SOPHIA COLLEGE FOR WOMEN (AUTONOMOUS)

Affiliated to

UNIVERSITY OF MUMBAI

Programme: Microbiology

Programme code: SMSMCB

M.Sc.-II Microbiology

(Choice Based Credit System with effect from the year 2021-2022)

Programme Outline: M.Sc.-II Microbiology (SEMESTER III)

Course code	Unit No	Name of the Unit	Credits
SMSMCB301		RESEARCH METHODOLOGY	4
	1	Basics of Research	
	2	Sampling, data collection, interpretation and report writing.	
	3	Scientific writing and ethics in research and publication.	
	4	Biostatistics	
SMSMCB302		FOOD MICROBIOLOGY	4
	1	Microbes in Food	
	2	Use of Microbes and their products in in Food industry	
	3	Control of Microbes in Food	
	4	Microbiological quality of Food	
SMSMCB303		ADVANCES IN BIOTECHNOLOGY-I	4
	1	Plant and Agricultural Biotechnology	
	2	Animal Biotechnology	
	3	Nanobiotechnology	
	4	Medical Biotechnology	
SMSMCB304		ENVIRONMENTAL MICROBIOLOGY-I	4
	1	Microbial Ecology	
	2	Soil, Plant and Marine Microbiology	
	3	Cultural and Physiological Methods for Studying Microorganisms in the Environment	
	4	Immunological and Nucleic acid Methods for Studying Microorganisms in the Environment	
SMSMCBP3		PRACTICALS	
SMSMCBP301		Research proposal writing	2
SMSMCBP302		Food Microbiology	2
SMSMCBP303		Advances in Biotechnology-I	2
SMSMCBP304		Environmental Microbiology-I	2

Programme Outline: M.Sc.-II Microbiology (SEMESTER IV)

Course code	Unit No	Name of the Unit	Credits
SMSMCB401		TOOLS AND TECHNIQUES: BIOMOLECULAR ANALYSIS	4
	1	Advanced Microscopy techniques	
	2	Spectroscopic techniques	
	3	Chromatographic techniques	
	4	Molecular biology techniques.	
SMSMCB402		PHARMACEUTICAL MICROBIOLOGY	4
	1	Main principles for pharmaceutical products	
	2	Premises and personnel management	
	3	Sterility in pharmaceutical products and other principles	
	4	Drug discovery	
SMSMCB403		ADVANCES IN BIOTECHNOLOGY-II	4
	1	Pharmaceutical Biotechnology and Bioethics	
	2	IPR and innovations, startups and Entrepreneurship	
	3	Microbial biofuels	
	4	Synthetic Biology	
SMSMCB404		ENVIRONMENTAL MICROBIOLOGY-II	4
	1	Extremophiles	
	2	Impact of Microorganisms on Environment	
	3	Environmental Monitoring and Water Pollution	
	4	Bioremediation and Waste treatment	
SMSMCBP4		PRACTICALS	
SMSMCBP401		Dissertation submission and presentation	2
SMSMCBP402		Pharmaceutical Microbiology	2
SMSMCBP403		Advances in Biotechnology-II	2
SMSMCBP404		Environmental Microbiology-II	2

PREAMBLE:

The M.Sc program at Sophia College (Autonomous) is open to both female and male students. The M.Sc course is an extension of the undergraduate curriculum dealing with all the branches of Microbiology at a considerable depth and blends the upcoming fields as well as advances in the subject. Research is an integral aspect of the curriculum and includes planning and execution of a dissertation. The outcomes of a number of the dissertations have been published in peer reviewed journals. Participation and presentations - both oral and posters in conferences, workshops and research meets is encouraged. Field projects, Educational visits and short-term internships are also included. The students who complete the postgraduate programme in Microbiology are well trained in the subject and find employment in areas like Quality control, Research and Development, Clinical Research, Teaching etc.

Program Objectives

PO1	To provide in depth knowledge to the learners in the conventional and emerging areas of Microbiology.
PO2	To help learners plan and execute research projects.
PO3	To train the learners to communicate the findings of the research projects effectively.
PO4	To create awareness among the learners about regulatory requirements and compliance, IPR and ethics.

PROGRAMME SPECIFIC OUTCOMES

PSO1	The learner will gain and apply knowledge about recent developments in Genetics, Virology, Cell Biology, Microbial Biochemistry, Medical Microbiology and Immunology, Environmental Microbiology, Food and Dairy Microbiology etc in order to solve problems affecting mankind.
PSO2	The learner will acquire knowledge about research methodology, plan and execute experiments using good laboratory practices, and interpret the experimental results effectively.
PSO3	The learner will be able to communicate their findings by virtue of doing poster /oral presentations in conferences/workshops, writing thesis, research papers, reports etc
PSO4	The learners will gain knowledge of regulatory compliance in various fields like clinical research, IPR and ethics by attending value added courses/seminars/webinars etc which may lead to employability.

SEMESTER 3

NAME OF THE COURSE	RESEARCH METHODOLOGY	
CLASS	MSc-II	
COURSE CODE	SMSMCB301	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1	To educate about the process of research, types of research and research design.
CO 2	To understand the detailed methodology involved in writing a research proposal.
CO 3	To analyze the different types of sampling methods, sampling designs and variables. To learn about methods of data collection, interpretation and report writing.
CO 4	To develop skills in scientific writing and understand ethics in research and publication.
CO 5	To use ICT as a tool to assist in writing research proposals and research outcomes
CO 6	To use biostatistics software in interpretation of data.

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to explain the process of research and differentiate between types of research.
CLO 2	The learner will be able to design a research plan.
CLO 3	The learner will be able to use appropriate methods of sample collection, methods of carrying out research and write a report on the same.
CLO 4	The learner will be able to write a research proposal, use anti plagiarism software to check if the proposal follows all principles of ethics in research and publication.
CLO 5	The learner will write a report for presentation in written and oral format using ICT.
CLO 6	The learner will be able to use the biostatistics software so that it can be applied to the data collected for validity and interpretation.

UNIT 1	Basics of Research (15 Lectures)
1.1	Meaning and objectives of research, research and scientific method, research process, research methods vs methodology. Criteria of good research, Problems encountered by researchers in India. (07L)
1.2	Types of research, conceptual vs empirical, applied vs fundamental, descriptive vs analytical, qualitative vs quantitative. (04L)
1.3	Research designs: Features of a good research design, different research designs. Case study, cross over study, case control design, cohort study design, multifactorial design, ex post facto. (04L)
UNIT 2	Sampling, data collection, interpretation and report writing. (15 Lectures)
2.1	Sampling and sampling design: Steps and different types of sample design. Methods of sampling: non probability, simple random, systematic, stratified, quota, cluster and area sampling, multistage and sequential sampling. Problems due to unintended sampling, ecological and statistical population in the laboratory. (04L) Variables: Nominal, ordinal, discontinuous and continuous.(02L)
2.2	Collection of data: Methods and techniques of data collection. Types of data collection: Primary and Secondary. Methods of primary data collection: Observation, Experimentation, Questionnaire, Interview, Schedules, Case pilot study etc. Methods of secondary data collection- Internal and External. (06L)
2.3	Interpretation and report writing: Techniques of interpretation and different steps involved in report writing, types of report, mechanics of writing a research report. (03L)
UNIT 3	Scientific writing and Ethics in research and publication (15 Lectures)
3.1	Abstract, Writing of Literature review, Aim and Objectives Methodology, References/ Bibliography and Preparation of manuscript for publication of research/ review paper. Peer reviewed, UGC CARE listed, indexed journals, citation index and role of citation, impact factor of a journal. Use of open sources such as Mendeley reference manager, LaTeX as writing software, storage using Google drive/ Dropbox. Science journalism. (07 L)
3.2	Use of computers in research: Computer technology, computer and researchers, software tools in the structure, design and preparation of thesis, layout, labeling of

	figures, legends, preparation of tables, layout, etc. Preparation of oral presentation and posters. (04L)
3.3	Ethics in research and publication: Citations, acknowledgement, conflict of interest, plagiarism, plagiarism checking tools. Overview of ethics in research: Overview of legislation and regulation, ethical guidelines in animal and clinical research. IPR and patent law. (04L)
UNIT 4	Biostatistics (15 Lectures)
4.1	Basics of Biostatistics: Measure of central tendencies, mean, mode, median. Measure of dispersion, Standard deviation, Standard error of means, P value concept. Use of appropriate software for computation of statistical data (05L)
4.2	Types of hypothesis**:** Basics concepts, types of hypothesis - Null and Alternate hypothesis, levels of hypothesis and testing of hypothesis.Parametric test: Z test, t test (1 tailed and 2 tailed test) of hypothesis. Different types of ANOVA test Non parametric test. (06L)
4.3	Correlation analysis & Regression analysis**:** interpolation and extrapolation, nonlinear data fitting, probit analysis etc. Software used for all of the above. (04L)
	Student activity: A hands-on workshop will be organized to help students learn about the various biostatistics softwares. A talk will be organized to inform students on how to go about writing scientific articles to promote science journalism as a career choice.

