KRISHNA VISHWA VIDYAPEETH (DEEMED TO BE UNIVERSITY), KARAD

Revised Syllabus (CBCS) For

Master of Science Microbiology/Biotechnology/Pharmaceutical Microbiology/Environmental Sciences

(Horizontal Mobility)

To be implemented from 2022-23

(In a Phase Manner)

M. Sc. Microbiology, Biotechnology & Pharmaceutical Microbiology

(First year Horizontal Mobility)

Prologue

The Faculty Allied Sciences (Then Krishna Institute of Biotechnology and Bioinformatics) was established in 2007 with Two Post graduate courses Microbiology, Biotechnology. Currently Five faculty members are engaged in Academic functions.

The seemingly overwhelming and ever expanding state of knowledge about microorganisms, their genetic material, Molecular Biology and Recombinant DNA Technology increases the scope of Biotechnology. This newly emerging branch of science offers something for everyone and it cultivates informed citizens who can make perceptive decisions on important events. Many discoveries made by Microbiologists and Biotechnologists have spawned new fields of science such as molecular Biology, Genetics, Enzyme Technology, Fermentation Technology, Bioengineering, Genetic Engineering, Immunology etc. Many studies have been made using Science and Biotechnology to understand the principles that govern life.

New developments are occurring constantly in these areas and thus Biotechnologies have become the mainstays of many technologies. This has necessitated the formation of the Biotechnology courses for the development of competent, smart and dynamic Biotechnologists that are required in Academic Institutes, Research organizations, Professional organizations and in various industries such as Pharmaceutical Industries, Enzyme Industries, Food and Dairy Industries, Wine and Alcohol Industries, Agro based Industries. **The Choice –Based Credits System(CBCS)** provides for a framework within which there is flexibility in the design of courses and their content ,simultaneously also providing the students a choice of the courses he/she wishes to study. The courses are assigned credits based on teaching hours, which in turn is linked to courses content and structure

The rapid pace of discovery and their application dictates a somewhat selective inclusion of theory paper / topics and practical and proper training of the students. The course is designed in such a way that students remain constantly busy with their studies through the Lecture and Practical periods, Seminar periods, Home assignments, Mid – term examinations (Periodic tests), Preliminary or term end examinations and also gets exposure to outside world through visits to Research Laboratories / Science Institutes / Industries of Microbiological /Biotechnological interest. The course also makes the provision for training in research through the research project (during one or two semesters) and / or Industrial training in organization of Microbiological interest. (During one semester / one summer vacation.)

Over all it is aimed to design **Two year post graduate (M.Sc.) course in Microbiology** with a balanced coverage of traditional and “cutting edge technology”

along with the necessary courses (Communication skills, Biostatistics, Computer science, Scientific writing and Presentation, Research training / Industrial training) as per the UGC guidelines and produce competent Biotechnologists to meet the demand of Industries, Research organizations and Academic Institutes in the country and abroad.

Process of Curriculum Design

The Choice-Based Credit System (CBCS) provides a framework within which there is flexibility in the design of courses and their content. At the same time it also provides the student a choice of the courses he/she wishes to study. The courses are assigned credits based on teaching hours, which in turn is linked to course content and structure.

Curriculum Designing Process

Following procedure was adopted for curriculum designing: For curriculum development first need analysis was done and then based on need analysis draft syllabus was prepared in the Departmental Curriculum Committee meeting and it was subsequently discussed in College Curriculum Committee meeting were all faculty members participated in the discussion and debated over the draft syllabus. The draft syllabus approved in the College Curriculum Committee meeting was sent to BOS were given by external subject experts were considered and incorporated in the final draft. The draft syllabus finalized in BOS was sent to Academic Council for it's approval.

When revising the syllabi for the courses, the courses to be implemented as well as the content of each course was extensively discussed and debated on, feedback obtained from students, faculty, subject experts from academic institutes, industry experts, alumni were extensively discussed and debated in the meetings of curriculum committees and BOS and the inputs were considered. Thus for the development of syllabus contributions came from external subject experts, faculty members, feedback obtained from students, alumni, external experts and members of industry.

M.Sc. Microbiology program objectives

After completion, the students are expected to understand the:

(a) Basic and applied aspects of microbial diversity and systematic taxonomy, Physiology, biochemistry and applications of basic aspects of microbial diversity.

(b) Principles, working and application of bioinstruments used in isolation and identification of microbes and structural determination of biomolecules,

(d) characteristics and significance of archea, algae, fungi, viruses,

(e) Impact of various groups of microbes on earth atmosphere, human, plant and animal health and technology development,

(f) structure, properties, pathways, significance and applications of microbial biomolecules,

(g) basic and applied aspects of Genetic makeup of bacteria, algae, fungi and viruses,

(h) causes, mechanisms and consequences of defect in gene/genome of microorganisms, and

(i) basic concepts of microbial enzymes, enzyme kinetics, regulation of enzyme activity, industrial applications of enzymes, enzyme function in non-aqueous environment.

Structure of M.Sc. program in Microbiology

M.Sc. Microbiology program is of two years duration and is conducted in four semesters. As recommended by UGC university has adopted a outcome-based education approach. The various courses of the program are designed to include classroom teaching, laboratory work, project work, seminars, home assignments, industrial visit etc.

Program Educational Objectives:

The objectives of the **M. Sc. Programme in Microbiology** is:

(i) To equip the students with the basic and applied knowledge of molecular mechanisms of cellular processes in living systems including microbes, plants, animals and humans.

(ii) To provide the students with laboratory (experimental) training so that they are competent enough to work in industries.

(iii) To provide the students with the current updates in the areas of Analytical Techniques , Industrial Fermentations, Environmental Biotechnology.

(iv) To train students with research work methodology through small project work.

(v) To generate competent skilled human resource for industries and research organization.

Eligibility

Candidates must have passed B.Sc. With minimum 50% marks with Biotechnology/ Microbiology/ Industrial Microbiology/ Zoology/Botany as principal subject or with Biochemistry/ Microbiology/ Botany/ Zoology as subsidiary subjects at B.Sc. II level

Course fees

As shown in Admission Broacher of respective year (Subject to change as and when required)

Duration

The duration of M.Sc. (Microbiology) degree program shall consist of two academic years divided in to four semesters. Each Semester consist of 90 working days. Each theory and practical course must be completed in 60 lectures/Practical periods, respectively of 60 min duration.

Medium of instruction

The medium of instruction and examination for each course shall be English.

Credit to contact hour

One credit is equivalent to 15 periods of 60 minutes each for theory course lecture. While credit weightage for self-learning based on e-content shall be 50% or less than that for lectures.

Attendance

The student enrolled for M.Sc. Microbiology must have 75% attendance in each course in order to appear for term end examinations, otherwise the candidate may not be allowed to appear for term end examination as per ordinance.

1. The entire M.Sc. course in Microbiology shall be covered in 16 [sixteen] theory papers, 7 [seven] practical course [semester I, II, III] and a project work / Industrial training [in lieu of one practical courses of semester IV] each semester there shall be four theory papers each carrying 100 marks and for first three semesters viz. semester I, II and III, there shall be two practical courses each practical course shall carry 100 marks. However, for semester IV there shall be a research project work / Industrial training of 100 [one hundred] marks in lieu of one practical course in addition to four-theory paper and one practical course.

Semester I: Four theory papers and two practical courses.

Semester II: Four theory papers and two practical courses.

Semester III: Four theory papers and two practical courses.

Semester IV: Four-theory papers. One practical course and a project work / Industrial training practical course for every student.

2] Each theory paper will be covered in four lectures of 60 minuteseach per week.

Practical course shall be covered in 04 practical turns of 04 clock hours practical periods per week.

3] A practical batch shall be of 12 [twelve] to 15 [fifteen] students.

4] For university practical examination the duration should be as shown below,

For every semester there shall be two / three days practical examination for not less than 5 ½ hours.

5] Each candidate must produce a certificate from the Head of the Department in his/her college / Institute / University stating that he/she has completed, in a satisfactory manner, a practical course on the lines laid down from time to time by Academic Council on the recommendations of Board of studies and that the laboratory journal has been properly maintained. Every candidate must have recorded his/her observation in the laboratory journal and a written report on each exercise performed. Every journal is to be checked and signed periodically by a member of teaching staff and certified by the Head Of the Department at the end of each semester. Candidates are to produce their journal at the time of practical examination.

6] There shall be one compulsory seminar of minimum 15 min. delivery per paper per semester for each student and there shall be two marks for each seminar in Internal evaluation.

During semester I & II students shall have to undertake an academic tour to visit a minimum one place of academic interests like Academic Institute/ Research Institution / R&D Department/Industry. The student should submit the report of their visit at the time of practical examination. The report should be duly certified by the Head of the Department of Microbiology, Biotechnology.

7] During semester Student is to undertake a research project [as part of the semester IV] which is to be started in the beginning of semester III so as to give enough time for duly completion of project. In the project student is to study research methodology Information collection (reference work) selection of topic, outline of the work, thinking and planning, project report writing in the form of dissertation or small Project Report and the submission of the project report [Introduction, Aims and objectives, Material and method, Results and Discussions, summary, Conclusions and Bibliography] For the research project work out of one hundred marks, fifty marks shall be given by university examiners though assessment of Project Report at the time of semester IV practical examination. The remaining fifty marks shall be given by the Committee for Internal Evaluation of Projects (CIEP) as an internal evaluation. CIEP is to be constituted by the Principal (and which shall be consisting of HOD, Guide / Teacher in - charge and at least one other faculty members). The method and process of Internal evaluation is to be worked out by the CIEP.

**1) The Institute or guide of student should locate the industry and depute the student in the industry for the period of one month

2) Student should complete its industrial training cum industrial project in the vacation period after semester II

3) Student should study microbiological and / or biotechnological aspects in industry and submit its report in the form of dissertation or small Project Report duly signed by industry authority, concerned guide and Head of the Department of Microbiology, Biotechnology.

M.Sc. Microbiology/Biotechnology/Pharmaceutical Microbiology/Environmental Sciences

Part I, Semester I (Horizontal Mobility)

M.Sc. Part I, Semester I (Horizontal Mobility) (w.e.f. 2022-2023)													
	Sr. No	**Course Code**	**Course Title**	**Teaching Hours/ Week**			**Marks**						**Credits**
							Internal		**External**		**Total**		
				T	**P**	**Total**	**T**	**P**	**T**	**P**			
	CGPA Theory Courses												
CGPA	1	PG HM – T101 **CC**	Foundation of Biosciences and Biodiversity	2	-	2	10	-	40	-	50	2	
	2	PG HM – T102 **CC**	Foundation of Physics, Biophysics and Chemistry for Biologists	2	-	2	10	-	40	-	50	2	
	3	PG HM – T103 **CC**	Foundation of Bioinstrumentation	2	-	2	10	-	40	-	50	2	
	4	PG HM – T104 **CCS**	Medical Microbiology & Immunology I	2	-	2	10	-	40	-	50	2	
	5	PG HM – T105 E1 **DSE**	Water& Wastewater Treatment	2	-	2	10	-	40	-	50	2	
	6	PG HM – T106 E2 **DSE**	Fundamentals of Environmental Science										
	CGPA Practical Courses												
CGPA	7	PG HM – P101 **CC**	Practicals related to the theory paper - Foundation of Biosciences and Biodiversity	-	4	4	-	10	-	40	50	2	
	8	PG HM – P102 **CC**	Practicals related to the theory paper - Foundation of Physics, Biophysics and Chemistry for Biologists	-	4	4	-	10	-	40	50	2	
	9	PG HM – P103 **CC**	Practicals related to the theory paper - Foundation of Bioinstrumentation	-	4	4	-	10	-	40	50	2	
	10	PG HM – P104 **CCS**	Practicals related to the theory paper - Medical Microbiology & Immunology I	-	4	4	-	10	-	40	50	2	

	11	PG HM – P105 E1 **DSE**	Practicals related to the theory paper - Water& Wastewater Treatment	-	4	4	-	10	-	40	50	2
	12	PG HM – P106 E2 **DSE**	Practicals related to the theory paper - Fundamentals of Environmental Science									
	Total			10	20	**30**	50	50	200	200	**500**	**20**
	Mandatory Non CGPA Courses											
Non-CGPA	13	PG HM – T107 **SECC**	Spoken English	0.5	1	1.5	25	25	-	-	50	1
	14	PG HM – T108 **AECC**	Yoga and Meditation	0.5	1	1.5	25	25	-	-	50	1
	Total			1	2	**3**	50	50	-	-	**100**	**2**

Total Credits for Semester I : 22 (T = Theory: 10, P = Practical : 10, Non-CGPA : 2)
CC : Core Course, CCS : Core Course Specialization, DSE : Discipline Specific Elective
SECC = Skill Enhancement Compulsory Course : 1, AECC = Ability Enhancement Compulsory Course : 1,
Total Credits for Semester I CGPA Course = 20 credits

M.Sc. Microbiology/Biotechnology/Pharmaceutical Microbiology/Environmental Sciences

Part I, Semester II (Horizontal Mobility)

M.Sc. Part I, Semester II (Horizontal Mobility) (w.e.f. 2022-2023)													
	Sr. No	Course Code	Course Title	Teaching Hours/ Week			Marks					Credits
							Internal		External		Total	
				T	P	Total	T	P	T	P		
	CGPA Theory Courses											
CGPA	1	PG HM – T201 **CC**	Foundation of Cell Biology	2	-	2	10	-	40	-	50	2
	2	PG HM – T202 **CC**	Foundation of Biochemistry – Biomolecules & Metabolism	2	-	2	10	-	40	-	50	2
	3	PG HM – T203 **CC**	Foundation of Environmental Pollution and Control	2	-	2	10	-	40	-	50	2
	4	PG HM – T204 **CCS**	Fundamentals of Molecular Bionanotechnology	2	-	2	10	-	40	-	50	2
	5	PG HM – T205 E1 **DSE**	Biostatistics and Bioinformatics	2	-	2	10	-	40	-	50	2
	6	PG HM – T206 E2 **DSE**	Quantitative Biology									
	CGPA Practical Courses											
CGPA	7	PG HM – P201 **CC**	Practicals related to the theory paper - Foundation of Cell Biology	-	4	4	-	10	-	40	50	2
	8	PG HM – P202 **CC**	Practicals related to the theory paper - Foundation of Biochemistry – Biomolecules & Metabolism	-	4	4	-	10	-	40	50	2
	9	PG HM – P203 **CC**	Practicals related to the theory paper - Foundation of Environmental Pollution and Control	-	4	4	-	10	-	40	50	2
	10	PG HM – P204	Practicals related to the theory paper -	-	4	4	-	10	-	40	50	2

