant DNA technology, production, and mechanism of action, applications – pain, ovarian cancer and immune thrombocytopenic purpura, limitations.</p> <p><b>Peptidomimetics:</b> Definition, design, features, analysis and application.</p> <p><b>Biosimilars:</b> Definition, design, features, analysis and application.</p>	1/ 15L

III	<p><b><u>Unit III: Activity Guided Drug Development</u></b></p> <p><b>Plant collection and Extract preparations:</b> Methods of Plant collection, solvent extraction (cold, hot, critical fluid extraction etc), screening of medicinal properties;  <b>Natural products:</b> methods of identification (Qualitative and Quantitative), isolation and purification (Chromatography), Characterization;  <b>Bio efficacy studies:</b> <i>In vitro</i> testing- Antimicrobial, Antidiabetic, Antioxidant, Anti Inflammatory and Anti larvicidal activities.  <b>Drug Development:</b> Introduction to the pharmaceutical industry, Natural drugs versus Synthetic drugs, Timeline of drug discovery, pharmacodynamics, plasma concentration and Cp-time curves, ADME and pharmacokinetics, Drug dosing and therapeutic window. Lead discovery and Lead optimization, Prescribing information for drugs, Pre-clinical and clinical trials, Regulatory approval. Disease Models in pharmaceutical research.</p>	1/ 15L
IV	<p><b><u>Unit IV: Pharmacogenomics and Drug design</u></b></p> <p><b>Drug designing:</b> types of pharmacogenetic knowledge and obstacles, variations of drug metabolizers, transporters, drug targets and biological milieu of drug action, Target binding and drug potency. Population differences in drug effects.  <b>Pharmacogenomics:</b> Cancer syndromes, neuropsychotic disorders, Alzheimer's disease, mental retardation, cardiovascular diseases, smoking and alcoholism, Eugenics and epigenetics of above disorders, Genetic influences on drug targets involved in pharmacodynamics, long QT syndromes, emerging technologies.</p>	1/ 15L

### PRACTICALS: RPSLScP401 (2 credits)

1. Residual DNA analysis of recombinant therapeutic protein.
2. Multiplex PCR.
3. Comparison of phytochemical extraction methods.
4. Separation and visualisation of a plant extract by HPTLC.
5. Bioautography for antimicrobial / antioxidant activity.
6. Anti-inflammatory/Anti-diabetic assay of a plant extract.

### References:

1. Molecular Biology and Biotechnology, 4<sup>th</sup> edition (2002) by J. M. Walker and R. Rapley
2. Biotechnology by Rehm & Reed
3. Biotechnology, An Introduction (2008) by S. Ignacimuthu, S. J.
4. Biotechnology, Concepts and Applications (2009) by R. R. Vittal and R. Bhat
5. Biotechnology, Principles and Applications (2007) by S. C. Rastogi
6. Medical Biotechnology, Himalaya Publishing House, Mumbai, (2008) by Jogdand S. N.,
7. Medical Biotechnology, Churchill Livingstone, Elsevier (2009) by Judit Pongracz, Mary Keen
8. Medical Biotechnology, Oxford University Press (2010) by Pratibha Nallari & V. Venugopal Rao,
9. Therapeutic peptides and proteins by A. K. Banga



10. Plant Bioactives and Drug Discovery: Principles, Practice, and Perspectives 1st Edition Valdir Cechinel-Filho(Author), Wiley Publication.
11. Drug Discovery from Plants By Angela A. Salim, Young-Won Chin, A. Douglas Kinghorn (Springer publication)
12. Bioassay Methods in Natural Product Research and Drug Development By Lars Bohlin, Jan G. Bruhn (Springer Publication).