REFERENCES:
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2. Das, S.K. (1986). An Introduction to Research, *Kolkata, Mukherjee and Company Pvt. Ltd.*
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9. Katz J.M. (2009). From Research to Manuscript: A guide to scientific writing, USA, *Springer Science*
10. Saravanavel, P. (1990). Research methodology. Allahabad, Kitab Mahal.

NAME OF THE COURSE	FOOD MICROBIOLOGY	
CLASS	MSc-II	
COURSE CODE	SMSMCB302	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1	To list microorganisms that are commonly associated with certain groups of foods
CO 2	To outline the process for making fermented dairy and vegetable foods products
CO 3	To emphasize the health benefits of probiotic bacteria.
CO 4	To outline various types of traditional and advanced methods of food preservation, their principles and their commercial applications.
CO 5	To give an overview of methods available for microbiological analysis of food and compare the methods in terms of advantages and disadvantages.
CO 6	To highlight the importance of control at source and the HACCP system with respect to food safety and quality.
CO7	To educate about the prevailing food safety standards and agencies involved in establishing and monitoring food safety regulations.

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to identify the sources of microbial contamination of food, relate specific microorganisms to spoilage of foods or certain foodborne illness.
CLO 2	The learner will be able to illustrate the steps in bread, cheese, idli & sauerkraut production.
CLO 3	The learner will be able to describe the properties of probiotic cultures and their possible health benefits.
CLO 4	The learner will be able to list and describe the applications of organic and inorganic food preservatives.
CLO 5	The learner will be able to give an overview of nonthermal methods of food preservation

CLO 6	The learner will be able to compare the conventional and rapid methods of detection of pathogens
CLO 7	The learner will be able to explain the basis of immunological, nucleic acid, and biochemical methods for detection of food borne pathogens.
CLO 8	The learner will be able to prepare food samples for determination of microbial load and choose appropriate sampling plans as per case number, also understand why some sampling plans are more stringent than others.
CLO 9	The learner will be able to outline the basic concepts of GMPs, recognize its limitations and explain the need for control at source.
CLO 10	The learner will be able to discuss the principles of the HACCP program.
CLO 11	The learner will be able to identify national and international agencies involved in food safety and quality.

UNIT 1	Microbes in foods (15 Lectures)
1.1	Important microbes in food: Bacterial groups, Molds Yeast, Virus, Protozoa. Important Foodborne pathogens. (03L)
1.2	Sources of microbes in food (03L)
1.3	Importance of Stress adapted microbes in food, Sublethally injured microbes, VBNC(def), Properties and significance. (03L)
1.4	Normal microbiological quality of foods and its significance: Fish, Meat, Raw and pasteurized milk, Egg and Egg products, Canned foods, Spices**.** (06L)
UNIT 2	Use of Microbes and their products in Food industry (15 Lectures)
2.1	Starter cultures: Bacterial, Yeast and molds,Concentrated cultures, Problems in starter cultures and control methods. (04L)
2.2	Microbiology of fermented foods: General method of production (05L) a. Bread b. Cheese – Swiss and Blue cheese c. Fermented vegetable products – Sauerkraut d. Idli
2.3	Microbes used as Probiotics (Examples, properties and benefits) (02L)
2.4	Microbial products used in food industry: Enzymes in food processing, food waste treatment, Food grade pigments, Flavour compounds, exopolysaccharides (04L)
UNIT 3	Control of Microbes in Food (15 Lectures)

3.1	Conventional methods a. Control by physical methods- (04L) i. Physical removal ii. Heat (Pasteurization, High heat processed foods) iii. low temperature (Chilling, Refrigeration, Freezing iv. reduced a_w, Intermediate Moisture food b. Control by chemical preservatives:organic acids and inorganic compounds (salt, nitrates, Sulphur based compounds) (02L)
3.2	Modern methods: (04L) a. Modified atmosphere,ozone b. Irradiation c. Antimicrobial preservatives of microbial, animal & plant origin d. Bacteriocins: Mode of action, delivery by nanoencapsulation
3.3	Novel emerging techniques of food preservation- Nonthermal method- HPP, PEF, PL, OMF, Ultrasound, cold plasma (05L)
UNIT 4	Microbiological quality of Food (15 Lectures)
4.1	Detection and enumeration of microbes in food: a. Conventional Methods- (02L) i. Direct Enumeration :Microscopic Counts, count using nonselective , selective, differential chromogenic media ii. Indirect count : Dilution to extinction, MPN, Dye Reduction test b. Detection of Microbial Toxins (01L) c. Rapid and automated methods for detection of pathogens:Metabolic Fingerprinting, Immunomagnetic Separation, Reverse Passive Latex Agglutination (RPLA) Method, Immunochromatographic Lateral Flow Assay,Hybridization Method , Microarrays and Mass-Spectrometry (03L) d. Bacteriophage for Detection of Pathogen (01L) e. Biosensors for detection of microbes in food.
4.2	Indicator microorganisms : Characteristics, Coliform and enterococci. (01L)
4.3	Microbiological Criteria, Sampling plan, Types (2 class and 3 class)and sampling procedures (01L)
4.4	New emerging food borne pathogens of concern (02L)
4.5	a. Control at source. (02L) b. Codes of GMP c. HACCP
4.6	Regulations and agencies monitoring microbiological safety of food: ICMSF, CDC, Food net, Codex Alimentarius, ISO22000, FSSAI (02L)

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2. Ray, Bibek., Bhunia, Arun . (2014). Fundamental Food Microbiology 5th edn. *CRC Press.*
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5. Adams, M R., Moss, M O. (2007). Food Microbiology, 3rd edn. *New age international publishers.*

NAME OF THE COURSE	ADVANCES IN BIOTECHNOLOGY-I	
CLASS	MSc-II	
COURSE CODE	SMSMCB303	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1	To introduce students to the various techniques involved in plant and animal biotechnology
CO 2	To familiarize students with the role of microbial genes in plant and animal biotechnology
CO 3	To inform about the applications and potential risks linked with plant and animal biotechnology
CO 4	To provide students with understanding of the emerging field of nanotechnology, its fundamentals and advances in the area of biotechnology
CO 5	To introduce students to both beneficial and harmful applications of biotechnology in the area of human health, with applications in medicine on one hand and bioterrorism on the other.

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to correlate the principles of molecular biology methods with emphasis on the application of recombinant DNA technology to plant and animal biotechnology.
CLO 2	The learner will be able to list the applications of plant and animal biotechnology
CLO 3	The learner will be able to understand the risks associated with plant and animal biotechnology
CLO 4	The learner will be able to understand the basic principles of nanobiotechnology and its applications.
CLO 5	The learner will be able to understand both the beneficial and harmful applications of biotechnology in the area of human health

UNIT 1	Plant and Agricultural Biotechnology (15 Lectures)
1.1	Plant Tissue Culture techniques -Callus and Suspension culture, Direct and Indirect Organogenesis, Micropropagation, Artificial seeds, Anther culture, Protoplast isolation, culture and fusion, Production of haploids, dihaploids Somaclonal variations, Germplasm conservation, Somatic hybrids, Cybrids (only Principles of the techniques). (03L)
1.2	Plant Transformation Technology – Vectors used for plant transformation (Agrobacterium based vectors and viral vectors only), Molecular breeding, plant selectable markers, Reporter genes, Positive selection, Selectable marker elimination, Transgene silencing, Strategies to avoid transgene silencing (04L)
1.3	Applications of transgenic plants - Production of secondary metabolites from plant cell cultures, Edible vaccines (01L)
1.4	Microbial genes in crop improvement- microbial genes for insect resistance, herbicide tolerance, modified product quality, abiotic stress tolerance, resistance, hybrid seed production, Photosynthesis and nitrogen fixation (04L)
1.5	Microbe – plant interactions: Plant Pathogen interaction, mutualistic interactions, mechanisms of resistance to plant viruses – protein-based resistance, RNA mediated silencing and genome editing tools (03L)
UNIT 2	Animal Biotechnology (15 Lectures)
2.1	Animal Tissue Culture: Primary culture, Organ culture, Embryo Culture, Established Cell lines (self study)
2.2	Creating Transgenic animals using nuclear microinjection, Alternate approaches to making transgenic animals (embryonic stem cells, nuclear transplantation, retroviral method) , Transgenic cattle, Transgenic birds, Transgenic fish, Transgenic mice, Transgenic mosquitoes (05L)
2.3	Applications of transgenic animals: Recombinant protein production, knockout mice for medical research, disease control (mosquito borne) and improving livestock (03L)
2.4	Location effects on expression of transgene, combating location effects on expression of transgene, targeting the transgene to a specific location, control of transgene expression, transgene regulation via steroid receptors, control by site-specific recombination using CRE or FLP (05L)
2.5	Developmental and imprinting defects in cloned animals, Risk associated with DNA ingestion (02L)
UNIT 3	Nanobiotechnology (15 Lectures)
3.1	Nanoscale systems, nanoparticles, nanowires, thin films and multilayers, Properties of nanomaterials (03L)