		CCS	Fundamentals of Molecular Bionanotechnology									
	11	PG HM – P205 E1 **DSE**	Practicals related to the theory paper - Biostatistics and Bioinformatics	-	4	4	-	10	-	40	50	2
	12	PG HM – P206 E2 **DSE**	Practicals related to the theory paper - Quantitative Biology									
	Total			10	20	**30**	50	50	200	200	**500**	**20**
	Mandatory Non CGPA Courses											
Non-CGPA	13	PG HM – T207 **SECC**	Soft Skill and Personality Development	0.5	1	1.5	25	25	-	-	50	1
	14	PG HM – T208 **AECC**	Human Rights and Human Values	0.5	1	1.5	25	25	-	-	50	1
	Total			1	2	**3**	50	50	-	-	**100**	**2**
Total Credits for Semester II : 22 (T = Theory: 10, P = Practical : 10, Non-CGPA : 2) **CC : Core Course, CCS : Core Course Specialization, DSE : Discipline Specific Elective** **SECC = Skill Enhancement Compulsory Course : 1, AECC = Ability Enhancement Compulsory Course : 1,** **Total Credits for Semester II CGPA Course = 20 credits**												

M. Sc. I Semester I

PG HM – T101 Foundation of Biosciences and Biodiversity

3-Credits-60-h

Unit I	**Introduction to plants, animals & microorganisms. 8-h** ▪ Origin of life ▪ Evolution of living beings ▪ History of evolution ▪ **Theories of organic evolution**- Lamarkism, Darwinism, Modern synthetic theory, Germ plasm theory, Mutation theory, Astrobiology, Neutral theory of evolution, Polymorphism-diversions, near neutral theory of evolution; Introduction to molecular evolution – Mechanism & modern molecular clock ▪ Microbial, plant and animal evolution and methods of determination.
Unit II	**Outline classification of prokaryotes & eukaryotes. 8-h** ▪ Plants, animals & microbes [Bacteria (Bergy's manuals & classification), yeast & molds, algae, protozoa, virus, lichens, mycorrhiza)
Unit III	**Ecology & Ecosystem: 15-h** ▪ Environment—Spheres **A. Fundamentals of ecology:** a. Definition, development, scope. b. Concept, components & functioning of ecosystem: Biosphere as an ecosystem, Ecological processes & life support system, Ecotone. c. Energy fixation (photosynthesis & chemosynthesis), Energy flow through food chains & food web – Photosynthetic microbes, Food sources for planet earth d. Ecological efficiencies & pyramids, trophic levels e. Influence of environmental factors on organisms & their adaptations **B. Population ecology:** a. Factors determining the abundance and distribution. b. Factors leading to the commonness, rarity & vulnerability of extinction of a species. c. Population dynamics – Patterns of survival, age distribution, dispersal & rates of change, attributes of k- selected & r – selected species, population growth. **C. Community ecology** Competition, Exploitation, Mutation, Concept of niche & key stone species, Nutrient cycling & retention – Biogeochemical cycles (C, N, P), Limiting factors & their tolerance, succession, development, climax & stability of ecosystem, ecological and succession models. **D. Quantitative Ecology:** ▪ Sample collection, Processing, Detection & estimation of Microbial population (metagenomics approach), metabolism, indices of diversity, species concept for prokaryotes & eukaryotes.

Unit IV	**1. Microbial, animals and plants interactions : 15-h** **A. Microbe-microbe:** Positive: Symbiosis, Synergism (proto-cooperation), Syntrophism, Mutualism, Protozoa (kappa), Algae – Fungi (lichens) Negative: Predation, Parasitism, Competition, Antagonism (amensalism), Bacteria-Bacteria (Bdellovibrio), Microbe-Virus (Phage) **B. Microbe – plant :** Azo, Rhizo, Azospirillum, Mycorrhiza (plant-fungi), Plant-Virus **C. Microbe- animal :** Bacteria-fish Bioluminescence (*Vibrio-fischeri* squid (Euprimna), Hydrothermal vents (metabolic-interactions-Rifetia-bacteria), Bacteria-aphid (*Buchnera aphidicola*-aphid), Insects-fungi, Ruminant bacteria, Earthworm- Bacteria, Paramecium – Kappa particles **D. Animal-animal :** Fish-Crab (Hermit) **E. Plants-plants** : parasitic plants **F. Animal**-Plant: Gypsy moths (insect) and plant surface ▪ **Ecology of unique microorganisms**: Endolithic microbes from Antarctica, Autotrophs, Bioluminescent bacteria, Magnetotactic bacteria, Extremophiles in toxic environment, Bdellovibrio, Rickettsia & Viruses, Nitrogen fixing bacteria, Bioleaching & bioconversions bacteria, oil prospecting microbes, microbes producing pharmacologically active agents, enzymes, Novel antifouling agents & antibiofilms, Microbial fossils, astrobiologic-forms, Unculturable microorganisms (Molecular approach), Bio-deteriorating forms, anoxygenic and oxygenic forms
Unit V	**Biodiversity: 14-h** ▪ Terrestrial & aquatic biomes. ▪ Climatic and edaphic factors of terrestrial biomes, Heinrich- Waller's biome climate diagram. ▪ Classification of land biomes with their soil, climate & vegetation characteristics, their natural history, wildlife, geography & human influences. ▪ Mountain biome: Replication of latitudinal changes in the altitudes of high mountains. ▪ Terrestrial biomes, Ecosystem diversity, Forest & vegetation types in India. ▪ Challenges & adaptation of life in aquatic biomes (fresh water – still & flowing, marine) ▪ Fresh water biome: (River, streams, lake, ponds) ▪ Marine biomes: (Mangroves, coral, island, kelp forest, salt water marshes, seashore, estuaries) and their natural history. ▪ Wetland – Definition, types, ecological functions & resources.

PG HM – P101: Practicals related to Foundation of Biosciences and Biodiversity

60 hrs.

1	Preparation of media for isolation & cultivation of bacteria, yeasts, molds, algae, protozoa, viruses & phages – Nutrient broth & agar, MacConkey's broth & agar, Standard Plate Count agar (SPC), Martin's Rose Bengal – Aureomycin agar, Glucose yeast extract agar, Glucose yeast extract – Malt extract agar, Sabouraud's agar, BG 11 broth & agar, Protozoa cultivation broth & agar, Bactotryptone agar, For Animal viruses (fertile eggs), for Plant viruses (TMV), (Tobacco plant)	06 hrs.
2	Aseptic techniques & good cell culture practices – ▪ Dilution plate method for cultivation & enumeration of microbes (bacteria, yeasts, algae, molds & phages), viable count method - SPC & MPN. ▪ Streak plate, pour plate, spread plate methods of isolation of bacteria, yeasts, algae, molds & phages. ▪ Slide & cover slip culture method for actinomycetes & molds. ▪ Single cell & spore isolation techniques.	04 hrs.
3	Staining techniques- ▪ Monochrome, Gram, Capsule, Spore, Metachromatic granules, nuclear material (bacteria & yeasts) & Lipid granules. ▪ Motility studies – Hanging drop for bacteria & fungal mounting (slide method)	06 hrs.
4	Isolation, relative abundance and frequency occurrence of bacteria, algae, fungi and protozoa in the natural ecosystem samples and cultural, morphological characterization & identification from air, water, soil and wastes: 1) Bacteria - *Bacillus, Lactobacillus, Akkermancia spp., Micrococcus, Proteus*, *Clostrdium* (potato, thioglycholate broth and candle jar), *Nitrobacter spp.* 2) Fungi – *Aspergillus*, *Fusarium, Mucor, Penicillium , Rhizopus, Saccharomyces spp., Rhodotorula, Candida,* White rot fungi , *Trichoderma spp.* 3) Algae – *Spirulina, Laminaria, Scenedesmus* 4) Protozoa – *Euglena spp., Paramecium spp., Plasmodium spp.* 5) *E. Coli* – Phages & Actinophages 6) Mycorrhyza (VAM fungi) 7) Lichens	12 hrs.
5	Study of unique microorganisms – Endolithic bacteria, Autotrophs, Photobacterium, Magnetobacterium, Bdellovibrio, Azospirillium, Thiobacillus, Extremophiles.	10 hrs
6	Characterization of Bacteria by special tests - a) Biochemical tests - sugar fermentation test, serological test (slide), tube agglutination	06 hrs

	b) Special test – IMViC test, hydrolysis of keratin, starch, fat, casein, urea, cellulose, pectin, lignin, Gelatin, chitin, H_2S production, Amino acid: deamination & decarboxylation tests, FDA hydrolysis.	
7	Preparation of bacterial & yeast protoplast, isolation of lysozyme from natural sources (fractional precipitation method), Cell wall isolation & component studies, chromatography.	04 hrs.
8	Induction of endospore formation in bacteria and ascospores in yeasts.	02 hrs
9	Determination of rate of photosynthesis in aquatic plant & estimation of chlorophyll content from photosynthetic system	02 hrs.
10	Vegetation studies by line, belt & quadract methods	02 hrs
11	Microbial interaction – Study of various interactions like microbes – microbe (different types) microbes – animals: Fish and bioluminacent bacteria	02 hrs.
12	Wetland studies (bird diversity)	02 hrs.
13	Study of mellanoidin degradation & removal of waste colours by using white rot fungi and bacteria	01 hrs.
14	Preservation of microbial cultures by slant, stab & soil culture (spores) techniques and by freeze drying technique	01 hrs.
15	Study of microflora in Winogradsky column	01 hrs.
16	Detection of siderophore production by microorganism (bacteria)	01 hrs.

M. Sc. I Semester I

PG HM – T102 Foundation of Physics, Biophysics and Chemistry for Biologists

3-credits- 60-h

Unit I	**Physics for Biologist: 15-h** ▪ **Fluids:** Pressure, Buoyancy, fluid flow. Viscosity, Surface tension, application to Hydraulics, Microbiology, Biotechnology, Environmental Science, Atmospheric sciences, Aerodynamics. ▪ **Waves and Oscillations:** Reflection, refraction, superposition, resonance, energy transport, absorption, Doppler effect , applications to water waves, acoustics, seismology ▪ **Optics:** Geometrical optics including dispersion, lenses, mirrors, interference, diffraction polarisation, applications to microscopy, imaging vision and crystallography. Fourier optics, Fourier transforms 1D & 2D, Dirac delta function and combination, discrete Fourier transforms and the sampling theorem, convolution, cross and auto correction. Fresnel and Fraunhofer diffraction. Polarized light including production and control of polarization. ▪ **Nuclear Physics:** Atomic nucleus, radioactive decay, half life, ionizing radiation, nuclear fission and fusion, Application to nuclear energy, radiation safety, nucleogenesis, carbon dating – effects of radiation on living tissues, background radiation, radon units for radiation exposure, applications of nuclear technology, nuclear medicine, contaminant tracing, ion beam analysis. ▪ **Thermodynamics** Carnot cycle, refrigerators, heat engine, throttling process, Helmholtz –Gibbs Free energies and phase transformations, heat energy and kinetic theory – heat & temperature internal energy, specific heat, ideal gas equation, kinetic theory interpretation of pressure and temperature. Work, heat and laws of thermodynamics, adiabatic lapse rate, radiant energy
Unit II	**Biophysics for Biologist: (Medical instruments) 5-h** Thermoregulation: Thermometric properties and types of thermometers. (Clinical thermocouple, bimetallic, platinum resistance, thermistors, thermometers), Body temperature and its regulation.
Unit III	**Biophysical Techniques : 15-h** ▪ Infra red spectroscopy ▪ Raman spectroscopy ▪ X ray diffraction analysis and crystallography ▪ Electron spin and Nuclear Magnetic Resonance (NMR)

	▪ Electron sprays M. S. analysis of biomolecule ▪ CD/ ORD Plasma emission spectroscopy ▪ Electron microscopy SEM, TEM, STM and atomic force microscopy.
Unit IV	**Radioisotopic/Tracer Techniques : 10-h** ▪ Radioisotopes, Half life and units of radioactivity, methods of detection and measurement of radioactivity (α, β and γ radiation) Geiger – Muller counters, Scintillation counters (Liquid and Solid), Autoradiography, salient features of scintillation counting. Radiation dosimetry, Cerenkov radiation, Principles and applications of tracer techniques in biology, Isotope Dilution Assay (RIA),Molecular imaging of radioactive material, radiomaterial safety guidelines
Unit V	**Chemistry for biologist: 10-h** ▪ Stoichiometry, Gibbs energy, chemical potential, chemical equilibrium, acid based reaction, solubility product, solubility of gases in water, the carbonate system, saturated and unsaturated hydrocarbons, radionuclides, chemical bonding, chemical reactions and equations, organic functional groups, classes of organic compounds, free radical reactions, catalytic processes.
Unit VI	**Electrochemical Techniques: 5-h** ▪ Electrochemical cell, Potentiometery & Voltametery, half cell, reaction, reduction potential, electrochemical series, Thermo dynamic potential function from cell potential measurement, Liquid junction potential, Huckel theory, overvoltage, overpotential ▪ Principle & applications of ion selective & gas electrodes, pH, oxygen electrodes & redox couples. ▪ Principle, apparatus, functioning & applications of nanometery.

PG HM – P102: Practicals related to foundation of Physics, Biophysics and Chemistry for Biologists

60 hrs.

1	Preparation of solutions - molecular weight, equivalent weight, atomic weight, normality, molarity, molality, normal solution, molar solution, % solution, PPM solution, w/w, v/v, w/v solutions, physiological saline required in life sciences practical work. Preparation of buffers - citrate, acetate, carbonate, bicarbonate, mixed, tris, borate, barbitone buffers	04 hrs.
2	Determination of E 24 index of biosurface active agents and bioimusifiers obtained from natural sources/microorganisms	04 hrs.
3	Study of fluid flow management using peristaltic pump	02 hrs.
4	XRD study of nanoparticles produced by microbial isolates from natural sources. (Demo)	02 hrs.
5	a) Calculation of half-life of isotopes in biological materials b) Determination of age of material on the basis of carbon data (Fossils, existing plants etc.)	02 hrs
6	Adiabatic lapse rate determination in the given data	02 hrs
7	Determination of viscosity of fluid like fermentation media.	04 hrs.
8	Determination of breakdown products using NMR, SEM, TEM, FTIM of used carbon source by microbial activity (interpretation of results)	02 hrs
9	Determination of halides by potentiometer	04 hrs.
10	Generation of electricity by using microorganisms - construction of biocell.	02 hrs
11	Construction of ion sensitive probes/ electrodes	04 hrs.
12	Determination of radioactivity- detection of particles in the given samples by GM counter	02 hrs.
13	To determine enthalpy and entropy change of a given reaction.	04 hrs.
14	Construction of cells and batteries, voltmeter and ammeter for detection of bioelectricity.	04 hrs.
15	Electron microscopic photographs of samples and interpretation of results. (Demo)	02 hrs.
16	Interpretation of results with respect to structure of samples (Molecule) using XRD, diffractography	02 hrs.
17	Interpretation of result for structure of DNA using autoradiographic data.	02 hrs.
18	Construct the manometer in the laboratory	02 hrs.
19	Effect of hypotonic/ hypertonic solution on cells	04 hrs.
20	Determination of pKa value of p- nitro phenol by using UV-Visible spectrophotometer.	02 hrs.