Ramnarain Ruia Autonomous College

**PAPER II**  
**Course Code: RPSLSc402**  
**Course Title: Applied Biotechnology**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> <b>At the end of the course students will be able to:</b>
<b>CO 1</b>	Describe the issues behind infertility, the physiology of reproduction, principles and techniques of ART, cryobiology and latest developments in the field.
<b>CO 2</b>	Classify nanostructures based on their structure and properties and explain the novel applications of this technology.
<b>CO 3</b>	Enlist the different types of biosensors and explain its working principle and outline the fluid characteristics at the microscale applications for designing microfluidics chips.
<b>CO 4</b>	Summarize the basic concepts of biomimetics and explain its applications.
<b>CO 5</b>	Analyse ways to create an accurate, quick but cost-effective diagnostic kit for a certain disorder or infection.
<b>CO 6</b>	Employ the basics of forensic science to perform simple experiments like hair microscopy and put their investigative and deducing skills to the test.
<b>CO 7</b>	Synthesize silver, zinc oxide and ferromagnetic nanoparticles in the laboratory and determine their biological activity.
<b>CO 8</b>	Demonstrate the design of microfluidics system by analysing various parameters.

## DETAILED SYLLABUS - Paper II

**Course Code: RPSLSc402**

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Assisted Reproductive Technology</u></b></p> <p><b>Introduction:</b> Male and female reproductive anatomy and physiology, the menstrual cycle, puberty, pregnancy. History of Assisted Reproductive Therapies (ART), Causes of infertility, testing and diagnosing infertility.</p> <p><b>In Vitro Fertilization (IVF):</b> Stimulation protocols for IVF, Baseline assessment, sperm and egg culture, cryopreservation. Risks of IVF.</p> <p><b>Other ARTs:</b> Preimplantation Genetic Screening/Diagnosis (PGS/D), Mitochondria replacement therapy (MRT), Assisted Zona Hatching (AZH). Fertilization using ICSI, embryonic culture at various stages of development, Grading embryos, <b>Transfer of embryos-</b> Direct embryo transfer, Zygote intrafallopian transfer (ZIFT).</p>	1/ 15L
II	<p><b><u>Unit II: Nanotechnology</u></b></p> <p><b>Nanobiotechnology:</b> Concept. Types of nanostructures (Carbon nanostructures, nanoshells, dendrimers, quantum dots, nanowires, liposomes). Potential risks of Nanobiotechnology.</p> <p><b>Synthesis of nanoparticles:</b> Physical, chemical and biological methods.</p> <p><b>Applications of nanotechnology:</b> medicine and diagnostics (antimicrobial properties, therapies, drug delivery including rate programmed drug delivery, Microencapsulation of cells. imaging) agriculture, environment.</p>	1/ 15L
III	<p><b><u>Unit III: New emergent Technology</u></b></p> <p><b>Biosensors:</b> Concepts. Types of biosensors: amperometric, potentiometric, conductometric, calorimetric, piezoelectric, evanescent wave sensors, Surface Plasmon resonance, whole cell biosensors.</p> <p><b>Biomimetics: Concept and applications:</b> Dry Adhesion (gecko lizard's foot), Water repulsion (lotus leaf), nanostructures in colour display (butterfly wings/ peacock feather).</p> <p><b>Microfluidics:</b> Fundamental characteristics of fluidics at microscales applications of microfluidics (cell separation, dip sticks).</p> <p><b>Biomechanics:</b> Introduction and Biotechnology in biomechanics.</p>	1/ 15L

IV	<p><b><u>Unit IV: Diagnostics and Forensics</u></b></p> <p><b>Diagnostics:</b> Inherited and non-inherited diseases, Direct Detection of Gene Mutations - Allele-specific Oligonucleotides and Restriction Enzyme Site Analysis, ARMS, Oligonucleotide Ligation, and Fluorescently Labelled DNA Sequencing; Indirect Diagnosis with Linked Genetic Markers, Cancer screening;</p> <p><b>Forensics:</b> Crime-Scene Investigation and Evidence Collection, the Study of Hair, Pollen and Spore Examination, Fingerprints, Forensic Anthropology. Death: Meaning, Manner, Mechanism, Cause, and Time. DNA Fingerprinting: Markers MLP, SLP, mitochondrial DNA, Y chromosome analysis, X chromosome analysis. Blood and Blood Spatter, Drug Identification and Toxicology SNPs.</p>	1/ 15L