3.2	Visualization at the nanoscale - Scanning tunneling microscopy, Atomic force microscopy (01L)
3.3	Weighing single bacteria and virus particles (01L)
3.4	Synthesis of nanostructures - physical, chemical and biological, microbiological methods - Biomolecules as nanostructures, Nanoparticular carrier systems, Micro and Nanofluidics. (04L)
3.5	Applications: Biosensors, drug and gene delivery systems, chip technologies, nano imaging, Nanomedicine and Cancer diagnostics and treatment, detection of viruses by nanowires, nanoengineering of DNA, DNA mechanical nanodevices, Biomolecular motors, Nano barcode (06L)
UNIT 4	Medical Biotechnology (15 Lectures)
4.1	Genetic Testing of diseases and disorders, Immunogenetics; prenatal diagnosis-chorionic villus sampling, amniocentesis, Pre-implantation diagnosis., Genetic counselling.(02L)
4.2	Gene therapy- general principles, vectors, gene targeting and tissue-specific expression, antisense technology, Aptamers, Ribozymes (02L)
4.3	Novel strategies to treat cancer- engineered cancer – killing viruses and apoptosis (03L)
4.4	Biowarfare and Bioterrorism - disease agents and purified as biowarfare agents, ribosome-inactivating proteins, agricultural biowarfare, genetic engineering of infectious agents, creation of camouflaged viruses, biosensors and detection of biowarfare agents (04L)
4.5	Tissue Engineering - Fundamentals, Growth Factors & morphogens, Extracellular Matrix, Cell adhesion and migration, Inflammatory and Immune responses to tissue engineered devices, Biomaterials, applications of tissue engineering, Introduction of 3-D organ printing, organ on chip (04L)

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3. Das HK. (ed) (2004). Textbook of Biotechnology, *Wiley India.*
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NAME OF THE COURSE	ENVIRONMENTAL MICROBIOLOGY-I	
CLASS	MSc-II	
COURSE CODE	SMSMCB304	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1.	To discuss the theories of origin of life, chemical and cellular evolution.
CO 2.	To describe the basic principles of microbial ecology and interactions among microbial populations.
CO 3.	To explain microbial environments and microbial diversity and interactions.
CO 4	To explain environmental sampling, collection and processing.
CO 5	To explain, discuss and apply the different methods for studying microorganisms in the environment.

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to recall the theories of origin of life and microbial evolution.
CLO 2	The learner will be able to explain basic principles of ecology and interactions among microbial populations.
CLO 3	The learner will be able to summarize physical and chemical properties of soil and microbial diversity.
CLO 4	The learner will be able to describe interactions of microorganisms with plants, mycorrhizae, nodule formation and fungal and bacterial diseases of plants.
CLO 5	The learner will be able to describe marine microbial biodiversity and symbiotic associations of microorganisms with marine animals.
CLO 6	The learner will be able to explain, compare and analyze cultural, physiological, immunological and nucleic-acid based methods for studying microorganisms in the environment.
CLO 7	The learner will be able to apply some of the methods used to study microorganisms in the environment.

UNIT 1	Microbial Ecology (15 Lectures)
1.1	Origin of life and Microbial Evolution (05L) a. Origins of life - chemical evolution, RNA world hypothesis, cellular evolution, evolution of organelles b. Evolution of physiological diversity
1.2	Microbial Ecology – Niche, habitat, ecosystem (01L)
1.3	Interactions among microbial populations (6L) a. Interactions within a single microbial population- i.Positive interactions, Negative interactions b. Interactions between diverse microbial populations- Neutralism, Commensalism, Synergism, Mutualism, Competition, Amensalism, Parasitism, Predation
1.4	Succession within microbial communities (03L) a. Autotrophic-Heterotrophic succession b. Examples of successional processes (any one example) c. Homeostasis and Secondary succession
UNIT 2	Soil, Plant and Marine Microbiology (15 Lectures)
2.1	Soil and Plant Microbiology (07L) a. Litho-Ecosphere b. Physical and chemical properties of soils c. Soil microbial communities d. Interactions with plant roots- Rhizosphere, plant root effects on microbial population, effects of rhizosphere microbial populations on plants, Mycorrhizae-Ectomycorrhizae and Endomycorrhizae e. Nitrogen fixation in nodules- Nitrogen fixing associations between Rhizobia and legumes, Non-leguminous nitrogen fixing mutualistic relationships f. Interactions with aerial plant structures g. Microbial diseases of plants and plant pathogens-bacterial and fungal diseases of plants
2.2	Marine Microbiology (08L) a. Planktonic environment b. Benthic habitat c. Microbial mats d. Brackish water (estuary) e. Physical, chemical and microbial characteristics of marine water f. Marine microbial populations- Bacteria, Fungi, Algae, Protozoa and Viruses (Cyanophages and other viruses) g. Horizontal gene transfer in marine microorganisms

	h. Symbiotic associations i. Symbioses of microalgae with animals (Types of association, Nature of dinoflagellate endosymbionts, Corals), ii. Symbioses of chemoautotrophic prokaryotes with animals (Chemoautotrophic endosymbionts in hydrothermal vent animals, Episymbiotic bacteria on vent animals, Chemoautotrophic endosymbionts in non-vent animals, Phylogeny and acquisition of symbiotic bacteria) iii. Light organ symbioses in fish and invertebrates (Flashlight fishes and anglerfishes, Sepiolids-bobtail squids), iv. Microbial symbionts of sponges v. Symbiosis and mixotrophy in protists vi. Metabolic consortia and mutualism between prokaryotes
UNIT 3	Cultural and Physiological Methods for Studying Microorganisms in the Environment (15 Lectures)
3.1	Environmental sample collection and processing (02L) a. Soils and Sediment- Sampling strategies and methods for surface soils, Sampling strategies and methods for the subsurface, Sample processing and storage b. Water- Sampling strategies and methods for water, processing water samples for virus analysis, processing water samples for detection of bacteria and protozoan parasites
3.2	Cultural Methods (03L) a. Cultural methods for isolation & enumeration of bacteria i. Enumeration and Isolation techniques ii. Plating methods iii. Most probable number technique b. Culture media for bacteria i. General media used for culturing bacteria ii. New approaches to enhanced cultivation of soil bacteria c. Cultural methods for fungi d. Cultural methods for Algae and Cyanobacteria e. Cell culture based detection methods for viruses
3.3	Physiological Methods (10L) a. Measuring microbial activity in pure culture b. Carbon Respiration i. Measurement of respiratory gases CO_2 and O_2 in laboratory and field studies ii. The application of respiration measurements in environmental microbiology iii. Tracer studies to determine heterotrophic potential iv. Anaerobic respiration as an indicator of microbial activity

	c. Incorporation of radiolabeled tracers into cellular macromolecules i. Incorporation of thymidine into DNA ii. Incorporation of leucine into protein d. Adenylate energy charge e. Enzyme assays- Dehydrogenase assay f. Stable isotope probing g. Functional genomics and proteomics based approaches
UNIT 4	Immunological and Nucleic acid Methods for Studying Microorganisms in the Environment (15 Lectures)
4.1	Immunological methods (04L) a. Immunoassays. i. Fluorescent immunolabeling ii. Immunomagnetic separation assays iii. Immunoaffinity chromatographic assays iv. Immunocytochemical assays
4.2	Nucleic acid based methods of analysis (11L) a. Extraction of nucleic acids from environmental samples b. Gene probes and probing- Fluorescent in situ hybridization (FISH) c. PCR Fingerprinting d. Metagenomics (Pyrosequencing, Shotgun cloning) e. Metatranscriptomics f. Metaproteomics g. Restriction fragment length polymorphism analysis i. RFLP analysis of whole genomes ii. RFLP analysis of PCR sequences iii. Fluorescent fragment length polymorphism techniques iv. Pulsed field gel electrophoresis v. Advantages and disadvantages of RFLP and PFGE analyses h. Denaturing/temperature gradient gel electrophoresis i. Theory, concept, advantages and disadvantages of DGGE and TGGE i. Reporter genes i. Theory and concept ii. Specific reporter gene systems iii. Advantages and disadvantages of reporter genes

REFERENCES

SMSMCB304

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Practicals- Semester 3 SMSMCBP3

NAME OF THE COURSE	RESEARCH PROPOSAL WRITING	
CLASS	MSc-II	
COURSE CODE	SMSMCBP301	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	-	50
PASSING MARKS	-	20

COURSE OBJECTIVES:

CO 1	To select a research topic and design a research plan.
CO 2	To write the origin of the research problem, interdisciplinary relevance and justification.
CO 3	To conduct literature search on the selected research topic.
CO 4	To write Aims and Objectives.
CO 5	To propose appropriate materials and methods in order to conduct the research
CO 6	To comment on the expected results.
CO 7	To write references using APA, Harvard style etc.
CO 8	To write a budget for conducting the research project
CO 9	To present the research proposal.