M. Sc. I Semester I

PG HM – T103 Foundation of Bioinstrumentation

3-credits- 60-h

Unit I	Technology fundamentals (Life science) : **7-h** ▪ Introduction, scope and importance of various techniques in life science. The goal of structural biology. ▪ Methods of studying cells, organelles, sub- cellular fractionation and marker enzymes. ▪ Cell disruption methods-Physical and Chemical ▪ Filtration Techniques: Gross filtration, Steri-Pad filtration, Membrane filtration (Macro filtration, Nano-micro filtration, Ultra filtration), Reverse Osmosis, Dialysis. ▪ Freeze drying, Fractional precipitation.
Unit II	Chromatographic Techniques: Basics of chromatography **10-h** ▪ Planar Chromatography: Paper and TLC- principle, material, methods and applications. ▪ Column Chromatography: a) Adsorption: Ion exchange - Principle, Kinetics, methods and applications, hydroxyl apatite. b) Affinity- Principle, Methods and applications. c) Partition Chromatography: Normal phase, Reverse phase, Ion-pair reverse phase, Chiral, Counter current ▪ Molecular exclusion chromatography (Gel filtration) Types of gels, techniques and applications. ▪ Gas Liquid Chromatography (GLC): Principles, equipments Evaluation of performance and comparison with traditional chromatography. ▪ High Performance Liquid Chromatography (HPLC): Principles, Basic instrumentation and applications, HPTLC. ▪ Chromatofocussing
Unit III	Centrifugal techniques: **6-h** ▪ Principles of centrifugation, velocity and buoyant density, Determination of sedimentation coefficient, RCF, Different types of centrifuges – table top, high speed, microfuge, refrigeration & Ultra centrifuge ▪ Types of rotors, usages of rotors, differential & density gradient centrifugation – rate zonal technique, Isopycnic centrifugation, gradient preparation – discontinuous and continuous, Preparative and Analytical centrifugation. ▪ Molecular weight determination and other applications in life sciences.
Unit IV	Electrophoretic Techniques: **10-h** ▪ Principles of Electrophoresis, factors affecting electrophoretic mobility, moving boundary and zonal electrophoresis

	▪ Paper Electrophoresis – Principle and procedures involved, applications, Cellulose acetate paper electrophoresis ▪ Gel Electrophoresis: (a) Protein Electrophoresis: Polyacrylamide Gel Electrophoresis (PAGE), Disc Electrophoresis, Native & SDS – PAGE and 2-D PAGE, Isoelectric focussing (IEF), Continuous flow electrophoresis (b) Nucleic acid Electrophoresis: DNA sequencing gels, Pulse Field Gel Electrophoresis (PFGE), RNA Electrophoresis, Agarose gel electrophoresis, capillary electrophoresis and applications.
Unit V	Manometric techniques : **3-h** ▪ Principles, apparatus, operative procedure and applications
Unit VI	Spectroscopic technique **: 8-h** ▪ General principles of electromagnetic radiation spectroscopy, principles and procedures, instrumentation and applications of UV – visible spectrophotometer, turbidometry and nephalometry, fluorimeter, luminometry, atomic absorption and mass spectroscopy, Plasma emission spectroscopy & flame photometer.
Unit VII	Immunochemical Techniques :**8-h** ▪ Antigen- Antibody reaction – visualization by agglutination, precipitation, gel diffusion & compliment fixation ▪ Radio immune assays (RIA) ▪ Enzyme linked immunosorbent assays (ELISA) ▪ Isolation of sub population of lymphocytes (T & B) by Fluorescent Activated Cell Sorter (FACS) ▪ Blotting techniques and their applications ▪ Immunoelectrophoresis – Immunoblotting technique, Immunohistochemistry, Fluorescence immuno assay
Unit VIII	Biotechnological & Environmental Techniques:**8-h** ▪ Techniques of extraction & purification of enzymes, soluble enzyme, membrane bound enzymes, purification- Salt, solvent, chromatographic & electrophoretic techniques. ▪ Immobilization of enzymes – Preparation, Properties & applications. ▪ Hybridoma formation techniques & its application in production of monoclonal antibodies. ▪ Nucleic acid based analytical methods of 16S & 18S r – RNA gene sequencing, analysis of gene expression. ▪ Air sampler - (high volume & handy air sampler), weather station, sound meter, lux meter etc.

PG HM – P103: Practicals related to Foundation of Bioinstrumentation

60 hrs.

1	Beer & Lambert's law & validation and calibration of λ max and molar / specific extinction coefficient Spectrophotometric / Colorimetric estimation of samples from organisms (microbes, plant, animals) Colorimetric estimation of pesticide / indole acetic acid (IAA)	12 hrs.
2	Chromatographic techniques – A) Separation of dyes & pigments by column chromatography (silica gel) B) Separation & identification of amino acid from hydrolyzed keratin (and differentiation as aliphatic, aromatic, and polar amino acid), plant pigments by paper / TLC chromatography C) Separation of enzymes using ion exchange chromatography, gel filtration & affinity chromatography	10 hrs.
3	Detection & estimation of pesticides & Volatile Organic Compounds organic acids foods using GLC – MS (demo)	0 hrs.
4	Separation of aromatic compounds using HPLC (demo)	02 hrs.
5	Electrophoresis : Separation of proteins & nucleic acid samples by agarose and Polyacrylamide Gel Electrophoresis (PAGE), MALDTOF, Iso Electric Focusing (IEF), assessing purity	04 hrs
6	Determine the relationship of given samples with respect to parentage using fingerprinting techniques (interpretation)	02 hrs
7	Immunological: A) Detection & isolation of T-lymphocytes using T- rosette test B) Precipitation of immunoglobulin from serum by ammonium sulphate C) Perform and interpret the results of the test of given samples using ELISA	06 hrs.
8	To perform fractionation and differential centrifugation of samples for subcellular components, determination of RCF	02 hrs
9	To perform & detect the cell disruption using various physical, chemical & biological methods	02 hrs.
10	Perform & confirm the bacteria-proof filtration of given samples	02 hrs
11	Sucrose & CsCl density gradient centrifugation of given sample & interpretation of results (budding yeast cells)	02 hrs.
12	Study metabolic reaction (evolution & absorption of gases) of the given sample using manometric techniques	02 hrs.
13	Determine the methane content of the biogas sample using Orsat analyser	02 hrs.
14	Measure the luminescence of given sample using luminometer	02 hrs.
15	Determine the G+C content of given sample using UV-Visible Spectrophotometer	02 hrs.

16	Interpretation the results of the structures of given sample containing DNA using autoradiograph	02 hrs.
17	Detection and estimate the antigen in the given sample using the data supplied based on RIA	02 hrs.
18	Perform complement fixation test of given sample	02 hrs.
19	Perform blotting techniques & interpret the result	04 hrs.

M. Sc. I Semester I

PG HM – T104 Medical Microbiology & Immunology I

Unit	Topics	Hours
Unit I	**Medical Microbiology** **(a) Mechanism of pathogenesis -** 1) Determinants of microbial pathogenicity - Bacterial survival strategies – adhesion, invasion & evasion, evading complement & killing macrophages 2) Toxigenesis (Mode of action) – In vivo, in vitro assay system for Diphtheria, Cholera, Botulism, Tetanus toxins and endotoxin of gram negative bacteria (plasmid & virulence, antigenic variation & virulence) (*Vibrio parahemolyticus*) 3) Bacterial resistance to host defences – Phagocytosis, specific & non-specific defences, bacteria survive in phagocytosis – *Legionella, Salmonella* & *Mycobacterium,* Bacteria persisting within host – chronic infections of Brucellosis & Typhoid fever 4) Mechanism & measurement of virulence regulations – Types of regulation, bacterial communication & virulence – quorum sensing signalling molecules, mechanism of quorum sensing in bacteria 5) Virulence factors - Enzymes (lysozyme, coagulase), antiphagocytic factors, toxins, Spore, capsule, cyst formation 6) Molecular basis of bacterial pathogenesis – Cytoskeletal modifications of host cells, virulence genes & pathogenicity islands. 7) Viral survival strategies – Antigenic variations, non-functional T-cell epitopes, interference with antigen processing & presentation & interference in immune effector mechanism. 8) Host counter attack - by toxin neutralization & opsonisation of bacteria, body produces lysozymes/ lactoferrin, transferrin & coagulase reacting factor 9) Patterns of diseases – Sign & symptoms, stages **(b) Epidemiology –** 1) Infectious disease cycle, characteristic of infectious disease in population, epidemiological methods – descriptive, analytical & experimental epidemiology, measurements of infection rate	

	2) Introduction to epidemiological modelling - types of models – Susceptible Infectious Recovered (SIR), susceptible Exposed Infectious Recovered (SEIR), disease prediction (infectious disease dynamics), a case study – disease prediction, epidemiological model – COVID -19 **(c) Pathogenesis & human microbiome** 1) Microbial biofilms – Structure, properties & formation, biofilm related infection on tissue surfaces, biofilm associated with medical devices & implants. 2) Microbiome – Introduction, human microbiome project, Gut microbiome, types of organisms, functions, role in health & disease	
Unit II	**(B) Immunology** 1) **Immunity** – Types of immunity, components of innate & acquired immunity, cells & organs of immune system, antigen presenting cells (humoral & cell mediated immune system), endogenous & exogenous pathways of antigen presentation, presentation of non-peptide antigens. 2) **Immunity to viral infections** – Antigenic drifts & shifts, interferon, interleukins, humoral & cell mediated immunity 3) **Immunity to bacterial infections** – Phagocytosis, role of complement & antibody, role of cell mediated immunity (CMI) & activated macrophages, bacterial strategies to avoid phagocytosis. Pathogen Recognition Receptor (PRR) & Pathogen Associated Molecular Patterns (PAMP) 4) **Complement system & cytokines** – Classical, alternate & lectin pathways of complement activation & function of complement system - types & general properties of cytokines, receptors, cytokine network & storm, immuneregulatory role of IL – 4, IFN – γ & TNB – β. 5) **Antigens** – Immunogenicity verss antigenecity, factors that influence immunogenicity – epitopes – Properties of B cell epitopes & T – cell epitopes, Haptens & adjuvants, antigen engineering – increasing immunogenicity. 6) **Antibodies** – Basic structure of immunoglobulin – the role of Multiple Myloma in understanding immunoglobulin structure, domain variable & constant regions, immunoglobulin classes & functions, applications & engineering of monoclonal antibodies, Freeman hybrid antibodies, immunogenetics (overview) 7) **Cell surface molecules & receptors** - i) Definition – General structure & mechanism (Dimerisation & rotation), Components of signal transduction (extra cellular signalling molecule, receptor proteins, intracellular signalling proteins & target proteins). ii) Immunoglobulin genes & proteins – multi gene organization of immunoglobulin genes, generation of antigen diversity, TCR genes, gene products & co-repressors.	

	iii) Structure & types (α, β, γ & δ) of gene organization & rearrangement, T- cell accessory membrane molecule, role of TCR – CD_3 complex in immune activation& signal transduction pathways, adhesion molecules in immune (IL – 2, GAK – SIAT, TCR – CD3 activation, Ras – map), kinase complex. iv) Activation, Structure & functions of B cell receptors, TOLL like receptor, Cytokine receptor, G – protein coupled receptors v) Major histocompatibility complex (MHC) – General organization and inheritance of MHC, MHC haptotypes, the structure of MHC class I & class II molecules, Organization of MHC class I & II genes, peptide bonding of MHC molecules, polymorphism of MHC class I & II molecules, cell distribution, human HLA complex, the role of HLA typing in organ transplantation & disease susceptibility/ resistance, structure & function of MHC antigens.	

PG HM – P104 Practical Medical Microbiology & Immunology I

Sr. No.	Practical	Hours
1	Techniques of Eggs inoculation	
2	Study of few virulence mechanisms in pathogens – Toxin production, phagocytosis, Capsule formation, Pigmentation, Enzyme production (lecithinase)	
3	Study of quorum sensing & quorum sensing inhibition, *Chromobacterium violacum*	
4	Microbial biofilm formation on various surfaces & determination of minimam inhibitory concentration (MIC)of an antibiotic	
5	Phenol coefficient of disinfectants	
6	Study of *Streptococcus mutans* (Dental caries) *Candida albicans* (Nail infections)	
7	Study of animal tissues and organ explants	
8	Precipitation of serum immunoglobulins by ammonium sulphate method	
9	Haemoglobin estimation by cyanmethaemoglobin method using Drabkins fluid as one of the criteria, uses for selection of blood donor during cell transfusion	
10	Blood grouping & compatibility testing / cross matching of blood for safe blood transfusion	
11	Determination of enzymes of oxidative stress – superoxide dismutase (SOD) & Catalase test	
12	Massive Blood transfusion (MBT) analysis of blood sample	
13	Serum lysozyme activity, Myeloperoxidase activity (MPO)	
14	Radio Immuno Sorbent test (RIST) & Radio Allergo Sorbent Test (RAST) – allergy test in children for IgE levels: Principles, significance and procedure (demo)	
15	Precipitation reaction of antigen, antibody, single radial diffusion (Radial Immuno Diffusion – RID)	

16	Rocket Immuno Electrophoresis (RIE)	
17	Agglutination technique – Determination of isoantibodies titer to human blood group antigens	
18	Visit to institute / industry for demonstration of enzyme linked immunosorbent spot (ELISPOT) / contraction stress test (CST) / FACS / Animal inoculation	
19	Study of Ouchterlony double diffusion method	
20	ELISA technique – Study antibody titre	
21	Haemoglutination (HA) test &Haemoglutination inhibition (HAI) test	
22	AME's for carcinogenicity & mutagenicity	
23	SDS – PAGE, Immunoblotting, Dotblot assay	
24	Demonstration of different cysts of pathogenic protozoa *Entamoeba histolytica, Giardia Spp*., Eggs of cestoda & nematodes	
25	Study of haemoparasites by blood films examination	

M. Sc. I Semester I

PG HM – T105E1: Water & Wastewater Treatment

3-credits- 60-h

Unit I	**Quality & Quantity of Water 10-h** ▪ Quality & quantity of water requiring for domestic irrigation, institutional (schools, hostels, hospitals), fire fighting, commercial (shopping complex, hotels & restaurants), industrial (pharmaceutical, dairy, sugar, pulp & paper etc.), pilgrimage places & recreation activities. ▪ Need of water quality standards for domestic and industrial purpose, specification for drinking water by Bureau of Indian Standards (BIS) & World Health Organization (WHO).
Unit II	**Characteristics of water and wastewater:10-h** ▪ **Physical characteristics**: solids, particle size distribution, turbidity, colour, odour, temperature, conductivity, density, Specific gravity & specific weight. ▪ **Chemical characteristics**: a) Inorganic non-metallic constituents- pH, Chlorides, Alkalinity, Nitrogen, Phosphorus, Sulphur, Gases etc. b) Metallic constituents – (heavy metals & other metals). c) Aggregate organic constituents – BOD, COD, SCOD, ThOD, TOC, DTOD, UV – absorbing organic constituents, oil & grease, surfactants etc.