#### PRACTICALS: RPSLScP402 (2 credits)

1. Synthesis of silver nanoparticles - biological method.
2. Preparation of gold nanoparticles/ ferromagnetic fluid/ corn flour non-Newtonian fluid
3. Antimicrobial activity of AgNPs by the tetrazolium microplate assay.
4. Antioxidant activity of AgNPs.
5. Demonstration of Laminar Flow in Microfluidic system
6. Hair microscopy for forensic analysis.
7. PAGE of DNA samples and silver staining.

#### References:

1. A Textbook of In Vitro Fertilization and Assisted Reproduction by Peter R. Brinsden (2005)
2. David K. Gardner, Ariel Weissman, Colin M. Howles, Zeev Shoham - Textbook of Assisted Reproductive Techniques, Fifth Edition, Volume 1 and 2, CRC Press (2018)
3. In-Vitro Fertilization, Third Edition by Kay Elder, Brian Dale - (2011, Cambridge University Press)
4. Bio - Nanotechnology by Madhuri Sharon.
5. Molecular Biology and Biotechnology, 4<sup>th</sup> edition (2002) by J. M. Walker and R. Rapley
6. Microfluidics for Biotechnology 2<sup>nd</sup> Edition by Jean Berthier and Pascal Silberzan
7. Introduction to microfluidics by Patrick Tabeling
8. Forensic Science: Fundamentals and Investigations, by Anthony J Bertino - Cengage Learning (2011)
9. Fundamentals of Forensic Science by Siegel, Jay A. Houck, Max M - 3rd Edition, Elsevier, Academic Press (2006).

**PAPER III**  
**Course Code: RPSLSc403**  
**Course Title: Environmental Biotechnology**

**COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> At the end of the course students will be able to:
<b>CO 1</b>	Enlist the challenges involved due to agricultural pests and its biological alternatives to use of harmful chemical pesticides.
<b>CO 2</b>	Explain the importance of Integrated Pest Management to sustain the least amount of crop damage while maintaining pest populations.
<b>CO 3</b>	Compare the use of chemical fertilizers with biological alternatives and the summarize the significance of genetic engineering to improve nitrogen fixation.
<b>CO 4</b>	Describe soil enriching techniques like composting, the ecological role of mycorrhiza, the emerging technique of aquaponics as well as the lucrative technique of phytomining of precious metals like gold.
<b>CO 5</b>	Enlist the issues of Solid Waste Management, associated laws and regulations, status of the steps taken by the government like the 'Swachh Bharat Abhiyaan' to manage waste generated.
<b>CO 6</b>	Describe the concept of remediation studying plants or microbes, explain various adaptive mechanisms for pollutant tolerance and applications for environmental protection.
<b>CO 7</b>	Perform analysis of soil, water for various parameters, identify indicator plants for certain environmental changes and specific plant specimens for heavy metal accumulation using respective methods.
<b>CO 8</b>	Isolate, select oil degrading bacteria for bioremediation, analyse effect of biopesticide on plant pathogens and perform algal culturing and oil production for biofuel.