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to select a research topic and design a research plan in consultation with the guide and keeping in mind the facilities provided by the department and common instrument facility available in other science departments.
CLO 2	The learner will be able to justify the need to carry out the proposed research work, highlight the interdisciplinary relevance and propose a hypothesis.
CLO 3	The learner will be able to review primary and secondary sources of data in order to collect literature in an hope to explore areas which have not been researched so far if possible, especially applications.
CLO 4	The learner will be able to write aims and list the objectives of carrying out the research project.
CLO 5	The learner will be able to describe the procurement and use of materials in the order to carry out the research. Also To propose appropriate materials and methods in order to conduct the research
CLO 6	The learner will be able to discuss the expected results after carrying out the key steps of the research project.
CLO 7	The learner will be able to write in text references and also list at least 25 references using APA, Harvard style etc at the end of the proposal.
CLO 8	The learner will be able to list the cost of the chemicals, glassware, instrumental analysis etc carried out during the research project.
CLO 9	The learner will be able to prepare a research proposal of about 25 -30 pages using ICT, check it for plagiarism and also present the same in the form of a Powerpoint presentation during the practical examination.

Sr.no	Name of the experiment
1	Research proposal writing. Hypothesis, Literature survey.
2	Plan of work and methodology.
3	Using anti plagiarism software to check the validity of the proposal.
4	Research proposal preparation using ICT tools and presentation using poster and defense.

NAME OF THE COURSE	FOOD MICROBIOLOGY PRACTICAL	
CLASS	MSc-II	
COURSE CODE	SMSMCBP302	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	-	50
PASSING MARKS	-	20

COURSE OBJECTIVES

CO 1	To isolate pathogenic microorganisms that are commonly associated with frozen raw foods.
CO 2	To outline the process for making popular traditional fermented food, monitor microbial succession as the fermentation progresses and study the characteristics of the final product.
CO 3	To impart hands-on experience of the quality control process and regulations for raw and pasteurized milk.
CO 4	To equip learners with practical skills in assessing microbiological quality of raw and processed liquid, solid, semisolid food as per prevailing food safety standards.
CO 5	To isolate probiotic bacteria.

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to detect and identify pathogens associated with frozen fish/poultry/meat using specific selective / differential chromogenic media.
CLO 2	The learner will be able to determine total aerobic count and lactic acid bacteria count of fermented Idli batter and monitor its progress at intervals by determining the lactic acid content using titration method.
CLO 3	The learner will be able to prepare food samples for determination of microbial load and determine the APC and coliform count in carrot and apple juice, salad, mayonnaise to comment on hygienic quality and shelf life
CLO 4	The learner will be able to carry out quality Assessment and Analysis of Milk (Raw, Packed) by performing DMC, RPT and SPC / LPC, Thermophilic/Psychrophilic, yeast-mold counts .
CLO 5	The learner will be able to conduct literature survey on latest novel detection methods for food borne pathogens/ toxins.

Sr.No	Name of the experiment
1	Microbiological study of fermented foods (Idli batter), Yoghurt
2	Microbiological load in carrot and apple juice, salad, mayonnaise.
3	Quality Assessment and Analysis of food :Milk (Raw, Packed)
4	Detection of pathogens in frozen fish/poultry/meat
5	Report to be written in journal on Novel detection methods for food borne pathogens/ toxins.

NAME OF THE COURSE	ADVANCES IN BIOTECHNOLOGY-I PRACTICAL	
CLASS	MSc-II	
COURSE CODE	SMSMCBP303	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	-	50
PASSING MARKS	-	20

COURSE OBJECTIVES

CO 1	To understand the principles and practices involved in setting up and running an animal tissue culture laboratory.
CO 2	To understand the designing and setting up a plant tissue culture laboratory and learn plant tissue culture techniques, media preparation, and sterilization methods.
CO 3	To acquire knowledge of the wet reduction method for synthesizing nanosilver using neem extract and bacteria.
CO 4	To learn to characterize nanosilver using UV spectrometry and interpret the characterization data.
CO 5	To compare the antimicrobial properties of nanosilver prepared through different methods.
CO 6	To evaluate the antimicrobial effects of nanosilver-coated gauze/textiles on different bacteria.
CO 7	To inculcate verbal communications skills through participation in seminars on applications of artificial intelligence in biotechnology.

COURSE LEARNING OUTCOMES

CLO 1	The learner will be able demonstrate proficiency in setting up and requirements of animal and plant tissue culture laboratory.
CLO 2	The learner will be able to prepare nanosilver using wet reduction methods and characterize it using UV spectrometry

CLO 3	The learner will be able to analyze and evaluate the antimicrobial effects of nanosilver on various bacteria.
CLO 4	The learner will be able to analyze the efficacy of nanosilver-coated gauze / textiles in inhibiting bacterial growth.
CLO 5	The learner will be able to demonstrate understanding of the applications of artificial intelligence in biotechnology.
CLO 6	The learner will be able to demonstrate proficiency in presenting and discussing contemporary topics in an engaging manner.

Sr. No	Name of the experiment
1	Laboratory design of Animal tissue culture laboratory (Visit or Video)
2	Laboratory design of Plant tissue culture laboratory (Visit or Video)
3	Preparation of Nanosilver By Wet reduction Method (Chemical), using Neem Extract & Bacteria (Biological)
4	Characterisation of Nanosilver by UV spectrometry and microscopic methods
5	Antimicrobial effect of Ionic silver and Nanosilver prepared by above methods
6	Study of Nanosilver coated Gauze/textiles for antimicrobial effect on different bacteria
7	Artificial Intelligence in Biotechnology: Student seminars

NAME OF THE COURSE	ENVIRONMENTAL MICROBIOLOGY- I PRACTICAL	
CLASS	MSc-II	
COURSE CODE	SMSMCBP304	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	-	50
PASSING MARKS	-	20

COURSE OBJECTIVES:

CO 1	To perform soil analysis by determining the organic matter and chloride content of soil
CO 2	To determine the effect of indole acetic producing bacteria on the growth of plants
CO 3	To develop Winogradsky's column, examine the growth and characteristics of purple and green sulfur bacteria using phase contrast microscopy
CO 4	To perform soil respiration method and tetrazolium reduction assay to determine the active microbial populations in soil
CO 5	To write detailed reports on bacterial and archaeal diversity and Viable but Non-culturable bacteria
CO 6	To review and discuss a research article on *Roseobacter* in marine environments in order to identify the role of the bacteria in the environment

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to calculate the organic matter and chloride content of soil and analyze the overall quality and health of soil

CLO 2	The learner will be able to estimate the indole acetic acid produced and determine its effect on plant growth
CLO 3	The learner will be able to set-up Winogradsky's column, classify and distinguish different layers of bacteria and determine the characteristics using phase contrast microscopy
CLO 4	The learner will be able to use soil respiration method and tetrazolium reduction assay to determine the active microbial populations in soil
CLO 5	The learner will be able to arrange and paraphrase the literature to write reports on bacterial and archaeal diversity and Viable but Non-culturable bacteria
CLO 6	The learner will be able to analyze and discuss the review article on *Roseobacter*

Sr. No	Name of the experiment
1	A detailed report to be written on Bacterial and Archaeal diversity containing important characteristics, examples and pictures of different groups of a. Bacteria- The Deinococci and Nonproteobacteria, Proteobacteria (Alpha, Beta, Gamma, Delta and Epsilon), Low G+C and High G+C Gram Positive bacteria b. Archaebacteria **Student activity**- Students to watch videos of Archaebacteria, Proteobacteria and Nonproteobacteria on YouTube.
2	Soil analysis- a. To determine the organic matter content of soil b. To determine the chloride content of soil.
3	Isolation of indole acetic acid (IAA) producing bacteria from rhizospheric soil and its effect on plant growth.
4	Study of algae, Purple sulfur and Green sulfur bacteria.
5	**Student activity-** Reading a review article on *Roseobacter* bacteria in marine environments followed by discussion. (Reference no 9)
6	Soil respiration method.
7	Dehydrogenase assay-Tetrazolium reduction test.
8	A report to be written in the journal on Viable but non culturable bacteria (VBNC)- Mechanism, methods for detection, resuscitation .