	d) Individual organic compounds (priority pollutants, VOC, disinfection byproducts, agrochemicals etc.) ▪ **Biological characteristics:** Microbes in water & wastewater, Use of indicator organisms, MPN test, Enumeration & identification of microbes. ▪ Toxicity test:Fish Bioassay & Onion root tip assay
Unit III	**Introduction to process, analysis & selection 10-h** ▪ Flow rate, Constituent concentration & mass loading. ▪ Reactors used in water and wastewater treatment. ▪ Mass – balance equation, Mass transfer ▪ Modelling- Ideal flow, Non-ideal flow (with & without tracers). ▪ Important factors in process selection of water & wastewater ▪ Selection of appropriate unit operations for the treatment & flowchart of water treatment plant. ▪ Preliminary, Primary, Secondary & Tertiary treatment processes. ▪ ETP, STP, WTP, CETP ▪ Specification of treated wastewater for disposal into surface water, on land and in marine water
Unit IV	**Unit operation process in water & wastewater treatment 10-h** ▪ **Physical unit operations** – Collection & pumping of water & wastewater, screening, filtration, coarse solid reduction, flow equalization, swirling & vortex, mixing & flocculation, gravity separation, grit removal, sedimentation, clarification, flotation, oxygen transfer & aeration, Skimming tank. ▪ **Chemical unit operations** – Coagulation, Chemical precipitation, Chemical oxidation, Chemical neutralization & stabilization, Disinfection, Water softening. ▪ **Biological treatment** – Objectives, Role of microbes in water & wastewater treatment, Types of biological processes for treatment, aerobic biological oxidation, Nitrification, Denitrification, Phosphorus recycling, Anaerobic fermentation & oxidation, Removal of organic compounds & Heavy metals a) Suspended growth biological treatment processes- Activated sludge process, aerated lagoons. b) Attached growth biological treatment processes- Trickling filters, rotating biological contractors (RBCs), FBR, USABR, ASBR & UPBAGR. ▪ Advanced treatment – Adsorption, Gas stripping, Ion exchange, Advanced oxidation, Distillation, Reverse osmosis
Unit V	**Treatment & disposal of sludge 10-h** ▪ Sludge cakes, energy recovery, Septic tanks, Soak pits etc. ▪ Grinding, Screening, Degritting, Blending, Storage, Thickening, Alkaline stabilization, Anaerobic digestion (Biomethanation), Aerobic digestion, Composting (Vermicomposting- aerobic, anaerobic), Conditioning, Heat drying, Incineration

	▪ Issues related to treatment plant ▪ Microbial consortium approach for wastewater treatment
Unit VI	**Industrial wastewater 10-h** ▪ Unit operations and flowchart of wastewater treatment plants of following industries – a) Dairy b) Pulp & Paper c) Galvanizing d) Sugar & distillery e) Pharmaceutical f) Automobile g) Leather h) Textile

PG HM – P105E1: Practicals related to Water& Wastewater Treatment

60 hrs.

1	Estimation of physical constituent in water/ wastewater i. Solid (TS, TDS, TSS, TVS etc.) ii. Turbidity iii. Colour, Odour iv. Temperature v. Electrical Conductivity vi. Density, Gravity	**4 hrs.**
2	Estimation of Chemical constituent in water/ wastewater i. pH ii. Chlorides iii. Alkalinity/acidity iv. Nitrogen v. Phosphates vi. Sulphur vii. Heavy metals by AAS viii. DO, BOD, COD (efficiency of waste treatment plant) ix. Oil and grease x. Surfactants xi. Hardness xii. Fluorides xiii. Na, K xiv. CO_2 xv. TOC	**16 hrs.**

3	Estimation of Microbial constituents in water/ wastewater i. MPN test	**2 hrs.**
4	Flocculation Jar test (Treatability test for effluents)	**2 hrs.**
5	Sampling, handing and preservation of water/ waste water samples	**1 hrs.**
6	MLSS, SVI, MLVSS	**1 hrs.**
7	Determination of flow rate of water and waste water by V-Notch method	**2 hrs.**
8	Zooplankton/ phytoplankton counting	**2 hrs.**
9	Toxicity testing- fish assay, Onion root tip assay	**4 hrs.**
10	Bacterial reduction of Nitrates from ground water	**2 hrs.**
11	Waste water treatment methods Preliminary, Primary, Secondary, Tertiary methods. Municipal/ Aromatic hydrochemicals from chemical industry Xenobiotics (recalcitrant), Treatment of distilled waste/ textile/ dairy/ tannery/ paper pulp/ waste from industry using GM technology/ medical using following strategies a) Preliminary- removal of stone/ gravel, wooden & metal pieces etc. b) Primary- Sedimentation, flocculation, centrifugation, filtration and clarification c) Secondary (Biological method) - Use of Microbial consortia (Preparation of consortia) ➢ Anaerobic treatment - Biometanation (recovery of biogas, sludge) ➢ Aerobic treatment – Activated sludge treatment of anaerobic effluent and sludge) – composting (vermicomposting) ➢ Removal and adsorption of colour by biomass, use of microbes (consortium) - bacteria, yeasts & molds (white rot fungi) d) Tertiary treatment (Chemical) – Disinfection & sterilization e) Safety majors (testing), Disposal (incineration, dumping), Waste disposal by dilution	**16 hrs.**
12	Isolation & purification of microbes having degradative plasmids and growing in polluted environment	**2 hrs.**
13	Recovery of toxic metal ions of an industrial effluents by immobilized cells	**2 hrs.**
14	Biotransformation of toxic chromium (Cr^{+6}) into nontoxic (Cr^{+3}) using bacteria like *Pseudomonas spp.*	**2 hrs.**
15	Preparation of activated sludge	**2 hrs.**

M.Sc. I Semester I

PG HM – T106E2: Fundamentals of Environmental Science

Unit 1: The Environment

- Physical environment - Soil weathering and soil formation, Soil composition, Soil profile, Soil erosion, Air and Atmosphere, Light, Temperature, Effect of latitude, Effect of altitude, Temperature and vegetation, Precipitation
- Adaptation to the physical environment - Plant's adaptation to water stress, Animal's adaptation to thermal stress, Homoeothermic and poikilothermic animals
- Ecotype and Ecads, Metabolic rate and size of individuals
- Shelford's law of tolerance - Ecological amplitude

Unit 2: Ecosystem Ecology

- Ecosystem components, Productivity, Autochthonous and Allochthonous, Patterns in primary productivity, Relationship between productivity and biomass, Measuring primary productivity, Oxygen emission method, Radioactive tracer method, Harvest analysis method, Energy flow, Concept of the trophic level, Food chains, Types of food chains, Ecological efficiencies, Ecological pyramid, Nutrient cycling, General model of nutrient cycling, Carbon cycle, Nitrogen cycle, Phosphorus cycle , Sulfur cycle,Water cycle, Decomposition
- Ecosystem services - Control of trophic structure: top-down versus bottom-up control, Types of Ecosystems, Aquatic ecosystem - Variation in light and temperature in aquatic ecosystem, Primary productivity in aquatic ecosystems, Marine ecosystems, Hot hydrothermal vents, Coral reefs ecosystem, Estuary Freshwater ecosystem, Lake Thermal stratification, Seasonal changes in water temperature, Nutrient inputs and cycling Wetlands, Terrestrial ecosystem - Forest ecosystem, Deforestation, Afforestation, Social forestry , Grassland ecosystem, Desert ecosystem, Types of deserts, Desertification
- Biomes - Biome distribution, Biome types, Tundra biome, Desert biome, Tropical grassland (or Savanna biome), Temperate grasslands, Tropical rainforests, Temperate, deciduous, forest biome, Taiga biome, Chaparral biome

Unit 3: Population Ecology

- Population characteristics - Population density, Natality, Mortality, Dispersion, Age structure and Age pyramids, Dispersal
- Population growth - Exponential growth and Logistic growth
- Life table: Age-specific mortality and survival, Gross and net reproduction rate
- Population regulation

- Concept of metapopulation
- Energy partitioning: r- and k-selection
- Home range and Territory

Unit 4: Community Ecology

- Community structure - Species composition, Species diversity, Diversity index, Simpson's diversity index, Shannon diversity index, Pielou's evenness index, Species-area curve, Disturbance and species diversity, Community diversity, complexity and stability
- Community gradient and boundaries
- Community: functional classification
- Plant communities - Life forms, Stratification, Vitality and Vigour Periodicity
- Island biogeography
- Ecological interdependence and interactions - Positive interaction - Mutualism, Commensalism, Negative interaction - Predation, Parasitism, Amensalism, Competition, The interaction compass
- Lotka-Volterra model - Dynamics of the predator–prey system
- Ecological niche - Ecological compression
- Effect of competition - Competitive exclusion principle, Competitive exclusion and coexistence, Resource partitioning, Character displacement
- Ecological succession - Pattern of succession, Types of ecological succession Primary and secondary succession Autogenic and allogenic succession, Autotrophic and heterotrophic succession, Progressive and retrogressive succession, Mechanism of succession, Concept of climax community, Models of succession

Unit 5: Biodiversity

- Levels of biodiversity - Genetic diversity, Species diversity, Ecosystem diversity
- Gradients and Magnitude of biodiversity - Biodiversity of India
- Uses of biodiversity - Ecosystem services, Prevention and mitigation of natural disasters, Source of economically important products, Aesthetic and cultural benefits, Consequences of biodiversity loss
- Threats to biodiversity - Habitat loss and fragmentation, Introduction of invasive species, Overexploitation, Climate change and pollution
- Extinction of species - Mass extinction, Susceptibility to extinction
- IUCN Red List categories and criteria
- Conservation of biodiversity - Ex-situ and in-situ conservation, Biodiversity Hotspots, Flagship and Umbrella species
- Protected Areas of India: National parks, Wildlife sanctuary, Conservation reserves and Community reserves, Marine protected areas, Biosphere reserves, Objectives of biosphere reserve, Structure of biosphere reserve, Sacred groves
- Biodiversity conservation: International and National efforts - International conservation strategies, Convention on Biological diversity, CITES, World

Heritage Convention (WHC), Convention on the Conservation of Migratory Species of Wild Animals, International Treaty on Plant Genetic Resources for Food and Agriculture, Convention on Wetlands (Ramsar Convention), International Plant Protection Convention (IPPC), National conservation strategies, Biological Diversity Act, Wildlife (Protection) Act, Project Tiger, Project Elephant and Project Cheetah, National Wildlife Action Plan, Forest Conservation Act

- Biogeographic classification of India

Unit 6: Pollution

- Air pollution - Composition of air, Sources of air pollution, Types of air pollutants, Criteria for air pollutants, Carbon monoxide, Ozone, Oxides of nitrogen, Particulate matter, Oxides of sulfur, Lead, Effects of air pollution, Effect on human health, Effect on plants, Loss of biodiversity, Acid rain, Eutrophication, Ozone depletion Greenhouse effect and Global warming, Climate change, Air quality standards, Ambient Air Quality Standards in India, WHO air quality guidelines, Air Quality Index, National Air Quality Monitoring Programme, Indoor air pollution, Acid rain, Control of air pollution
- Noise pollution - Sources of noise pollution, Effect of noise pollution, Standards and guidelines of ambient noise level in India
- Water pollution - Causes of water pollution, Industrial discharges, Disposal of sewage, Surface run-off, Types of water pollutants, Indicators of water pollution, Groundwater pollution, Water quality indicators, Physical indicators, Chemical indicators, Biological indicators, Water quality standards, Effects of water pollution, Control of water pollution, Wastewater treatment, Sludge treatment, Bioaccumulation, bioconcentration and biomagnifications
- Soil pollution - Solid waste management, Hazardous waste treatment, Solid waste management , Bioremediation, Bioindicator, Environmental Impact Assessment (EIA)

Unit 7: Climate Change

- Climate change - Climate change and Global warming, Climate change: Evidences.
- Greenhouse effect - Greenhouse gases, Increase in greenhouse gas concentrations, Global-warming potential of greenhouse gases
- Global warming, Climate change: Impacts, Responding to climate change
- Earth Summit, UNFCCC, Kyoto Protocol, Doha Amendment, Kyoto mechanisms Copenhagen Accord, Paris Agreement, Emission trading/Carbon trading
- Ozone depletion - Montreal Protocol
- Environmental Laws in India - Forest and Biodiversity, Environment and Pollution

- Environmental footprints - Carbon footprint, Nitrogen footprint, Water footprint, Ecological footprint
- Living Planet Index
- Bioprospecting - Nagoya Protocol

PG HM – P106E2 Practicals

1	Determination of texture and analysis of soil	**4 hrs.**
2	Study of relationship between productivity & biomass, measurement	**4 hrs.**
3	Preparation of ecological pyramids	**4 hrs.**
4	Study of zooplankton, phytoplankton of fresh water/marine water	**4 hrs.**
5	Wetland study (Productivity of lake)	**4 hrs.**
6	Study of vegetation by Line, Belt, Quadract method	**4 hrs.**
7	Study of population density, mortality, natality, dispersion, age, structure, age pyramid of population using data provided.	**4 hrs.**
8	Study of population growth – logistic & exponential curve e.g. bacteria, animals	**4 hrs.**
9	Calculation of species diversity index – Simpson, Shannon, Pielou's evenness from Line, Belt, Quadract data	**4 hrs.**
10	Study of ecological interactions – Positive – Syntrophism (proto cooperation), synergism, mutualism, commensalism, symbiosis. Negative – Parasitism, ammenesalism, competition, predation, antagonism.	**4 hrs.**
11	Preparation of PBR (public biodiversity register)	**6 hrs.**
12	Case studies on climate change	**2 hrs.**
13	Estimation of greenhouse gases	**4 hrs.**
14	Estimation of carbon footprint	**6 hrs.**
15	Determination of living planet index	**2 hrs.**

16	EIA case studies	

M.Sc. I Semester I

PG HM – T107SECC: Spoken English

Unit A: Traditional and Structural Grammar and Composition

1. Language :
   English as a foreign language
2. Writing English :
   Sentence structure, Essay composition, Summary writing, precise writing and comprehension
3. Reading English :
   Importance of reading, the process and mechanics of reading, Intensive and extensive reading: Rapid reading, making notes as you read, writing book review.
4. Use of Vocabulary :
   Meaning of words, precise usages, synonyms and antonyms, technical terms, context, superfluous words
5. Using a Dictionary :
   Definition of dictionary, types of dictionaries, information in dictionary, use of dictionary
6. Use of good English :
   Noun, pronoun, adjective, verb, adverb, conjunction, preposition, interjection, the article, tenses, spelling, use and misuse of words, abbreviations, active and passive voice, punctuation, remove 'too'.
7. Phonology :
   Pronunciation of vowels and consonants in English
8. Public speaking in English and oral presentation in English.