## DETAILED SYLLABUS - Paper III

Course Code: RPSLSc403

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Biological Controls and Biopesticides</u></b></p> <p><b>Chemical Pesticides:</b> Spectrum of chemical pesticides for control of biotic stress: uses, advantages and disadvantages.</p> <p><b>Spectrum of biological pesticides:</b> types, advantage on chemical pesticides, mode of action, stability and formulation in natural and genetically modified organisms, Selective targeting, Molecular mechanism of resistance development and strategies including integrated pest management.</p> <p><b>Biopesticides from Plants:</b> Neem and pyrethrins, mode of action on insect pests, Bio-control against fungal diseases of plants.</p> <p><b>Biological Controls:</b> Viral/ fungal/ bacterial parasites for control of insect pests, life cycle, symptoms and mode of action.</p>	1/ 15L
II	<p><b><u>Unit II: Nitrogen Fixation and Biofertilizers</u></b></p> <p><b>Nitrogen fixation:</b> Molecular genetics: <i>nif</i> genes and regulation of <i>nif</i> gene expression, <i>fix</i> genes.</p> <p><b>Biofertilizer:</b> definition, methods of manufacture, application to soil and seed.</p> <p><b>Aquaponics: fish culture and plant culture using this water.</b></p> <p><b>Mycorrhiza:</b> Types, importance to plant health (nutrient uptake, resistance to stress, microbial symbiosis), importance of network analysis, role in ecosystem (Plant to plant interaction).</p> <p><b>Biofuels: Liquid and gaseous.</b> Bioenergy: Biofuels - Introduction, in the form of gas–hydrogen and methane (biogas), biofuel in form of liquid– ethanol and diesel, biofuel from phytoplankton.</p>	1/ 15L
III	<p><b><u>Unit III: Bioremediation</u></b></p> <p><b>Solid management:</b> Types, need, unit processes, laws and regulations.</p> <p><b>Composting:</b> physical and chemical factors, microbiology, health risk from pathogens, odour sources.</p> <p><b>Adaptation:</b> Effect of metals and salts on the growth of microbes and higher organisms. Different adaptation mechanism to tolerate higher concentration of metals by organisms.</p> <p><b>Bioremediation:</b> using natural, genetically engineered bacterial systems and plants with examples. <b>Heaps. Dumps and biomineralization</b></p>	1/ 15L

<b>IV</b>	<b><u>Unit IV: Phytoremediation and phytomining</u></b>  <b>Phytoremediation:</b> Contaminants treated, Contaminant removal mechanisms of plants, Site conditions, Procedure, Types of phytoremediation, Criteria for good phytoextractors. Improvement of phytoremediation using genetic engineering. Advantages and disadvantages of phytoremediation. Aquatic plants used for wastewater treatment. Indicator plants, Restoration of soil, water and air quality citing suitable examples. <b>Phytomining:</b> Factors influencing metal uptake by plants in soil, Implementing phytomining, extraction of valuable minerals/ metals from low grade ore/soils. <b>Biotechnology in gold mining/ extraction.</b>	<b>1/ 15L</b>

**PRACTICALS: RPSLScP403 (2 credits)**

1. Soil analysis - chloride, organic matter, & calcium carbonate content.
2. Waste water analysis - pH, Total solids, BOD, Hardness, acidity, alkalinity and chlorides.
3. Effect of Neem pesticides on plant pathogens.
4. Staining of mycorrhiza from root tips.
5. Analysis of metals accumulation in plants.
6. Identification of indicator plants for environmental conditions
7. Biofuels production from algae.

**References:**

1. Environmental Biotechnology by M. H. Fulekar
2. Environmental Sciences: Odum
3. Environmental Biotechnology: Alan Scragg
4. Environmental Biotechnology: BimalBhattacharya and Ritu Banerjee
5. Environmental pollution control engineering. C. S. Rao. New Age International Publishers.

**PAPER IV****Course Code: RPSLSc404****Course Title: Protein Studies, Biomathematics and Advanced Bioinformatics.****COURSE OUTCOMES:**