ASSESSMENT DETAILS:

Internal assessment (50 marks)

Part 1: Test (25 marks)

- Students will be given a test from any of the units for 25 marks. The duration of the test will be 50 minutes. (Multiple choice questions- 10 marks, Answer in one word/sentence - 05 marks, Subjective questions - HWY, Justify, Differentiate between, Diagrammatically etc. - 10 marks).

Part 2: Test (25 marks)

- Students will be given a test from any of the units for 25 marks. The duration of the test will be 50 minutes. (Multiple choice questions- 10 marks, Answer in one word/sentence - 05 marks, Subjective questions - HWY, Justify, Differentiate between, Diagrammatically etc. - 10 marks).

Part 3: Activity (25 marks)

- An activity for 25 marks would be given in the form of a creative learning process. (Powerpoint presentation, Viva, Report and Viva, Preparation of study material and viva on the same, any other activity)

The best two marks will be considered for the Internal assessment total out of 50

Semester end examination (50 marks)

If Online

- The question paper shall consist of two parts - Part A and B. Part A will consist of 30 marks MCQs (including both 1 and 2 mark MCQs) whereas Part B will consist of 20 marks subjective having 5 mark questions **OR** The question paper will be a 50 mark paper having MCQs of 1 and 2 marks.

If Offline

- The duration of the paper will be two hours.
- There shall be five compulsory questions.
- Q1-4 shall correspond to the four units. Q1-4 shall contain an internal choice (Q1A or Q1A and Q1B or Q1B and so on). Q1-4 shall carry a maximum of 10 marks.
- Q5 shall be from Units 1 to 4. Q5 shall carry a maximum of 10 marks (attempt any 2 of 4)

Practical Assessment

- The duration of the practical exam will be three days.
- There will be 50 marks practical per paper.
- To appear in the practical exam, students must bring a properly certified journal.

SEMESTER 4

NAME OF THE COURSE	TOOLS AND TECHNIQUES: BIOMOLECULAR ANALYSIS	
CLASS	MSc-II	
COURSE CODE	SMSMCB401	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1	To explore the advanced microscopic techniques and their applications in various fields including Nanobiotechnology.
CO 2	To understand the basic and advanced spectroscopic techniques in judging purity and properties of an analyte.
CO 3	To explore the various chromatography techniques for separation and analysis of compounds.
CO 4	To familiarize about molecular biology techniques like PCR, FISH etc

COURSE LEARNING OUTCOMES:

CLO 1.	The learner will be able to explain the principle, instrumentation and applications of various microscopic techniques in order to find out the size, shape and structure of an organelle/ microorganism/ surface/nanomaterial.
CLO 2.	The learner will be able to explain the principle, instrumentation and applications of various spectroscopic techniques in order to explain the properties like lambda max, dispersion, purity etc.
CLO 3	The learner will be able to analyze the principle, instrumentation and applications of various chromatographic techniques for separation of molecules of interest and study their characteristics like molecular weight.
CLO 4	The learner will be able to discuss appropriate methods for amplification of DNA/ detection of RNA to help in genetic analysis of a sample.

UNIT 1	Advanced Microscopy techniques (15 Lectures)
1.1	Principle, working and applications of a. SEM and TEM. (03L) b. Scanning Probe Microscopes - Scanning Tunneling microscope (STM), Atomic force microscope (AFM), Magnetic force microscope (MFM), Scanning near field microscope (SNOM). (06L) c. Confocal microscopy. (02L) d. Fluorescence microscopy, high resolution fluorescence microscopy, fluorescence recovery after photobleaching and Forster resonance energy transfer. (04L)
UNIT 2	Spectroscopic and Centrifugation techniques (15 Lectures)
2.1	Principle, working and applications of (02L) a. Atomic absorption spectroscopy. (02L) b. Nuclear magnetic resonance (02L) c. Mass spectroscopy: ESI-MS and MALDI - MS (03L) d. FTIR (02L) e. Preparative ultracentrifugation (02L) f. Analytical ultracentrifugation (02L)
UNIT 3	Chromatography and Electrophoresis techniques (15 Lectures)
3.1	Principle, working and applications of a. Gas chromatography (02L) b. High performance liquid chromatography (02L) c. Supercritical fluid chromatography (02L) d. High performance thin layer chromatography. (02L) e. Isoelectric focussing. (01L) f. 2D electrophoresis (02L) g. Immunoelectrophoresis (02L) h. Capillary electrophoresis (02L)
UNIT 4	Molecular biology techniques (15 Lectures)

4.1	a. .Methods of extraction of DNA/RNA (01L) b. Variation / Modification of Basic PCR techniques: Hot start, Multiplex, Broad range, Nested, Real time, Quantitative and Arbitrary PCR. (03L) c. Hybridization array technologies: application of microarrays in Microbiology, Microarray platform technologies(oligonucleotide microarrays and cDNA microarrays) (05L) d. FISH with other techniques (confocal laser scanning microscopy, microautoradiography, flow cytometry, immunofluorescence, microsensors, nucleic, peptides etc) (06L)
	Student activity: A visit will be organized to an institute in order to study the use of advanced techniques in research. Students will be encouraged to present the use of an advanced technique published in a research paper for detection, separation and identification of compounds.

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SMSMCB401

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NAME OF THE COURSE	PHARMACEUTICAL MICROBIOLOGY	
CLASS	MSc-II	
COURSE CODE	SMSMCB402	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1.	To summarize the basic principles of Quality assurance, Quality Control and GMP in the pharmaceutical industry.
CO 2.	To explain the design, structure and layout of pharmaceutical premises.
CO 3.	To discuss the principles of personnel management and personnel hygiene and health in the pharmaceutical industry
CO 4	To explain the concept of GCLP.
CO 5	To recognize the importance of sterility in the pharmaceutical industry and methods of sterilization used.
CO 6	To develop an understanding of the Quality assurance in manufacture of sterile products and sterility testing.
CO 7	To explain the importance of HACCP.
CO 8	To describe cosmetic microbiology, antimicrobial preservation efficacy and microbial content testing
CO9	To familiarize with the fundamental processes involved in development of new or more effective and safe drugs
CO10	To highlight the importance of modern analytical techniques and bioinformatics in the process of drug discovery.

COURSE LEARNING OUTCOMES:

CLO 1.	The learner will be able to explain the relationship between Quality assurance, Quality Control and GMP.
CLO 2.	The learner will be able to explain the design, layout and structure of pharmaceutical premises.

CLO 3	The learner will be able to recall the responsibilities of the key personnel in the pharmaceutical industry, the training given and explain the principles of personnel hygiene and health in the industry and justify its significance.
CLO 4	The learner will be able to recall GCLP.
CLO 5	The learner will be able to list the pharmaceutical products that need to be sterile.
CLO 6	The learner will be able to describe, categorize and differentiate between the methods of sterilization used in the pharmaceutical industry.
CLO 7	The learner will be able to explain the Quality assurance in manufacture of sterile products and HACCP.
CLO 8	The learner will be able to explain sterility testing and its importance and apply these skills in testing the sterility of a pharmaceutical product.
CLO 9	The learner will be able to explain antimicrobial preservation efficacy and microbial content testing of cosmetics and apply the same in the practicals.
CLO 10	The learner will be able to devise an SOP
CLO 11	The learner will be able to explain the terms and describe the steps involved in the new drug development
CLO 12	The learner will be able to list various natural resources useful for drug discovery.
CLO 13	The learner will be able to compare traditional methods of drug discovery with that of the modern tools used in high throughput screening.