Unit B: Communication Skills

1. **Communication as part of science:**
   Language – a means of Communication; Communication – Meaning of Communication, Definitions; Principles of communications; Communication – Situation for and need of communication, Importance of communication Features, objectives and functions of communication, Communication cycle, Elements of Communication, Communication process, stages in Communication process.

2. Types of Communications:

Formal – Informal, Verbal – Nonverbal, Vertical – Horizontal – Diagonal

3. Principles of effective communication:

Definitions of effective communication; Communication barriers and ways to overcome them; Developing effective messages – Knowledge about the audience, purpose of communication, structure of message, selecting the proper channel, avoiding barriers in communication, facilitating feedback.

4. Non -Verbal Communication

Non – verbal codes: Body Language, chronemics and Artifacts

5. Illustrating with visuals:

Photographs, tables, graphs, flow charts, figures, maps, picture diagrams, pie diagrams, family tree.

6. Formal written skills

i. Report writing: Seminar report, Conference report, Progress report, Investigative report, Accident report, Fall/rise in the Production, Joining report
ii. Applications: Job Application with resume (C.V.), Sick leave application, Application for getting particular information (eg. prospectus / prescribed admission / scholarship form).
iii. Business correspondence: Enquiry letter, Order letter, Complaint letter, Adjustment Letter
iv. Office drafting: Circular, Notice, Memo, Defining and Describing object and Giving Instructions

M.Sc. I Semester I

PG HM – T108 AECC: Yoga and Meditation

Unit 1: Introduction, Meaning, definition, Objectives; Introduction to Ashtangyoga; Performing Yogabhyasa

Unit 2: **Suryanamaskar:** Introduction, Postures, Benefits and practice

Unit 3: **Asanas :** Vajrasan, Padmasan, Vakrasan, UttanPadmasan, Pawanmuktasan, Shavasan, Bhujangasan, Shalabhasan, Makrasan, Tadasan, Verasan, Ardhachakrasan- Introduction, Postures, Benefits and practice.

Unit 4: **Pranayamanas**

AnulomVilom, Bhramari, Kapalbhati and Bhasrika; Omkar Sadhana, Prayer and Guruvandana

Unit 5 **Meditation**

Meditation types and practice

M. Sc. I Semester I

PG HM – T109VAC: Research Methodology – Value added

Unit I	**Research terminology and fundamentals** 1) Definition on research, scientific thinking, significance and general characteristics of research, objectives, classification and type of research, types of research methods. 2) Research methods verses methodologies, research and scientific methods, criteria of good research. 3) Identification and formulation of research problem, topic
Unit- II	**Communication and scientific writing** **Communication skills-** 1) Importance of communication through English, the process of communication and factors that influence the communication – sender, receiver, channel, code, topic, message, context, feedback, noise, filters and barriers 2) Verbal and non- verbal communication: body language 3) Comparison of general communication and business communication, scientific communication. 4) Presentation skills- Structure of presentation, types of presentation – Oral, Power Point Presentation, Handling of Power Point, Slides organization, content, body language, gestures, voice modulation, online/ virtual presentation (Webinars) (MS team, ZOOM etc.) **Scientific Writing-** 1) History and basic concepts in scientific writing 2) Language as means of communication – English language 3) Scientific writing verses unscientific writing- Scientific writing in English language 4) Good English and grammar in scientific writing - Basic grammar, Tenses, Voices, Prepositions and Conjunctions, conditional sentences, count and non count nouns, concord and punctuations, use and misuse of words, jargons and avoiding jargons, use of abbreviations, accepted abbreviations and symbols, common error in the style and in spellings. 5) Organizing time, information and ideas – selection of topic and outline formulation of research proposal, thinking and planning, information collection, adopting scientific style, Paragraph writing – paragraph, order of paragraph, writing and revising of paragraph, sentence connection, order of sentences, cohesion and coherence, contradiction, tautology, symantec anomaly, circumlocution using dictionaries/

thesaurus/ guides/ spell check/ grammar check/ logical sequences relevance/ scientific writing/ written English, connectivity

6) Main requirements of scientific documents - reader as the target of the document, accuracy, appropriateness, clarity, simplicity, brevity, precision, balance, consistency, impartiality, sincerity, objectivity, control of interest in scientific writing.
7) Scientific methods – Concept, hypothesis, theory, law, design of experiment, inductive & deductive reasoning.
   - Hypothesis – Meaning, nature, functions, types of hypothesis, formulation & characteristics of good hypothesis
8) Data collection and processing – Definition, scope & limitation of data collection & processing.
   - Sampling – Sampling frame, importance of probability sampling, simple/random sampling/stratified random sampling, cloistral sampling, limitation sampling
   - Types of data, collection of data, classification & tabulation. Diagrammatic & graphical representation, primary & secondary data.
   - Measurement scales, variables & their measures.
   - Validity, effect measure & choice of statistical test.
   - Experimental protocols.
9) General structure of scientific reports (types of scientific documents) – Journal articles, books, posters, conference, papers, thesis, review papers, books reviews, project & conference reports.
10) Writing a scientific papers – IMRAD/IRDAM acronym/ system, literature search, title, listening of authors & addresses, abstract, key words, introduction, material –method, result & discussion, summary & conclusion, stating the acknowledgement, tables/graphs/diagrams & illustrations
    - Citing the references – (style of referencing, citation styles – Harvard, Vancouver, APA, MLA, reference writing)
11) Publication process – Key boarding the manuscript, submission of manuscript to peer reviewed journal/ publication agency (e.g. UGC CARE list I (list approved by UGC) & list II (globally indexed databases – web sciences, ISI USA, SCOPUS, PUBMED, Thomson Reuters – having impact factor. NAAS India impact granting), copyright transfer, plagiarism – legal aspects of scientific authorship, open access, the review process, reports, proof reading, gallery proofs (dealing with editors), publication of document, ordering reprints
12) Presentation of scientific research paper – Oral presentation, poster presentation, presentation in conferences & in symposia, thesis presentation (viva voce/ open defence) presentation & submission of proposal to funding agencies – selection of research topic, review of literature, writing research proposal & presentation (submission).
13) Structure of thesis – Title, author & their institution, abstract/ summary, certificates (students undertaking, guide certificate, plagiarism checker certificate, ethical clearance), acknowledgements, list of content, abbreviations, introduction, literature survey, aim & objectives, material & methods, results & discussion, conclusion/

	recommendation, bibliography, annexure (chemicals, glasswares, reagents, media used with composition, paper publication etc.). 14) Use of computers in research methodology – Basics –Hardware/ software, application programme, binary programme, system programme, utility programme and programming, input unit, ALU unit (Arithmetic Logic Unit), control unit/RAM, ROM, PROM, EPROM, EEPROM, Magnetic core memory, Secondary storage devices; Computer programming language & operating system – Batch operating system, Personal Operating System (PCS), MS word, MS excel, MS power –point etc.,

Practical course Research methodology **60 hrs.**

1	Literature review on any current research topic of 10-20 typed pages using Google search or any search engines (it can be on research project topic)	02 hrs.
2	Writing suitable title of research papers, search of instruction s to authors from website of scientific journal (its analysis and comparison)	02 hrs.
3	Assignment on analysis of data/results/conclusions	02 hrs.
4	Writing abstract for research paper	02 hrs.
5	Writing summary and conclusion for given scientific paper	
6	Writing a bibliography for given research paper	02 hrs.
7	Writing the hypothesis for a research project	02 hrs.
8	Oral presentation (preparation)/webinar with different tools	03hrs.
9	Identification and formulation of research problem (may be for project work)	03hrs.
10	Preparation of research paper for publication (may be on their research project)	08hrs.
11	Searching of journals indexed in PubMed, globally indexed database (Medline, Web of Science, with good index factor – Thomsum Reuter, Scopus, Elsevier, Nature, indexing - NAAS India, UGC care lists I & II, research papers - Q1, Q2, Q3, Q4 grades/quality.	08hrs.
12	Prepare a plagiarized and non plagiarized document (use of plagiarism checker)	03 hrs.
13	Preparation of list of Referees for thesis- regional/state, national, international referees with their details (Biodata)	03 hrs.
14	Ph. D. processes –Entrance exam, registration, proposal, research work, progress reports, thesis writing, paper publications, submission of synopsis (pre thesis - mock	04 hrs.

	defence/ presentation) and thesis submission, Viva voice, declaration of results, A case study (as per UGC guidelines)	
15	Using computer, preparation of research document – a case study (Use of MS word, MS power point, voice to text, MS Excel, Photoshop, Mobile application- use of mobile for research) creating WhatsApp group, mail ID, MAC ID)	03 hrs.
16	Editorial note- writing research paper – a case study	03 hrs.
17	Review paper (Preparation and publication) – case study	06 hrs.

M. Sc. I, Semester II

PG HM – T201 Foundation of Cell Biology

3-credits-60-h

Unit I	**Dynamics and organization of cell:** ▪ Universal features of cell ▪ Comparison of prokaryotes and eukaryotes ▪ Structural organization and functions of cellular organelles. ▪ Cell wall and extracellular matrix - matrix protein and matrix polysaccharides, Nucleus ▪ Mitochondria- structure, Electron transport chain, proton pump, genetic system. ▪ Chloroplast- structure, energy capture from sunlight, genetic system, Plastids. ▪ Golgi (bodies) Apparatus - intracellular signal and vesicular trafficking; the molecular mechanism of membrane transport and the maintenance of compartmental diversity, transport from Endoplasmic reticulum (ER) through the Golgi network to lysosomes. ▪ Lysosomes, Peroxisomes and vacuoles ▪ Plasma membrane- membrane structure and function, lipid bilayer, membrane proteins, spectrins, glycophorines, multipass membrane proteins, bacteriorhodopsin, membrane models.	12 hrs.
Unit II	▪ Membrane Transport - Passive and active diffusion, osmosis, ion channels and electrical properties of membrane (Na^+ and K^+ pump, Ca^{+2} pump, ATPase pump) ▪ Transport of antibiotics that increase the ionic permeability of membranes ▪ Proton gradient in halobacteria	10hrs

	▪ Protein Transport- Post translational transport, Co translational transport, protein transport and protein secretion pathways, endocytosis and exocytosis in prokaryotes and eukaryotes. ▪ Symport, Antiport, membrane vesicle trafficking, signal hypothesis	
Unit III	▪ Intracellular compartments and protein sorting Intracellular compartmentalization of cells - transport of molecules between the nucleus and cytosoles, Peroxisomes, Endoplasmic Reticulum (ER), transport of proteins into Mitochondria and Chloroplast	6hrs
Unit IV	▪ Specialised cells (muscle and nerve cells) - structure and function of muscle cells - striated, non- striated and cardiac, structure of neuron, neurotransmitters and their receptors, nerve impulses, agonist and antagonist interactions	4hrs
Unit V	▪ Cytoskeleton: the cell assembly and dynamic structure of cytoskeletal filaments, regulation of cytoskeletal filaments of cells, microtubules, actin and intermediate filaments, actin binding proteins, structure and function of cilia and flagella, molecular motors and cell behaviour.	6hrs
Unit VI	▪ Cell – Cell interactions/ Cell – ECM interactions, communications and signalling – General principles of cells communications (nitric oxide gas signals and nuclear receptors, 3 classes of surface receptors), signalling through G- protein linked cell receptors, ▪ General principles of cell signalling ▪ Signalling through enzyme linked cell surface receptors – tyrosine kinase, docking sites, Ras- Map kinase, PI-3 kinase, TGF-β, signalling pathways by regulated proteolysis - role of secondary messengers, signalling in plants – serine/ threonine kinases, role of ethylene - phytochromes. ▪ Cell junctions and cell – cell adhesions ▪ cell adhesion molecules, anchoring, adherence junctions, cadherins, integrins, transmembrane proteioglycan clodins and accludins, gap junctions – tight junctions, adherins, desmosomes, selectins, N-CAM , desmosomes and hemidesmosomes, plasmodesmata, extracellular matrix of animals, cell mobility and migration	10hrs
Unit VII	▪ Cell division ,differentiation and cell cycles – Mechanism of cell division – M – phase, Mitosis, cytokinesis, germ cells and fertilization – meiosis, eggs, sperms ▪ Differentiation – stem cells, their differentiation into different cell types and organization into specialized tissues. ▪ Cell cycle and programmed cell death – molecular events of cell division and cell cycle, cell cycle - check points, control and intracellular regulation of cell cycle events - cyclins, cyclin dependent kinases, inhibitors. ▪ Apoptosis and necrosis – extracellular control of cell growth and apoptosis ▪ Autophaging	12hrs

PG HM – P201 Practicals related to Foundation of Cell Biology

Sr. No.	Practical	Hours
1	In-vitro demonstration of Phagocytosis and calculation of phagocytic index	02 hours
2	Separation of lymphocytes using phycol – Hypaque method & viability count using trypan blue staining, MTT assay & neutral bright up take assay	03 hours
3	Cell permeability testing – Osmatic fragility	01 hours
4	Study of glactose / antibiotic transport in yeast & bacteria	03 hours
5	Preparation of protoplast – yeast, bacteria, plant	03 hours
6	Induction of ascospores in yeast and endospores in bacteria	03 hours
7	Isolation of cell organelles by differential centrifugation techniques from plant/ animal sources	03 hours
8	Isolation of mitochondrial & chloroplast DNA ▪ Isolation of chloroplast, checking photophosphorylation ▪ Isolation of mitochondria, checking of activity of respiratory enzyme succinate dehydrogenase	03 hours
9	Cell motility studies (bacteria, algae, cyanobacteria, protozoa)	01 hours
10	Cell death (apoptosis studies- using flow cytometer) (demo)/ cell culture	02 hours
11	Isolation & identification of mutagens of plant origin (demo/video)	02 hours
12	Comparison of various cell viability techniques	03 hours
13	Study of mitosis & meiosis with onion root tip cells	03 hours
14	Temporary preparation of polytene chromosomes from chironomus larvae salivary gland	02 hours
15	Isolation of nuclei from rat liver / yeast cells	02 hours
16	To count RBCs & WBCs from blood by blood staining method	02 hours

17	Chlorophyll estimation by spectrophotometer – spectrum & light scatter studies	02 hours
18	Study of magnetic / electric field on behaviour of cells (microorganisms)	02 hours
19	Isolation of bacterial cell wall & study of components by chromatographic techniques	03 hours
20	Staining of plant cell wall	01 hours
21	Staining of muscle fibers / nerve cells	01 hours
22	Study of quorum sensing and its inhibition in microorganisms	03 hours
23	Contact inhibition studies in growing animal cells	03 hours
24	Study of stem cells & their types and their differentiation	02 hours
25	Isolation & purification of lysozyme from egg white, isolation and purification of enzymes from snail gut (*Helix pumatia*)	03 hours
26	Isolation & identification of reserve food material from bacteria & yeast	02 hours