<b>COURSE OUTCOME</b>	<b>DESCRIPTION</b> At the end of the course students will be able to:
<b>CO 1</b>	Summarize the types, mechanisms, quality control systems of protein trafficking and targeting machinery to various cellular compartments.
<b>CO 2</b>	Explain the concept of folding pathways involved in proteins achieving their native conformation with the associated thermodynamics aspects and the chaperon families that help in the process.
<b>CO 3</b>	Elaborate on the ability of all the biomolecules to interact with each other to carry out all the metabolic processes.
<b>CO 4</b>	Describe the concepts and list advanced tools used in the field of proteomics to give an overall perspective of complete protein studies under one roof.
<b>CO 5</b>	Enlist various applications of drug designing.
<b>CO 6</b>	Solve basic calculus problems as well as examples in biological scenarios using mathematics which is required to understand ecological modelling, growth curves, population genetics, epidemic modelling, enzyme kinetics, analysing drug efficacies as well as cancer treatment modelling to name a few.
<b>CO 7</b>	Isolate, perform partial purification of enzyme and determine molecular weight by SDS-PAGE separation.
<b>CO 8</b>	Perform <i>in silico</i> molecular docking, analyse protein binding site, protein-protein interactions and predict secondary structure using appropriate software tools.



## DETAILED SYLLABUS - Paper IV

**Course Code: RPSLSc404**

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><b><u>Unit I: Protein Trafficking and Targeting</u></b></p> <p>Intracellular and membrane protein trafficking and targeting; Secretory pathways in prokaryotes and eukaryotes;</p> <p>Co-translational transport (protease protection assay) - Endocytic pathways; Signal sequences; secretory proteins and membrane protein synthesis and docking. N-glycosylation in the ER and Golgi.</p> <p>Quality control - UPR, ERAD and proteosomal degradation.</p> <p>Post-translational transport - Targeting of mitochondrial, chloroplast, peroxisomal and nuclear proteins;</p> <p>Vesicle biogenesis and ER to Golgi transport; ER translocation of polypeptides (soluble and transmembrane); ER chaperons; SNAPs and SNAREs; Methods of studying Protein Transport; Disorders of protein transport.</p>	1/ 15L
II	<p><b><u>Unit II: Protein folding and Biomolecular interactions</u></b></p> <p><b>Thermodynamics:</b> The laws of thermodynamics, enthalpy, entropy and free energy concepts and their relevance to biological systems.</p> <p><b>Protein Folding:</b> Folding pathways; Intermediates of protein folding; Compact Intermediates; Hierarchical and non-hierarchical folding mechanisms; Molten globule structure; Role of chaperons (trigger factor, prefoldin), heat shock proteins (Hsp70, Hsp90), chaperonins (Group I &amp; II) and enzymes in protein folding (PDI, PPI). Protein folding disorders.</p> <p><b>Biomolecular Interactions and diseases:</b></p> <p>Structural and functional aspects of proteins and DNA: Relationships between structure and function and their role in human diseases; Protein-DNA interactions; Protein-RNA interactions; Protein-Protein interactions; Protein aggregation; Non-Enzymatic glycosylation (Protein- sugar interactions); Methods to study these interactions.</p>	1/ 15L

III	<p><b><u>Unit III: Advanced Bioinformatics</u></b></p> <p><b>Genomics:</b> Basic concepts on identification of disease genes, role of bioinformatics- OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays.</p> <p><b>Proteomics:</b> Introduction and current status, Prediction of secondary structure: PHD and PSI-PRED method. Tertiary (3-D) Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology Modelling (Ramchandran plot), fold recognition, threading approaches, and ab-initio structure prediction methods.</p> <p>Application in drug designing: Drug targets, Lead Identification and Modification, Computer-Aided Drug Design.</p>	1/ 15L
IV	<p><b><u>Unit IV: Biomathematics</u></b></p> <p>Binomial Theorem (without infinite series), Determinants, Matrices, Rank of Matrices by Diagonalisation method Limit and derivatives, Differentiation (including differentiability), Successive Differentiation, Integration – Definite and Indefinite (ordinary, method of substitution, special trigonometric function, partial fraction) Application of integration to find area, Differential equations --homogeneous and Linear ODE's and its simple applications to biological problems. Applications of maths in biology.</p>	1/ 15L