UNIT 1	Main principles for pharmaceutical products (15 Lectures)
1.1	Quality management in the drug industry (11L) a. Quality assurance b. Good manufacturing practices for pharmaceutical products (GMP) c. Sanitation and hygiene d. Qualification and validation, Complaints e. Product recalls f. Contract production and analysis g. Self-inspection and quality audits h. Personnel i. Training j. Personal hygiene k. Premises l. Equipment m. Materials n. Documentation o. Good practices in production

	p. Good practices in quality control
1.2	GMP and regulations (04L) a. Good manufacturing practice i. EU good manufacturing practice ii. FDA and CFRs iii. Key aspects of GMP compliance iv. Ten rules of GMP v. Risk management b. The role and development of pharmacopoeias c. Importance of inspections in the life cycle of medicines d. Role of the company regulatory affairs department e. CDSCO guidelines
UNIT 2	Premises and personnel management (15 Lectures)
2.1	Premises and contamination control (03L) a. Requirements for a pharmaceutical production facility b. Contamination types and sources, control
2.2	Premises: location, design, structure, layout, services and cleaning. (04L)
2.3	Personnel management (02L)
2.4	Training (03L)
2.5	Personnel: Hygiene and health (03L)
UNIT 3	Sterility in pharmaceutical products and other principles (15 Lectures)
3.1	Quality control and GCLP (03L)
3.2	Sterile products (03L) a. Pharmaceutical products which need to be sterile b. Methods of sterilization- steam sterilization, SIP, dry heat, radiation sterilization, ,gas sterilization and filter sterilization
3.3	Assurance of quality in the manufacture of sterile products (05L) a. Clean rooms b. Sterile products manufacturing area or suite c. Changing rooms d. Air supply e. The sterile manufacturing area- construction, materials and finishes f. Personnel g. In-process control of sterilization processes h. Examination for particulate contamination i. Sterility testing j. Leaks and leak testing k. Pyrogen/endotoxin testing

	l. Parametric release
3.4	Non-sterile manufacture and packaging - Solid dose manufacture (tablets and capsules), Liquids, creams and ointments, packaging (01L)
3.5	HACCP (01L)
3.6	Cosmetics- Definition, Introduction to cosmetics microbiology, Antimicrobial preservation efficacy and microbial content testing (02L)
UNIT 4	Drug designing (15 Lectures)
4.1	Modern Methods of Drug Discovery:important terms
4.2	Natural products for lead identification
4.3	Drug Discovery Tools, Combinatorial Chemistry
4.4	High throughput screening technology
4.5	Rational Drug Designing , The role of protein 3D structures in the drug discovery process, Proteomics, Bioinformatics, In silico Modelling, Molecular Modeling, Structure Prediction
4.6	Concept of Pharmacokinetics and Pharmacodynamics Clinical studies

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NAME OF THE COURSE	ADVANCES IN BIOTECHNOLOGY II	
CLASS	MSc-II	
COURSE CODE	SMSMCB403	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1.	To familiarize students with the various categories of biotechnological products used in the area of human health care.
CO 2.	To raise students' awareness of the bioethical concerns linked to applications of biotechnology in areas of plant, animal and human health
CO 3.	To educate students about basic concepts IPR regarding biotechnology inventions and research and the requirements for patent filing.
CO 4	To provide students with the fundamental knowledge of concepts related to entrepreneurship and funding resources.
CO 5	To introduce students to the biofuels from microbial sources and the associated technology required for production and the challenges involved.
CO 6	To introduce students to the fundamental concepts associated with manipulating biomolecules and their applications

COURSE LEARNING OUTCOMES:

CLO 1.	The learner will be able to describe the applications of biotherapeutics in human health care.
CLO 2.	The learner will be able to analyze ethical issues associated with biotechnology and recognize risks associated with inadequately researched biotechnology
CLO 3	The learner will be able to outline the types of Intellectual Property Rights (IPR) principles, specifically as initiatives to safeguard various intellectual works.
CLO 4	The learner will be able to recognise the basic requirements of entrepreneurial ventures and the associated opportunities
CLO 5	The learner will be able to outline microbial biofuel production strategies and recognize the associated economical and environmental challenges involved in production.

CLO 6	The learner will be able to understand the fundamental processes involved in manipulating functional biomolecules

UNIT 1	Pharmaceutical Biotechnology and bioethics (15 Lectures)
1.1	Therapeutics a. Proteins therapeutics – Cytokines, Interferons, hormones (Insulin, Human Growth Hormone) Recombinant blood products, Enzymes, monoclonal and recombinant antibodies (04L) b. Nucleic acids -antisense RNA, Ribozymes, Chimeric RNA- DNA molecules, Aptamers, Interfering RNAs (02L) c. Vaccines- Subunit, vaccines, peptide vaccines, DNA vaccines, attenuated vaccines vector vaccines (02L) d. Chimeric antigen receptor T cells in cancer therapy (01L)
1.2	Bioethics a. Principles of ethics, Perceptions of ethical biotechnology, Bioethical concerns - genetically modified organisms, Gene Therapy, Organ Replacement, Antibiotics and Antiviral Agents (03L) b. Bioethics and Interference with the Natural World - Bioethical issues related to Transgenic Crops, Transgenic Animals, Animal Cloning, Genetic Screening in Pregnancy and Abortion, Stem Cell Research, Human Cloning, Eugenics, Selective Breeding, Transgenic Humans and Designer Children (03L)
UNIT 2	Biotechnology and IPR and innovations, startups and Entrepreneurship (15 Lectures)
2.1	Intellectual Property Rights (IPR) and Protection (IPP), Rationale of Patent in Research and Scientific Innovations, Biotechnological Patents (02L)
2.2	Requirements for Patentability- Patentable subject matter, Novelty, Invention in Biotechnological Research, Industrial Applicability (02L)
2.3	Patent Specifications and Basic Component of License Agreement in IP System, Categories of Biotechnological Patents (02L)
2.4	Introduction to entrepreneurship - entrepreneurial opportunity, entrepreneurial planning, commercialization process and strategy, financial management, human resource management, marketing and partnering strategies, collaboration and negotiation skills (05L)
2.5	Funding of entrepreneurship ventures (02L)

2.6	Schemes of DBT and the Department of Industrial Policy and Promotion (01L)
2.7	Government initiatives for startups (01L)
UNIT 3	Microbial biofuels (15 Lectures)
3.1	Types of energy sources - primary and secondary energy sources, biomass and Biomass conversion processes, generations of biofuels and production technologies, advantages of biofuels (05L)
3.2	Bioprospecting of Microorganisms for Biofuel Production (02L)
3.3	Biofuels from algal biomass- algae strain selection, cultivation, harvesting, oil extraction, Integrated algal biofuel production and wastewater treatment, Photosynthetic Production of Ethanol Using Genetically Engineered Cyanobacteria (07L)
3.4	Bioelectricity- Microbial Fuel Cells- Principle, design, substrates and applications (01L)
UNIT 4	Synthetic biology (15 Lectures)
4.1	Manipulation of genes a. Chemical synthesis of oligonucleotides using Phosphoramidite method, Applications of synthesized oligonucleotides, gene assembly, genome synthesis (02L) b. Directed Mutagenesis: Oligonucleotide directed mutagenesis with M13 and plasmid DNA, PCR amplified oligonucleotide directed mutagenesis, Random mutagenesis with degenerate oligonucleotide primer and nucleotide analogues, Error-prone PCR (02L)
4.2	Manipulation of Gene Expression a. In Prokaryotes- Use of strong and regulatable promoters, Fusion proteins, unidirectional tandem gene arrays, DNA integration into host chromosome (02L) b. Heterologous protein production in eukaryotes: S*accharomyces cerevisiae*, *Pichia pastoris*, Baculovirus-Insect cell, mammalian cell (03L)
4.3	Protein Engineering - Post translational modifications and improving Improving protein stability, using non natural amino acids, DNA Shuffling, Combinatorial Protein Libraries, Biomaterials Design, Engineered Binding Proteins (04L)
4.4	Applications of synthetic biology (02L)

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NAME OF THE COURSE	ENVIRONMENTAL MICROBIOLOGY-II	
CLASS	MSc-II	
COURSE CODE	SMSMCB404	
NUMBER OF CREDITS	4	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	50	50
PASSING MARKS	20	20

COURSE OBJECTIVES:

CO 1	To explore extremophiles, their diversity, and survival strategies in extreme habitats.
CO 2	To examine the applications of extremophilic microorganisms in biotechnology, various industries, and biofuel research.
CO 3	To summarize the role of microorganisms in sulfur and iron cycles.
CO 4	To discuss the consequences of biogeochemical cycles, including biocorrosion, concrete corrosion, and acid mine drainage.
CO 5	To explain the significance and mechanism of biofilm formation in nature, along with methods for controlling it.
CO 6	To describe the process of environmental monitoring and the role of microorganisms in it.
CO 7	To elucidate the process of eutrophication in aquatic systems, methods for detecting fecal pollution of water, and oil spills.
CO 8	To categorize methods of bioremediation for treating waste containing chemicals, metals, gasses, and oil.
CO 9	To develop an understanding of methods for managing solid waste such as kitchen waste, plastics, and e-waste.

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to describe various extreme habitats on the planet and the life forms thriving in such environments.
CLO 2	The learner will be able to explain the molecular adaptations in extremophilic microorganisms that enable their survival in extreme conditions.
CLO 3	The learner will be able to justify the importance of extremophilic microorganisms and their enzymes and other products in various industries and biotechnological applications.