M. Sc. I, Semester II

PG HM – T202 Foundation of Biochemistry – Biomolecules & Metabolism

3-credits-60-h

Unit I	**Introductory Biochemistry**:**2-h** • Scope of biochemistry • What is biochemistry? • Goals of biochemistry • Roots of biochemistry • Biochemistry as discipline & an interdisciplinary science • Biochemistry as chemical science • Biochemistry as biological science • New tools in biological revolution • Uses of biochemistry
Unit II	**Basic concepts in Biochemistry**:**5-h** • Common organic compounds found in living system. • Common functional groups in biochemistry – OH, CHO, C= O, NH_2, C - NH_2, SH, ester, ether, methyl, ethyl, phosphor, guainidio, imidazole etc. • Common ring structures in biochemistry • Isomerism, epimers, anomers, chiral carbon atom, chair & boat form, Glucopyranose & fructopyranose • Isotopes • Energetics

	• Redox systems • High energy compounds
Unit III	**Water : Structure & properties1-h** ➢ Water as a solvent ➢ Ionization ➢ Ionic equilibrium
Unit IV	**Structural features and chemistry of macromolecules** (Biomolecules)**3-h** ➢ Chemical bonding : Introduction to chemical bonds, covalent bonds, ionic bonds, hydrogen bonds, coordinate bonds, metallic bonds, Vander waals forces.
Unit V	**Carbohydrates, lipids and proteins**:**15-h** ➢ Structure, properties and biological functions of carbohydrates, proteins & lipids. ➢ Protein chemistry: Structure, function & relationship in model proteins like Ribonuclease, Myoglobin, Haemoglobin, Chymotrypsin ➢ Proteins – Levels of organization of protein structures – primary, secondary, tertiary & quaternary structures. Determination of primary structure (sequence of amino acids) of polypeptide (N-terminal determination, C- terminal determination, partial hydrolysis, overlapping sequences etc.), α- helix of polypeptide, reverse turns, Ramchandran plot. Structure & functions of globular proteins, conjugated proteins, immunological techniques to investigate proteins, artificial synthesis of polypeptide. LCD, NMR & X-Ray crystallography. ➢ Protein folding – Anfinsen's dogma, Levinthal paradox, Co-operativity in protein folding, free energy landscape of protein folding & pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation. 1) Amino acids – Structures, properties, functions & classification of common & uncommon amino acids. 2) Peptides – Prepeptide & peptide bonds, partial double bond, nature of peptide linkage, types of peptides, lengths of peptide chains. 1) Biosynthesis & regulation of amino acids and proteins (overview) 2) Catabolism of proteins & amino acids, proteolysis & putrification 3) Amino acids related to citric acid cycle 4) Amino acids and their metabolites as neurotransmitters & biological regulations. 5) Lectins 6) Stickland reaction ➢ Nitrogen metabolism : Glutamate dehydrogenase, glutamate synthase & glutamine synthetase, Urea cycle ➢ **Lipid chemistry:**

1) Fatty acid – Types & nomenclature
2) Saturated & unsaturated fatty acids
3) Structure & function of mono, di & triglyceride, Phospholipids, sphingolipids (membrane lipids), Glycerophospholipids, galactolipids, sulfolipids, sterols
4) Structure & function of steroids, terpenes & prostaglandins
5) Lipids as signals, cofactors and pigments, storage lipids
6) Phosphatidyl inositols and sphingosine derivatives as intracellular signals, Eicosanoids, Prostaglandins, Thromboxanes, Leukotrienes, Vitamins: A, D, E and K, ketone bodies formation.
7) An outline of method of the extraction, separation and identification of cellular lipids.

- Lipid Metabolism – Overview of fatty acid metabolism, synthesis & degradation of fatty acids, β & Omega oxidation of lipids, role of acylcarnitine in transport. Activation & transport of fatty acids to Mitochondria

1) Steroid metabolism: Structure of steroids, biosynthesis of cholesterol, bile acids, other isoprenoid compounds.
2) Eicosanoid metabolism: Structure, biosynthesis & catabolism, biological action.
3) Phospholipid metabolism: Structure, biosynthesis of phospholipids (in bacteria), glycerol phospholipid metabolism (in eukaryotes)
4) Hormones in regulation of metabolism: Classification of hormones on basis of chemical structure & mechanism of action, hormone synthesis, signal transduction, steroids & thyroid hormones, endocrine glands & their secretion - ketone bodies formation.

- **Carbohydrate chemistry –**

Nomenclature of carbohydrates & types
(a) Monosaccharides & disaccharides
(b) Polysaccharides
(c) Glycoconjugates

Carbohydrate as informational molecules – the sugar code, An outline of methods of carbohydrate analysis.

- **Metabolism** **16-h**

Synthesis of Carbohydrates :

- Interconversion of sugars, gluconeogenesis, synthesis of disaccharides & polysaccharides.
- Regulation of blood glucose & homeostasis, glycogenesis & regulation.
- **Catabolism of carbohydrates.**
    1. General scheme of catabolism - Historical & experimental details in derivation of metabolic pathway.

	2. Glycolysis & catabolism of hexoses - catabolism of glucose to pyruvate, catabolic fate of pyruvate, substrate level and oxidative phosphorylation, ATP synthesis, Pentose sugar pathway (phosphoketolase) of glucose oxidation, glycolysis aerobic & anaerobic respiration, Electron Transport Chain. 3. The citric acid cycle: Tri carboxylic acid cycle (TCA)/ Kreb cycle, Production of acetyl CoA, reactions of citric acid cycle and mchanism, energetics, Anaplerotic reactions, regulation of the citric acid cycle, The glyoxylate cycle, coordinated regulation of glyoxylate and citric acid cycles. 4. Hexose monophosphate shunt - Entner – Dudoroff (ED) pathway, glycolate pathway, Cori cycle, role of mitochondria in apoptosis and oxidative stress 5. Complex carbohydrates – Types and general function, aminosugars, sialic acid & mycopolysaccahrides, glycoproteins & proteoglycans, blood group sugar compounds, Sugar nucleotides, bacterial cell wall compounds, lectins (specificity, characteristics & uses), pectins & xylans
Unit VI	**Nucleic acids – chemistry**: Structure of nucleosides /nucleotides & nomenclature – Denovo & Salvage pathways of nucleic acid synthesis (a) Structure of DNA: Watson – Crick's Model, A, B and Z form of DNA, Unusual DNA structures – palindromes, mirror repeats, inverted repeats, hairpin (or cruciform), Hoagsteen pairing, triplex DNA's, G tetraplex DNA, H – DNA, Tm & it's relation to GC content. (b) RNA: monocistronic and polycistronic RNA, base – paired helical structure in RNA. (c)Chemical and enzymatic degradation of nucleic acids - Denaturation and renaturation of double stranded DNA and RNA, DNA hybridization, Chemical synthesis of DNA (automated), methods of DNA sequencing , large scale DNA sequencing.
Unit VII	➢ **Porphyrin's Chemistry** - Chlorophylls, Cytochromes and Hemoglobin, leg –haemoglobin, Rhodopsin, Chemistry of microbial pigments, photosynthesis and photophosporylation – dual role of cytochrome B6F and C6 in cyanobacteria, cytochrome P450, photophosporylation in halophiles – Halobacterum salinarium, ATP synthase of chloroplast ➢ **Vitamin chemistry:** (Water soluble and fat soluble vitamins): Structure and functions of: (a) Water soluble Vitamins – Vitamins B1, B6, B12, Folic acid, Pantothenic acid, Niacin and Biotin.

	(b) Fat soluble Vitamins – Vitamins A, D, E and K.
Unit VIII	**Enzymology 13-h** ➢ Basic concepts - Nomenclature and classification of enzymes according to International Union of Biochemistry & Molecular Biology (IUBMB) ➢ Types of specificities – Substrate & products, bonds, group relative of absolute specificity, factors responsible for specificity ➢ Structure of Enzymes– Physical structure of enzyme, monomeric & oligomeric, concept of active site, Ogstin's experiment, Lock & Key, induced fit hypothesis. ➢ Enzyme kinetics – Introduction to chemical kinetics, kinetics of single substrate, enzyme catalysed reactions - Wilhelmy's & Brown's Work, Henri, Michaelis – Menten derivation, Briggs – Haldane Modification, Significance of the Michaelis – Menten Equation and K_m, modifications of Michaelis – Menten Equation- Lineweaver – Burk Plot, Eadie – Hofstee, Hanes Plots - Eisenthal and Cornish – Bowden plot, kinetics of multi substrate reactions. ➢ Inhibition: Basic concept, kinetics, examples & significance of reversible & irreversible inhibitions. ➢ Enzyme regulation: Ribozymes/ isoenzymes / artificial enzyme types & therapeutic applications. ➢ Applications of enzymes in various fields.
Unit IX	• Oxidation of aliphatic & aromatic hydrocarbons; α, β, Omega oxidation, β – ketoadipate, valerate & gentisate pathway • Pasteur & Crabtree effect

PG HM – P202 Practicals related to Foundation of Biochemistry – Biomolecules & Metabolism

1	Preparation of buffers and validate Henderson-Haselbach equation	02 hrs.
2	Estimation of carbohydrate from samples (food, feed & microorganisms) • DNSA method (fruit juice) • Phenol Sulphuric acid (Deubois) (Bacterial cells) • Anthrone method (starch from potato, reducing and total sugar)	03 hrs.
3	Estimation of glucose, glycogen and fructose from liver cells by glucose oxidase and resorcinol method respectively.	02 hrs.
4	Determination of amino acids by ninhydrin method	01 hour.

5	Determination of protein content by a) Biuret method b) Lowry method c) Dye binding method d) UV- Spectrophotometric method e) Bradford's method	04 hrs.
6	Viscosity studies of proteins	01 hour.
7	Estimation of proline, lysine, tryptophan content in plant sample	03 hrs.
8	Estimation of lipids/fats by a) Acid value b) Saponification value c) Iodine number d) Gravimetric/ solvent extraction method	04 hrs.
9	Determination of pk values of buffers by titration curves	01 hour.
10	Interpretation of Ramchandran plot	01 hour.
11	Estimation & isolation of cholesterol/lecithin from egg yolk	03 hrs.
12	Estimation of RNA (Orcinol method) & DNA (Diphenylamine method) (UV Spectrophotometric methods) from samples	04 hrs.
13	Electrophoretic separation of serum protein by Agarose and PAGE	04 hrs.
14	Degradation of aromatic compounds like napthaline by using microorganisms	03 hrs.
15	Separation and identification of sugars from juices by TLC	03 hrs.
16	Induction of β- galactosidase in *E. coli*	03 hrs.
17	Estimation of inorganic phosphate by Fiske & Subbarao method.	02 hrs.
18	An enzyme purification (any one) amylase/ protease/lipase/ invertase/restriction endonuclease/ thermostable DNA polymerase/ celluloses/ pectinase/ chitenase/ glucose kinases/ keratinase from microbial source a) Preparation of cell free lysate/ supernatant b) precipitation by solvent/ salt followed by dialysis c) enzyme assays d) Purification of enzyme by any one method ion exchange chromatography / gel filtration/ affinity chromatography and generation of purification table e) Factors affecting enzymes activity - substrate (Km) , enzyme concentration, pH, temperature and metal ions f) Assessing purity of enzyme by SDS PAGE	10 hrs.
19	Separation of lipids/ fatty acids by TLC & paper chromatography from membrane lipids of halophilic archea	03 hrs.

20	Clarity of veins of leaves of plants by biochemical methods and the presentation of cleared leaf structures (leaf vein clarity studies)	03 hrs.
21	Extraction and qualitative detection of different phytochemicals using chemical methods – tannins, saponins, flavonoids, alkaloids, glycosides, sterols and phenolic compounds	

M. Sc. I, Semester II

PG HM – T203 Foundation of Environmental Pollution and Control

Unit 1: Water Pollution and Control

Freshwater Pollution:

- Types and sources of freshwater, inorganic and organic pollutants responsible for water pollution: Biological pollutants; Pesticides; Radioactive pollutants, etc. effluent standards, drinking water standards, characteristics of domestic waste, Characteristics of agricultural waste.
- Consequences of water pollution: Effects on health, on biosphere and on economy.
- Remedial measures of freshwater pollution
- Case studies on freshwater pollution

Ground water Pollution:

- Sources, groundwater contamination zones
- Groundwater remediation *in situ* and *ex situ* techniques; bioremediation strategies of groundwater using bio-venting, biosparging, bio-slurpping, permeable reactive barriers
- Groundwater monitoring using Piezometer, slug and pumping tests; Darcy's Law for estimation of hydraulic parameters, numericals, simulation for aquifer yield prediction, Artificial recharge and induced infiltration, land subsidence;
- Coastal aquifers and sea water intrusion, Environmental regulatory bodies preventing groundwater pollution
- Case studies on groundwater pollution

Marine Water Pollution:

- Sources, types and consequences;

- Ballast water pollution, pollution due to off shore drilling, deep mining, oil extraction and other sources
- Marine water pollution prevention methods, control measures using bioremediation (bio-surfactants, microcosms), physical (booms, skimmers, absorbents etc.) and chemical methods (dispersants, detergents etc)
- Case studies on marine water pollution

Unit 2: Soil Pollution and Control

- Types, effects and sources and consequences, Mechanism of interaction of waste with soil, Transport processes (biological process-microbial transformation of heavy metals), Specifications for disposal of sewage and effluent on land for irrigation and ground water recharge.
- Methodology of wastewater disposal on land in India. Impacts of usage of land for solid waste disposal (municipal and industrial solid wastes including fly ash from thermal power station, lime sludge from pulp and paper mills), Disposal of hazardous solid waste (heavy metals, toxic organic compounds) on land and its impact on soil pollution, deterioration of soil due to mining activities
- Case study on soil pollution

Unit 3: Air Pollution and Control

- Causes and effects: Definition, Composition of air, Classification of air pollution, Sources, Effect of gaseous and particulate pollutants on animals, plants and human health, Economic effects of air pollutants, Vehicular Pollution, Industrial Pollution.
- Air Pollution - Meteorology and Chemistry
- Wind as a factor, temperature structure, role of atmospheric stability, dispersion of air pollutants, Chemical Principles and Troposphere and Stratospheric Ozone Chemistry: Ozone formation & destruction, Polar Stratospheric Clouds (PSPs)
- Air Quality Analysis - Air monitoring instruments and techniques: SOx, NOx, O_3, HC, Pb, CO, Particulate Matters, etc.
- Air Pollution Control Technology - Equipments and Basic Operating Principle; Control of air pollution by fuel selection, principle and working of – cyclones, scrubbers, settling chambers, fabric filters and electrostatic precipitators; Control of gaseous pollutants – absorption, adsorption, condensation, vapor incineration.
- Air Quality Management: Policy and Institutional Framework, Ambient Air Protection Policy, Air Quality Norms, Regulation of Emissions from Stationary & Non-Stationary Sources; Public Informing and Participation in Decision Making Process, Planning and Implementation of Ambient Air Protection Measures.