### PRACTICALS: RPSLScP404 (2 credits)

1. Isolation and partial purification of Acid/ Alkaline phosphatase from potato
2. Analysis of purification fold of the extracted enzyme
3. Determination of molecular weight of enzyme by SDS-PAGE.
4. *In silico* drug designing using Click2Drug and Autodock Vina.
5. Motif Finding- MEME and TomTom
6. Secondary Structure Prediction: Porter 5.0
7. Tertiary Structure: ExPasy in SWISS

### References:

1. Molecular cell biology by Lodish (5<sup>th</sup> Edition).
2. Biochemistry by Stryer.
3. Biochemistry by Harper.
4. Introduction to Bioinformatics- Attwood, Parry-Smith and Phukan.
5. Bioinformatics: Sequence and Genome Analysis- David W. Mount.
6. Bioinformatics and Functional Genomics- Jonathan Pevsner.
7. Fundamentals of Bioinformatics: Harisha S.
8. Bioinformatics and Molecular Evolution: Higgs & Attwood.
9. Bioinformatics: Harshwardhan Pal.

## Assessment Modalities

### **Online Examination:** (Deviation from the usual modality)

Owing to the pandemic situation prevailing in 2020 and continuing in 2021, the external examinations (Semester End) may be conducted online as per the instructions/circulars received from the University of Mumbai and Maharashtra State notifications from time to time. The conventional mode of external examination will commence again only after the declaration of normalcy by the Government authorities.

### **Theory Examination Pattern:**

- Assessment of theory is divided as Internal and External where internals are given weightage of 40 marks and external theory written exams are given 60 marks.

#### **A) Internal Assessment: 40 Marks**

- Assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / preparation of business plan/ creative writing / mock audit / meme making assignment / video assignment / survey / debate pertaining to syllabus topics chosen or allotted.
- Students are informed at least a month in advance about the portions for topics of the assignments or presentations via emails or on google classroom and marking scheme in the form of rubrics are known to them and hard copies depicting the names of students with topics and rubrics are maintained as proofs with their signatures with date.
- Below is an example of the rubrics.

#### **Rubrics chart for presentations**

	<b>Total</b>	<b>80-100%</b>	<b>60-80%</b>	<b>40-60%</b>	<b>20-40%</b>	<b>0-20%</b>
Content	05	5	4	3	2	1
Presentation skills	05	5	4	3	2	1
Questions answered	05	5	4	3	2	1
Questions asked	03	3	2.4	1.8	1.2	0.6
Time management	02	2	1.6	1.2	0.8	0.4
<b>Total</b>	<b>20</b>	<b>20</b>	<b>16</b>	<b>12</b>	<b>08</b>	<b>04</b>

**B) External Examination- 60 Marks**

Duration - The examinations shall be of **2 ½ hrs duration**. Theory question paper pattern is for 60 marks with 60% choice as shown below.

Semester	Papers	Units covered	Question numbers and choice	Marks for each question	Total marks
IV	I, II, III, IV	1	Q1 - A, B, C (any two out of three)	06	12
		2	Q2 - A, B, C (any two out of three)	06	12
		3	Q3 - A, B, C (any two out of three)	06	12
		4	Q4 - A, B, C (any two out of three)	06	12
		1 question each from all 4 units	Q5 - i, ii, iii, iv (any three out of four)	04	12
Total marks					60

**Practical Examination Pattern: 50 Marks**

- Assessment of practicals only consists of External evaluation with a weightage of 50 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
IV	1, 2, 3, 4	Q1. Major experiment	30
		Q2. Identification	10
		Q3. <i>Viva voce</i>	5
		Q4. Journal	5
Total marks			50

## Overall Examination & Marks Distribution Pattern

### Semester IV

PAPER	EXAM	MARKS	GRAND TOTAL
I (150 marks)	Theory	60	600 marks
	Internals	40	
	Practicals	50	
II (150 marks)	Theory	60	
	Internals	40	
	Practicals	50	
III (150 marks)	Theory	60	
	Internals	40	
	Practicals	50	
IV (150 marks)	Theory	60	
	Internals	40	
	Practicals	50	

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