CLO 4	The learner will be able to describe the role of microorganisms in the sulfur and iron cycles, elucidating their contributions to biogeochemical processes.
CLO 5	The learner will be able to explain the consequences of biogeochemical cycles and the role of microorganisms in processes such as biocorrosion, acid mine drainage, and bioleaching.
CLO 6	The learner will be able to recall the mechanism of biofilm formation and discuss methods for controlling biofilm growth.
CLO 7	The learner will be able to explain various processes for monitoring environmental pollution and apply the knowledge to detect pollution, including metals, BOD, COD, and fecal *E.coli* contamination of rivers and lakes.
CLO 8	The learner will be able to describe eutrophication and oil spills as serious problems in aquatic systems, along with methods for detecting fecal contamination of water and microbial source tracking.
CLO 9	The learner will be able to explain, categorize, and compare various methods of bioremediation and discuss the use of microorganisms in the treatment of waste.
CLO 10	The learner will be able to justify the importance of solid waste management in maintaining environmental sustainability and public health.

UNIT 1	Extremophiles (15 Lectures)
1.1	Extreme environments and Extremophiles a. Introduction, extremophiles and polyextremophiles b. Extreme environments i. Hydrothermal systems ii. Polar environments iii. Acid environments iv. Hypersaline and alkaline environments v. Deep-subsurface environments vi. Extraterrestrial environment c. Molecular adaptations and survival strategies in Thermophiles, Psychrophiles, Halophiles, Alkaliphiles, Acidophiles, Piezophiles, Xerotolerant and Radiation resistant organisms d. Sampling from extreme environments and enrichment culturing methods for isolation of extremophiles e. Culturing of extremophiles in fermenters f. Applications of extremophiles i. Applications of extremozymes in industry and biotechnology ii. Extremophiles in biofuel synthesis. iii. Carotenoids iv. Biopolymers v. Compatible solutes

	vi. Medical applications
UNIT 2	Impact of Microorganisms on Environment (15 Lectures)
2.1	Biogeochemical cycling (03L) a. Sulfur cycle b. Iron cycle
2.2	Consequences of Biogeochemical cycles (03L) a. Microbially influenced corrosion (Biocorrosion) i. Metal corrosion ii. Microbially induced concrete corrosion b. Acid mine drainage and metal recovery, Uranium leaching
2.3	Biofilms (08L) a. The biofilm formation process: attachment, maturation and dispersion to planktonic mode of growth. b. Communication in biofilms: Quorum sensing & other chemical signaling molecules c. Biofilm-related diseases: Cystic fibrosis, Dental plaque, Wounds, Urinary infection, Prosthetic joint infection, Cardiac valve infection. d. Biofilm resistance to antibiotics & host immune system: Limited antibiotic penetration, Horizontal gene transfer, Reduced growth rate, Persister cells, Efflux pumps, EPS matrix protection e. Beneficial biofilms: Application of biofilms in wastewater treatment and microbial leaching of ores. f. Biofouling: health risks and financial losses in the medical, marine and industrial fields. g. Biofilm eradication :Methods and commonly used biocides such as surfactants, enzymes, triclosan, chlorhexidine, quaternary ammonium compounds**.**
2.4	Climate change and Combating Greenhouse effect using microbes (01L)
UNIT 3	Environmental Monitoring and Water Pollution (15 Lectures)
3.1	Environmental monitoring (05L) a. Definition of pollution b. Sampling- Land sampling, water sampling and air sampling c. Physical, Chemical and Biological analysis d. Determination of biodegradable organic material e. Monitoring pollution f. Bioindicators g. Biomarkers- Biochemical and genetic indicators h. Toxicity testing using biological material- toxicity testing using plants and algae, Luminescent organisms, Ames test, molecular biology biomarkers i. Biosensors

3.2	Pollution of Aquatic Systems (10L) a. Nature of pollution i. The concept of the self-purification of water as basis for the understanding of pollution ii. Kinds of pollutants iii. Pollution by eutrophication- Algal blooms iv. Biological Indicators of Pollution by Eutrophication b. Pollution of Water with Reference to Human Health i. Microbiological examination of water for fecal contamination- Principle of Indicator organisms, Procedure for the determination of fecal contamination, Methods used in the enumeration of indicator organisms in water, Standard water analysis, Total Maximum Daily Loads and Microbial source tracking in water pollution, Microbial source tracking, Methodologies employed in MST- Molecular, biochemical and chemical methods, Choice of the MST method to use c. Pollution by petroleum in oceans and seas i. Oil spills- Behavior of Oil in an Oil Spill
UNIT 4	Bioremediation and Waste treatment (15 Lectures)
4.1	Bioremediation (12L) a. Introduction, Synthetic compounds, petrochemical compounds, Inorganic wastes b. Bioremediation strategies- Indigenous microorganisms, stimulation of indigenous microbial growth, Bioaugmentation, use of genetically manipulated organisms, Planned release of genetically engineered microorganisms in the environment and concerns regarding the same. c. Bioremediation techniques in situ- Bioremediation on land, land farming, Bioventing, Biosparging, stimulation d. Bioremediation techniques ex-situ- Composting, biopile process, use of bioreactors, novel technologies e. Bioremediation of metals- Biosorption, extracellular precipitation f. Bioremediation of gases g. Bioremediation of textile dyes/effluent- types of textile dyes, bioremediation methods, role of bacteria, fungi, yeasts, molds, microbial consortia and biofilms, mechanisms behind bioremediation of textile dyes- (biosorption, biodegradation, mineralization, bioaccumulation), factors affecting degradation, immobilization of bacterial cells, Optimization procedures- Response surface methodology, Environmental concerns- effects on humans and water bodies h. Bioremediation of oil spills

4.2	Solid waste management (03L) a. Solid waste management by reduction, collection, recycling and incineration b. Treatment/degradation of kitchen waste, composting, vermicomposting, waste-to-energy technique, landfilling c. Treatment of slaughterhouse/abattoir waste d. Case studies of implementation of ideas- Entrepreneurs e. Management of biomedical waste, plastic and e-waste

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Additional reading

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Practicals- Semester 4 SMSMCBP4

NAME OF THE COURSE	DISSERTATION SUBMISSION AND PRESENTATION	
CLASS	MSc-II	
COURSE CODE	SMSMCBP401	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	-	50
PASSING MARKS	-	20

COURSE OBJECTIVES

CO 1	To conduct research according to the proposed research plan.
CO 2	To maintain a journal for entry of results obtained.
CO 3	To outsource samples for advanced instrumental analysis.
CO 4	To outsource identification of microorganisms isolated during the research work.
CO 5	To explain and discuss the results obtained.
CO 6	To prepare a manuscript on the research conducted using ICT.
CO 7	To present the research work.

COURSE LEARNING OUTCOMES

CLO 1	The learner will be able to purchase chemicals of appropriate grade, standardize and carry out experiments according to the plan of work. Understand the modalities of preparing media, reagents etc, their sterilization and discard.
CLO 2	The learner will be able to maintain a journal for entry of raw data, discuss

	the data with the guide regularly and then proceed further with the research work.
CLO 3	The learner will be able to submit samples for GC-MS, SEM, TEM, FTIR to institutes that can carry them out for various types of information that can help in gaining more knowledge about the research work.
CLO 4	The learner will be able to give a promising microorganism isolated during the research work for identification using 16S or 18S analysis if possible
CLO 5	The learner will be able to describe in detail citing cross references the results obtained with appropriate discussion.
CLO 6	The learner will be able to prepare a thesis in a specified format suggested by the department with appropriate in text references, figures, tables, etc using ICT.
CLO 7	The learner will be able to present the research in the form of a poster for assessment by an external examiner. Also write a research paper and try to publish it in a scientific journal.

Sr. No	Name of the experiment
1	Experimental work as per plan of work and methodology
2	Interpretation, discussion and conclusion of research work.
3	Preparation of manuscript- dissertation using ICT
4	Preparation of poster, its presentation and defense.

NAME OF THE COURSE	PHARMACEUTICAL MICROBIOLOGY PRACTICAL	
CLASS	MSc-II	
COURSE CODE	SMSMCBP402	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	-	50
PASSING MARKS	-	20

COURSE OBJECTIVES

CO 1	To familiarize with validation process in pharma industry
CO 2	To outline the application of regulations and standards related to manufacture of medicines and other healthcare products
CO 3	To impart hands-on experience of the quality control process and regulations for cosmetic products
CO 4	To equip learners with practical skills in assessing sterility of pharmaceuticals as per prevailing standards
CO 5	To develop expertise in writing SOPs

COURSE LEARNING OUTCOMES

CLO 1	The learner will be able to judge the quality of a cosmetic product by determining its Microbial load.
CLO 2	The learner will be able to carry out quality assessment by testing the sterility of injectables as per Pharmacopoeia.
CLO 3	The learner will be able to prepare a report on Endotoxin and pyrogen testing in pharmaceutical products as well as Validation in the Pharmaceutical industry.
CLO 4	The learner will be able to critically read and analyze the Standard Operating Procedures (SOPs) in the pharmaceutical industry and devise SOPs for steam sterilization, UV spectrophotometric analysis and other equipment and processes.
CLO 5	The learner will be able to test and comment about the antimicrobial effect of preservatives added to the cosmetic / pharmaceutical preparations.