- Strategies for Air Pollution Control - Control of air pollution by fuel selection and utilization, by process modification or equipment, by site selection and zoning, etc.
- Case Studies on Air Pollution – Bhopal gas tragedy

Unit 4: Noise Pollution and Control

- Introduction to noise and vibrations, physics of sound and hearing, noise pollution -sources and effects.
- Noise control at source - Source path receiver concept, control by design, control by redress; Noise control in the transmission path- acoustical separation, physical barriers, isolators and silencers; protecting the receiver - personal protection device
- Noise Monitoring and Impact Criteria - Noise measuring techniques, national standard for noise, noise monitoring methods - Weighted Sound Level, Basic Noise Unit; Maximum Sound Level (L_{max}) During a Single Noise Event; Sound Exposure Level (SEL); Exposure from a Single Noise Event Hourly Equivalent Sound Level (L_{eq} (h)); Day-Night Sound Level (L_{dn}): 24- Hour Exposure from All Events; A Noise-Exposure Analogy for L_{eq} and L_{dn}
- Investigation and assessment of impact of noise, considerations in applying the Noise Impact Criteria; Mitigation Policy Consideration; determining the need for Noise Mitigation.
- Case studies on noise pollution

Unit 5: Radiation Pollution and Control

- Radioactivity – types and measurement, detection of nuclear radiations – G. M. counter, scintillation counter, semi-conductor detector.
- Radiation hazards and safety – natural and manmade; Internal and external radiation hazards, safe handling methods, personal dosimeter, reactor safety.
- Interaction of radiation with matter, units of measurements, half-life period, radiation dose measurement, biological effects and health hazards associated with radiation, Interaction of radiations with biological cells, somatic and genetic effects.
- Classification of radio-active wastes – gas, solid, liquid.
- Control measures – treatment and disposal of radio-active waste, generation of waste from various sources. ICRP recommendations. AERB classification, maximum permissible dose.
- Case studies on radiation pollution - Three miles and Chernobyl accidents.

Unit 6: Solid and Hazardous Waste Management

- Introduction - Definition, Historical development, Source and type based classification, chemical and physical composition, Environmental and health impacts due to solid waste and its handling; Characterization: physical & chemical characteristics, implications for solid waste management; Factors affecting solid waste management: Climate, financial, cultural constraint, quality and quantity of waste.
- Municipal Solid Waste management in India - Generation, Collection, segregation, Transportation, Transfer stations, processing and disposal; Assessment of existing situation & possible areas for improvement
- Industrial solid waste management: Pulp and paper, Sugar, thermal power station, textile, food processing, mining, agriculture, distillery, pharma, poultry, religious waste and GM industry etc.
- Treatments and disposal: Waste processing, Recovery of biological and chemical conversion products composting, biomethanation, RDF system, hydrolysis, pyrolysis, plasma gasification, incineration, sanitary landfills; resource conservation and recycling
- Biomedical waste management: Definition, scope, categorization, segregation, packaging/colour coding and container used, treatment, transport and disposal, status in India.
- Hazardous waste management: Identification and sources, characteristics and categorization, collection, segregation, packaging, labeling, transportation, processing (3R), risk assessment and waste management treatment and disposal, storage and leak detection, site selection criteria, manifest system and records, Indian scenario, Responsibilities of various authorities.
- Electronic waste management: A growing problem, sources, segregation, collection, recovery of valuable materials, treatment and disposal methods
- Plastic waste management- types of plastic, sources, the problem of plastic waste, degradation of plastics, recycling & alternatives to plastic (bioplastic), Maharashtra Plastic Ban notification 2018
- Construction and demolition waste management

Unit 7: Indicators of pollution – air, water, soil and its significance

Unit 8: Astrobiology and space pollution: case study

PG HM – P203: Practicals

Sr. No.	Practical	Hours
1	Testing of water sample with respect to drinking water standards (WHO, IS)	06 hours
2	Determine disposable feasibility of a treated industrial waste on soil / in the water	04 hours
3	Detect the nature / source of pollution in well water samples nearby agro based industries (pesticide, distillery etc.)	04 hours
4	Adsorption of pollutant as a way of remediation in the purification of polluted groundwater	02 hours
5	Case study on polluted fresh water / ground water	03 hours
6	Case study of marine water pollution	03 hours
7	Case study on air pollution/ radiation (Bhopal gas tragedy, Chernobyl and Japan atomic power plant explosion, three miles)	02 hours
8	Air quality monitoring for SO_x ,NO_x , O_3, HC, Pb, CO, PM	04 hours
9	Average air metrological studies (temperature, pressure, moisture/ humidity, visibility, wind direction / speed, rain / precipitation)	04 hours
10	Case studies on soil pollution and bioremediation (pesticides / heavy metals)	04 hours
11	Analysis of soil parameters – Moisture, temperature, pH, water holding capacity, NPK, bulk density, agrochemical content etc.	06 hours
12	Noise pollution - case studies on noise pollution, average sound levels in festivals and monitoring of noise	02 hours
13	Radiation pollution – Detection of radioactivity in the air, water, soil, food samples – milk, grains, agro products, fruits and vegetables by suitable methods	04 hours
14	Calculate the half life of given radioisotopes from given data	01 hours
15	Categorisation, segregation & results interpretation of given waste sample	02 hours
16	Preparation of the bio-cement using microorganisms	04 hours
17	Preparation of bioplastic using microorganisms and other biomaterial as a substitute to synthetic plastic	05 hours
18	Case study on Astrobiology Space pollution	02 hours

M. Sc. I, Semester II

PG HM – T204 Fundamentals of Molecular Bionanotechnology

Unit	Topics	Hours
Unit I	Introduction to Nanotechnology/Nanosciences, History of nanotechnology and its emergence, Concept of nanobiotechnology, nanowire, nanomedicine, nano quantum dots, nano composite, nanoparticles	
Unit II	Types of Nanoparticles and their properties- Quantum dots, polymeric nanoparticles Types of nanomaterials – Carbon nanomaterials (Fullerin, nanotube, nanofibers, nanowires, buchy ball) Magnetic nanoparticles, Nano structures- organic and inorganic nanoparticles, bionano structure – protein, carbohydrate, lipid and DNA based, fundamentals of Bionanotechnology- Nanomotors of biological systems- ATP synthase, Nanomachines (nanoturbine), flagellar motors in bacteria, linear molecular motors, collagen Metal Nanoparticles (Zinc, Cadmium, Platinum, Silver, Gold and Titanium), metal oxides nanoparticles, dendrimers, composites	
Unit III	**Methods for synthesis on nanoparticles** Top down and Bottom up approaches; Physical, Chemical and Biological methods Chemical precipitation and co- precipitation; polyol, borohydrate reduction methods, Solgel synthesis, microemulsion synthesis, hyrothermal synthesis, solvothermal synthesis, microwave assisted synthesis, sonochemical assisted synthesis, core shell nanocomposites, quantum dots (QDs) synthesis, Microbial/ Plant mediated nanoparticles production, overview and concepts of microbial/ plant mediated nanoparticles production methods; Biosynthesis of nonmaterials -biosystem as nanofactories, bacteria as machinery for synthesis of nanometals- gold, silver, zinc, cadmium and platinum, role of magnetotactic bacteria (natural synthesis of magnetic nanoparticles), nanobiotechnology and viruses, fungi and actinomycetes as fabricators of nonmaterials, plants as nanoenginers and algae as nanotechnologist-(diatoms)	
Unit IV	**Physicochemical characterization of nonmaterials** Optical (UV visible, FTIR, Photoillumination spectroscopy, fluorescence) X-Ray diffraction (XRD), Electron microscopy (SEM, TEM, AFM, and STM), surface and composition (ECSA, EDAX), particle size analysis and charge distribution analysis- imaging and size (electron microscopy, light scattering- dynamic light scattering (DLS), NTA, Zeta potential); Toxicity evaluation of nonmaterials, cytotoxicity and genotoxicity *in vivo* test/assays, its contentment, fate of nonmaterials, environmental and health impacts of nanoparticles (ecotoxicology)	
Unit V	**Application of nanoparticles in** 1) Protein, Lipids, DNA and RNA (DNA and proteins as templates for molecular nanotechnology and nanoelectronics 2) Protein targeting-Small molecule/ nonmaterial- protein interactions, nonmaterials - cell interactions, manifestation	

	ofsurface modification (polyvalency), nonmaterials and nanomedicine, diagnostics/ drug delivery and therapeutics, Peptide/ DNA coupled nanoparticles, lipid nanoparticles for drug delivery (protein and nanoparticles mediated drug delivery), inorganic nanoparticles for drug delivery, targeted drug delivery, metal/metal oxide nanoparticles (antibacterial/ antifungal/ antiviral activities), anisotropic and magnetic particles (hyperthermia), MRI, imaging surface modified nanoparticles, MEMs/ NEMs based nonmaterials, disease diagnosis at proteomic level, Biosensors (nucleic acid and protein based), Lab on chips, applications in gene therapy, cancer biology (manipulation of cell and biomolecules, cytoskeleton and cell organelles); Use of nanoparticles in MRI, DNA and protein microarray, toxicology in nanoparticles – dosimetry	
Unit VI	Applications of nanobiotechnology in 1) Food sciences- food processing /food packaging/ detection of pathogens 2) Nanosensors 3) Nanotechnology for environment – water purification, remediation, desalination, monitoring water quality and detection of pollutants 4) Nanotechnology in the development of green chemistry- green nanotechnology 5) Nanotechnology in agriculture 6) Nanotechnology in nanobiodevices, nanoimplants and cosmetics	

PG HM – P204: Practicals

1	Synthesis of metal (Gold, Silver), metal oxides (Zinc, Platinum, Titanium), nanoparticles synthesis by chemical, microbiological (bacteria, actinomycetes, yeasts and molds, algae, green synthesis) and plant based methods, purification of nanoparticles Sunlight induced, rapid and induced biogenic synthesis of silver nanoparticles using aqueous leaf extract of *Oscimum santum* Synthesis of magnetic nanoparticles by co-precipitation methods	
2	Characterization of nanoparticles by spectroscopic methods (UV visible), XRD and FTIR scan , DLS, NTA, Zeta potential, Electron microscopy of thin films of nanomaterials, determination of absorption coefficient for different wavelength.	
3	Study of stabilization of nanoparticles	

4	Survival curve and antimicrobial effect of gold and silver nanoparticles on growth of pathogenic bacteria and fungi, MIC and MBC determination and its estimation.	
5	Cytotoxicity testing of nanoparticles using MTT – Trypan blue assay	
6	Study of dye decolourization activity	
7	Synthesis of gold nanoparticles, its assembly and conjugation with biomolecules (bovine serum albumin -BSA)	
8	SDS PAGE gel sift assay for study of nanoparticles biomolecules assembly	
9	Preparation of PGLA – tetracycline functional nanoparticles using imulstion diffusion method / nanoprecipitation / dilution method	
10	Conjugation between PGLA & tetracycline	
11	Study of synergistic effect of antibiotics & nanoparticles	
12	Study of preparation & characterization of carbon nanotubes/ fullerin / nanofiber/ nanowires	
13	Study of magnetic nanoparticles – magnetotactic bacteria	
14	Study of ATP synthase as nanoturbine & collagen as nanomachine / motor / molecular motor	
15	Study of purification of water using nanotechnology/ use of nanosensors	

M. Sc. I, Semester II

PG HM – T205E1 Biostatistics and Bioinformatics

Part A: Biostatistics- **20-h**

Unit I	Fundamentals of statistics 1) Nature of environmental data – empirical & experimental 2) Concept of population & sample, statistical inference
Unit-II	Univariate data – 1) Frequency distribution & their properties (including Skewness & Kurtosis), histogram, frequency curve & ogive curve 2) Measures of central tendency – Mean, median & mode 3) Measures of dispersion – Range, variance, standard deviation & coefficient of variance. 4) Presentation of data – summary, statistics & graphical representation methods, Carl Pearson coefficient & Spearman's coefficient of correlation.
Unit-III	Bivariate data – 1)Obtaining bivariate data by measuring two variables on a single sampling unit. 2)Summary statistics for bivariate data - mean, standard deviation & covariance, correlation coefficient 3)Scatter plot & it's interpretation

Unit IV	Multivariate data - Multivariate analysis, PCA, Q-mode & R-mode factor analysis, time- series data analysis, moving averages, wavelet analysis/spectral analysis, introduction to MATLAB.
Unit V	Hypothesis testing – Null & alternate hypothesis, Type I & Type II errors, Level of significance, power of test, p-value
Unit VI	Parametric test – 1) Large sample tests – Testing significance of single population mean, testing of two population mean 2) Small sample tests – Testing significance of single population mean, testing difference between two independent normal population mean, testing difference between two correlated normal population mean, testing significance of correlation coefficient 3) X^2test (Chi square test) – Testing single population (t- test), variance testing, testing goodness of fit, testing association between two attributes 4) F-test - Testing equality of variance. 5) ANOVA – One Way & Two Way (ANOVA) classified data
Unit VII	Nonparametric tests – Man-Whitney U-test, Wilcoxon signed rank test, The Kruskal – Wallis H-test
Unit VIII	Probability – Concept, basic laws, applications, Mendelian segregation, concept of probability, Distribution – Binomial & Poisson distributions, normal distribution & their applications to biology
Unit IX	Vital statistics – Death rate & death ratio – measures of mortality & morbidity, statistical software – Excel, XPSS Sampling – advantage of sampling over census, population growth model, mathematical model for pandemics
Unit X	Statistical Quality Control (SQC) - Meaning of quality/ Statistical quality control, control chart for variables (X – Bar & R – charts)