Sr. No	Name of the experiment
1	**Student activity-** a. Critically read Standard Operating Procedures (SOPs) from Quality in the Manufacture of Medicines and other healthcare products , John Sharp and b. Write a SOP on your own on any basic microbiological/analytical process like steam sterilization, UV spectrophotometric analysis etc.
2	A detailed report to be written on Validation in the Pharmaceutical industry.
3	Sterility testing of a pharmaceutical product and reporting (as per Pharmacopeia).
4	A detailed report to be written on Endotoxin and pyrogen testing in pharmaceutical products.
5	Determination of Microbial load in a cosmetic product.
6	Efficacy testing of preservatives.

NAME OF THE COURSE	ADVANCES IN BIOTECHNOLOGY-II PRACTICAL	
CLASS	MSc-II	
COURSE CODE	SMSMCBP403	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	-	50
PASSING MARKS	-	20

COURSE OBJECTIVES

CO 1	To understand the criteria for patentability and the process of obtaining patents.
CO 2	To understand the fundamental principles of ethics and identify the key ethical concerns related to biotechnology
CO 3	To inculcate an entrepreneurial mindset in students
CO 4	To screen potential algal strains as potential sources of biofuel based on lipid content staining and lipid extraction.
CO 5	To expose students to industrial applications of biotechnology.
CO 6	To update students with case studies of successful entrepreneurs in the field of biotechnology.
CO 7	To update students with artificial intelligence applications in the field of biotechnology.

COURSE LEARNING OUTCOMES

CLO 1	The learner will be able to understand the process of obtaining patents.
CLO 2	The learner will be able to understand the importance of intellectual property rights in protecting innovations and managing IP in biotechnology
CLO 3	The learner will be able to explore areas in biotechnology for setting up a business.
CLO 4	The learner will be able to screen algal strains for biofuel production by performing Nile red staining and estimating the lipid content.

CLO 5	The learner will be able to connect theoretical information with implementation in an industrial context.
CLO 6	The learner will be able to analyze how individuals were able to translate the theoretical information into commercially viable case applications in the field of biotechnology.
CLO 7	The learner will be able to cite examples of the recent developments in the rapidly evolving field of artificial intelligence in the area of biotechnology.

Sr. No	Name of the experiment
1	Assignments on IPR-Case studies on different patents granted
2	Report on International Bioethics survey on specific concerned issues
3	1 page description of student's business idea
4	Lipid staining of microalgae - Nile red / Sudan black B staining
5	Extraction of lipids from microalgae
6	Visit to Pharmaceutical industry
7	Case study- The Successful Entrepreneur
8	AI and Biotechnology- student seminars

NAME OF THE COURSE	ENVIRONMENTAL MICROBIOLOGY-II PRACTICAL	
CLASS	MSc-II	
COURSE CODE	SMSMCBP404	
NUMBER OF CREDITS	2	
NUMBER OF LECTURES PER WEEK	4	
TOTAL NUMBER OF LECTURES PER SEMESTER	60	
EVALUATION METHOD	INTERNAL ASSESSMENT	SEMESTER END EXAMINATION
TOTAL MARKS	-	50
PASSING MARKS	-	20

COURSE OBJECTIVES

CO 1	To perform the enrichment and isolation of thermophiles and halophiles from soil/mangrove/compost/sea and to detect the presence of enzymes such as amylase, lipase, cellulase and xylanase in the isolates
CO 2	To enrich and isolate alkaliphiles from soil or mangrove soil and study their cultural characteristics
CO 3	To develop and examine microbial biofilms using crystal violet assay
CO 4	To estimate the chromium, to determine the pH, BOD, COD and human fecal pollution and antibiotic resistance in rivers and lakes of Mumbai in order to detect water pollution
CO 5	To analyze packaged/bottled drinking water as per BIS standards for the presence of coliforms and *E.coli*.
CO 6	To write detailed reports on carbon credit and hazardous waste management in order to sensitize and make students aware of the environmental issues
CO 7	To arrange for a visit to Maharashtra Pollution Control Board, Central/Regional Laboratory or Common Effluent Treatment Plant, Kopar Khairane Navi Mumbai to show the treatment of domestic and industrial waste and sludge treatment.

COURSE LEARNING OUTCOMES:

CLO 1	The learner will be able to enrich and isolate thermophiles and halophiles and detect the presence of enzymes in the isolates

CLO 2	The learner will be able to enrich and isolate alkaliphiles from soil or mangroves and study their cultural characteristics
CLO 3	The learner will be able to analyze biofilms using crystal violet assay
CLO 4	The learner will be able to judge the pollution in river and lake water by calculating the chromium content and determining the pH, BOD, COD, and fecal pollution
CLO 5	The learner will be able to judge and evaluate the quality of packaged bottled drinking water by detecting the presence of coliforms and *E.coli* as per the BIS standards
CLO 6	The learner will be able to write detailed reports on carbon credit and hazardous waste management
CLO 7	The learner will be able to correlate and recall the treatment process observed at the Common Effluent Treatment Plant or Pollution Control Board

Sr. No	Name of the experiment
1	Enrichment and isolation of thermophiles from soil/ mangrove soil/ compost/ any other environment. To determine whether the isolated bacteria are obligate thermophiles. Detection of amylase, lipase, cellulase and xylanase enzymes.
2	Enrichment and isolation of halophiles from sea/ mangrove soil. Detection of amylase, lipase, cellulase and xylanase enzymes.
3	Isolation and characterization of alkaliphiles from soil/ mangrove soil.
4	Visualization and study of biofilms using crystal violet assay.
5	Detection and monitoring of water pollution in rivers and lakes of Mumbai (any one river and lake from the following- Mithi river, Oshiwara river, Poisar river, Dahisar river, Tulsi lake, Vihar lake)- a. Estimation of Chromium b. Determination of pH, BOD and COD c. Detection of human fecal pollution (*E.coli and fecal Streptococci*) d. Determination of Antibiotic resistance in *E.coli* isolates
6	**Student activity-** Detection of coliforms and *E.coli* from packaged/bottled drinking water as per BIS standards.
7	A report to be written on carbon credit.
8	Visit to Maharashtra Pollution Control Board, Central/Regional laboratory **OR** Common Effluent Treatment Plant, Kopar Khairane, Navi Mumbai to learn treatment of domestic and industrial waste and sludge treatment. A report to be written on this in the journal.
9	A detailed report to be written on hazardous waste management. (Minimum 5 references to be included. **Reference no 28** is compulsory.)

ASSESSMENT DETAILS:

Internal assessment (50 marks)

Part 1: Test (25 marks)

- Students will be given a test from any of the units for 25 marks. The duration of the test will be 50 minutes. (Multiple choice questions- 10 marks, Answer in one word/sentence - 05 marks, Subjective questions - HWY, Justify, Differentiate between, Diagrammatically etc. - 10 marks).

Part 2: Test (25 marks)

- Students will be given a test from any of the units for 25 marks. The duration of the test will be 50 minutes. (Multiple choice questions- 10 marks, Answer in one word/sentence - 05 marks, Subjective questions - HWY, Justify, Differentiate between, Diagrammatically etc. - 10 marks).

Part 3: Activity (25 marks)

- An activity for 25 marks would be given in the form of a creative learning process. (Powerpoint presentation, Viva, Report and Viva, Preparation of study material and viva on the same, any other activity)

The best two marks will be considered for the Internal assessment total out of 50

Semester end examination (50 marks)

If Online

- The question paper shall consist of two parts - Part A and B. Part A will consist of 30 marks MCQs (including both 1 and 2 mark MCQs) whereas Part B will consist of 20 marks subjective having 5 mark questions **OR** The question paper will be a 50 mark paper having MCQs of 1 and 2 marks.

If Offline

- The duration of the paper will be two hours.
- There shall be five compulsory questions.
- Q1-4 shall correspond to the four units. Q1-4 shall contain an internal choice (Q1A or Q1A and Q1B or Q1B and so on). Q1-4 shall carry a maximum of 10 marks.
- Q5 shall be from Units 1 to 4. Q5 shall carry a maximum of 10 marks (attempt any 2 of 4)

Practical Assessment

- The duration of the practical exam will be three days.
- There will be 50 marks practical per paper.
- To appear in the practical exam, students must bring a properly certified journal.