Part B: Bioinformatics- **20-h**

Unit I	**Introduction to Bioinformatics – Bioinformatics resources** • Use of bioinformatics in major research areas, knowledge of following databases used w.r.t. organization of data, Contents and format of database entries, retrival of data using textbased search tools, sources of data (e.g. sequence projects, individual scientists, patent offices, etc.), methods for deposition of data to databases • Major Bioinformatics resources - National Centre for Biotechnology Information (NCBI), European Bioinformatics Institute (EBI), Expert Protein Analysis System (ExPASy), the knowledge of various databases & bioinformatics tools available at the resources, Major content of the databases, purpose & utility in the lifesciences. • Open access bibliographic resources & literature databases – basic concept & applications in life sciences, the significance & need for such

	resources, how to search and use these resources/ databases with special reference to PubMed, PubMed central, public library of sciences
Unit- II	Biological Search Engines – • SRS & ENTREZ • Biological databank – PDB, MMDB, NDB (Structural database) • Derived databases – Prosite, Pfam, PRINTS, CATH, SCOP, DSSP, FSSP, DALI, BLOCKS, Prodom • Nucleic acid – Genebank, EMBL, DDBJ • Protein databases – UniProtKB, SwissProt, TrEMBL • Genome databases - NCBI, EBI, TIGER, SANGER, (Viral genomes, Archeal, bacterial genome) • ORFs (ORF Finder, Intron - Exon Finder), ESTs, Codon Biases, Redundancy, Conserved Motif, Patterns, Blocks, Domains, Multalign, dialign, GeneBee, TMPred, GOR, Chou-Fasman NNPredict, Promoter Finder, NEB Cutter
Unit- III	Biological data analysis – • Overview, concepts & tools • Sequence comparison by dot-matrix & dynamic programming • Pairwise sequence analysis by Needleman - Wunsch algorithm, Smith - Waterman alignment algorithm • Scoring matrices for nucleic acid and protein: PAM, BLOSSOM, CSW, MDM • Databases search (pairwise alignment) : BLAST & FLSTA, Psi-BLAST • Multiple Sequence Alignment: Basic concepts, Progressive and Hierarchical approaches, PRAS, CLUSTAL-W, applications • Immunoinformatics databases
Unit IV	Protein structure prediction- • Necessity of protein structure prediction – Basic approaches, comparative modelling. • Secondary structure prediction. • Fold recognition. • Homology modelling • Ab- initio methods
Unit V	• Genomics & Proteomics 1) Genomics • Large scale genome sequencing strategies, gene networks – basic concepts & computational models, such as λ repressor & lac-operon. • Functional genomics & comparative genomics • Identification of genes with unknown function, genomic analysis of pathogenic microbes & extremophiles, environmental genomics (metagenomics) 2) Proteomics - Functional Proteomics, structural & protein modelling 3) Metabolomics – metabolic pathway databases – KEGG, ECOCyc and MetaCyc, Metabolic pathway prediction 4) Enzyme-compound & reaction databases – • Ligand – Biochemical & reaction databases

	• Enzyme – Enzyme database • BRENDA 5) Chemoinformatics – Introduction, applications in pharmaceutical industries (structure based drug design & drug discovery) – (Pharmacogenomics) 6) Immunoinformatics – Overview, reverse, vaccinology, rational vaccine design.
Unit VI	Microarrays – • DNA microarray – Understanding of microarray data correlation of gene expression data to biological processes & computational analysis tool, especially clustaling approaches, bioinformation prospective on human diseases, SNP • Protein arrays – Bioinformatics based tools for analysis of proteomics data (tools available at ExPaSy proteomic server), databases (such as InterPro) and analysis tools, prediction of 3D structure of protein
Unit VII	Taxonomy & phylogeny Basic concepts of phycogenetic analysis & tree constructions, rooted / uprooted trees/ approaches for phylogenetic tree constructions; phylogenetic analysis algorithm such as HyperChem, In-2, Viewverlite, SWISS Prot, AliBee, Phylip, TCS Biosuite, Maximum, ParsiMony, UPGMA, Transformed distance, Neighbours- relation, Neighbour-Joining, probabilistic models and associates algorithms such as probabilistic models of evolution and maximum likelihood algorithm

Sr. No.	Practical	Hours
1	Assignment on Google for scientific information search by using Pub-Med, Medline, Pub – Med central for biological information.	01 hour
2	Visiting NCBI, EMBL, Uniprot, Genebank, ENTEZ, SwissProt, TrEMBL, Websites & services available, software tools available, databases maintenance (sequence information resource)	01 hour
3	Creating & populating databases – MS access	02 hours
4	Introduction & use of various genome databases	02 hours
5	Retrieving protein & nucleic acid databases – from databases – (Assignment on Genebank & study of nucleic acid & protein sequence data)	02 hours
6	Assignment on single & multiple, Pairwise sequence alignment, Using BLAST, CLUSTAL & CLUSTAL W, Similarity searching & interpretation of results (Orthologs, Paralogs & homologs)	03 hours
7	Construction of Phylogenetic Tree – Phylogenetic analysis of protein & nucleic acid sequences	02 hours
8	Structure of proteins – Secondary, tertiary & quaternary, bond angle, bond length, different interactions, identification of chain helices, special groups, metal ions, CATH/SCOP, Classification of given proteins, Structure prediction databases (PDB), ligand protein interactions, Studying 3D protein structure using RASMOL (through common line) - Model building & energy minimization	04 hours
9	Use of gene prediction methods (GRIAL, Genscan, Glimmer)	02hours
10	Use of RNA structure prediction tools	02hours
11	Use of different primer designing & restriction site prediction tools	02hours
12	Motif finding, KEGG, DDBJ, PIR	01 hour
13	Introductions to Bio Edit	01 hour
14	Constructing of 3D models by using SPARTAN	01 hour
15	Introduction to Chimera	01 hour
16	Molecular docking & drug designing – exercises	02hours
17	Gene annotation	01 hour
18	Proceed to analyse the tetrad in the *Neurospora crassa* from given data	01 hour

PG HM – T206 E2 Quantitative Biology

Unit 1: FOUNDATION COURSE IN MODERN BIOLOGY

Cell as the basic unit of life; Cell aggregates: tissues, organs and organisms; Molecules of life: nucleic acids, proteins, carbohydrates and lipids, their structure and function; Genome organization and replication; Gene expression and regulation; Thermodynamics of biological systems; Biomolecular interactions; Immune system; Drug action and drug discovery; Biodiversity.

Unit 2: INTRODUCTORY BIOMATHEMATICS & BIOSTATISTICS

Numbers and Algebra; Functions and equations; Trigonometry and Coordinate geometry; Limits and Discontinuities; Introductory Calculus: Differentiation and integration; Vectors and Matrices; Fourier and Laplace Transforms; Set theory and Group theory; Statistics and Probability: Distributions, Correlation and Regression; Principal Component Analysis; Clustering; Fractals; Applications

Unit 3: BIOINFORMATICS

Role of computers in Biology and Medicine, Biological databases: Primary and secondary databases for Proteins, Nucleic acids (DNA/RNA), Metabolic pathways, Microbial and Cellular data bases, NCBI, EMBL, KEGG, DDBJ, SWISSPROT, PDB, PIR etc.; Tools for DNA sequence analysis, protein sequence analysis; Usage of sequence alignment and searching tools for Gene Identification, Genome Annotation, ORFs, ESTs, Codon biases, Redundancy, Search engines; Conserved motifs, patterns, blocks, domains, Secondary and tertiary Structure prediction tools; FASTA, BLAST, PSI-BLAST, CLUSTALW, Multalign, Dialign, GeneBee, MotifScan, TMPred, GOR, Chou-Fasman, NNPredict, Promoterfinder, NEBcutter, Genscan, ORF Finder, IntronExon finder etc.; Using Biological databases; Structure visualization and Building; Protein Sequence Analysis; Genome Analysis; Protein Secondary and Tertiary structure prediction; Homology Modeling; Phylogenetic Analysis Software and Tools: Swiss PDB Viewer, Hyperchem, InsightII, Viewerlite, Rasmol, BLAST, Alibee, Phylip, CLUSTAL, GLIMMER, TCS Biosuite Special topics: Bioinformatics perspectives on human diseases; SNPs; DNA microarrays

Unit 4: COMPUTATIONAL BIOLOGY

Methods and algorithms for Biological data analysis and interpretation. Algorithms for Genome analysis & Gene finding: Markov models and Fourier Transform techniques; Theoretical models for Sequence Comparisons of Nucleic acids & Proteins. Sequence and structural, global and local, pairwise and multiple alignment techniques. Algorithms for homology based protein structure prediction with applications, their merits and limitations in protein folding. Practical Aspects of Homology Modeling. Approaches for protein structure prediction: Homology Modeling, Rosetta Stone. Importance of Parallelization and clustering in computational biology, Introduction to biomolecular modeling and simulation; Methodologies and Algorithms for Analysis of DNA & Protein sequences. Probabilistic and Discriminative approaches with applications to genome and protein sequence analyses. Computational approaches to protein structure prediction: Threading and Homology based approaches, Experimental techniques for 3-D structure

elucidation: X-ray crystallography, Gene prediction: Interpolated Markov Model, Hidden Markov Model, Dynamic programming, Significance of computational approaches in studying protein & DNA structure and function.

Unit 5- MODELING AND SIMULATION

Introduction to ab-initio, semi-empirical & molecular mechanical methods, Theory and Practice of Energy minimization, Monte Carlo and Molecular Dynamics simulations. Generation of Electrostatic potential and field maps, Theoretical methods to calculate binding free energies and rate constants. Methods to model Nucleic Acids (DNA & RNA).

Unit 6- GENOMICS AND PROTEOMICS

Structural Proteomics, Experimental techniques for protein structure elucidation X-Ray crystallography, 2-D Electrophoresis, MALDI-TOF, Mass spectrometry, Protein microarrays, Bioseparation, Structural, Functional and Comparative Genomics, Microbial Genomics

Unit 7- DRUG DESIGN

Disease / disorder and Drug targets. Concept of receptor / target site. Concepts in molecular recognition. Drug-like properties and associated empirical rules. structure based drug design; Applications of QM methods; Molecular descriptors in QSAR studies, Small molecule force field parameters (charges), potentials, Active site identification algorithms, ligand docking algorithms, thermodynamics & kinetics of protein-drug binding. Drug stability, synthesizability and drug delivery.

Unit 8- SYSTEMS BIOLOGY

Emerging new ideas on treating biological systems as systems of molecular networks. Elements of system modeling and mathematical methods to formulate system's response to perturbations. New directions in metabolic pathways and cellomics to better understand organization of tissues, organs and organisms.

PG HM - T207 SECC Soft Skill and Personality Development

Planning and Goal setting:
Five skills needed to achieve carrier goals: Human perceptions, Understanding people, types of soft skills, Need for achievement and Spiritual Intelligence, Developing potential and self actualization

Conflicts and stress: Types of conflicts, conflict resolution skills, Types of stress, causes of stress, effects of stress and regulating the stress, Habits – Good and Bad habits, Forming Habits of success, Breaking bad habits.

Communication skills- Communication cycle advanced and essentials, Basic telephonic skills. Communication barriers- Interpersonal transactions, mis -communication Technology and Communication - Email- Principle, Netiquettes, E-mail etiquettes

Presentation skills: Overcoming fear, Becoming a professional, the role of body language, effective reading and using visuals.

PG HM - T208 Human Rights and Human Values

Unit 1: Human rights - Introduction, concept, nature and scope of Human rights. Fundamentals rights and Fundamental duties, Interrelation between rights and duties

Unit 2: Human rights in India
Basic / fundamental human rights
1) Right to equality
2) Right to freedom.
3) Right to freedom of religion.
4) Right against exploitation.
5) Cultural and educational rights.
6) Right to constitutional remedies.

Unit 3:
A. Declaration of human rights and national human rights commission of India and International human rights commission and their roles.

B. Rights of women and children, the minorities of human right, Human rights of economically disadvantaged society.

Unit 4: Human Values
Meaning, Definition, Importance of values, Types of values, Five core human values – Right conduct, Peace, Truth, Love and Non violence and conservation of values.

M. Sc. Part I Semester II

PG HM - T209 VAC : Intellectual Property Rights

Unit	Topics	Hours
Unit I	• Introduction to intellectual property & IP industries– General introduction to IP & IPR, types of IP – Patents, Trademarks, Trade secretes copyrights & related right, designs, geographical indication, biodiversity importance & legislation, plans variety protection (new GMOs) & farmers right, traditional knowledge. • History & role of international (conventions) treaties – GATT, WTO, WIPO, TRIPS, Budapest Treaty, CBD, Nagoya protocol, international framework for protection of IP, IP as factor in R&D, IPs of relevance to biotechnology, Agriculture, environmental, bioinformatics & pharma sector	**13 hrs.**
Unit II	• Concept of "Prior art" – need of prior art for IP types, Classification – search & it's implication invention in context of 'Prior art', patent databases, searching international databases, countrywide patent search, USPTO, EPTO, India etc., analysis & report formation.	**08 hrs.**
Unit III	Patent • Basics of patent – Eligibility criteria, Classification of categories, special patents & patenting biological products, Patentable & nonpatentable invention in India & abroad, Process of patenting, patent search & inventor's homework, drafting patent, patenting systems, rights of patent holders, assignment & licencing of patents & patent infringement, case studies, patent agent. • Patent drafting – National, PCT & conventional patent application, PCT & its implication, Role of country patent office, procedure for filling requirements, national & international patent applications forms, Fees & timelines, Cost & financial assistance for patenting, Introduction to existing schemes. • Indian patent act 1970, Patent rules 2003, Recent amendments, Definition: Anticipation, opposition, Biopiracy, Precautions before patenting – disclosure & non-disclosure. • Relevant case studies (3-4 cases – relates to patentability criteria, anticipation, infringement, opposition & biopiracy)	**10 hrs.** **13 hrs.**
Unit IV	• Patentability of Biotechnology inventions – Patentability of Biotechnology invention in India, Statutoric provision regarding biotechnological invention under the current patent act 1970 (& as amended 2005), Biotechnological inventions as patentable subject matter, territorial nature of patents, from territorial to global patent regime, interpreting TRIPS in the light of biotechnology inventions, feasibility of uniform global patent systems, merits & demerits of uniform patent law, Relevance of existing international patent, Tentative Harmonization Efforts - Implications of setting of uniform world patent system.	**08 hrs.**
Unit V	**Bioethics** Introduction, Bioethics in health culture – Euthanasia, artificial reproductive technologies, prenatal diagnosis, Genetic screening, Gene therapy, Organ transplantation, Ethics of clinical research, bioethics in research, Cloning & stem cell research, Human of animal experimentation, Agricultural biotechnology, Genetically engineered food, Environmental risk, Labelling & public opinion, bioterrorism: Carrier opportunities in the field of IPR.	**08 hrs.**

Sr. No.	Practical	Hours
1	To study a patent & to develop a patent application / process (Fermentation/ Microbial/ Animal products/ Process & design for production)	10 hour
2	Create a document for a copyright – e.g. industrial design, practical protocols, thesis protocol	06 hour
3	Turmeric, Basmati rice patents – Case studies	05 hours
4	Patent – Microorganism (GMO) as patent	05 hours
5	Leaf venation procedure as process design / patent	
6	To detect & suspect – Bioterrorism – detection of pathogenic microorganisms on the commonly used items *Bacillus anthrisis* on currency notes, plant pathogens in the plant seeds, nuisance plant (parthenium), *Pascalia glavca*, etc., viruses (pathogen through mosquito/ therapeutic agent, drug & food items, air, water, soil, pathogenic microbial bombs)	20 hours
6	Euthenaia - Samadhi and Sanjeevan samadhi	2.5 hours
7	Case study – • Organ transplantation – e.g. Kidneys, Coma (movie) • Prenatal sex diagnosis • Clinical research (unethical clinical trials) • Human cloning • Experiments on animals (unethical trials) • GMOs productions (by violating regulations e.g. BT Brinjal) • Plant varieties – e.g. Alphonso mangos (deception of farmers , fingerprinting) •	12 hours
8	Journal club – Review article writing on - Carrier opportunities in IPR/ IPR inspector/ Bio piracy	