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UNIVERSITY OF MUMBAI

Syllabus
for
Semesters III and IV
Program: M.Sc.
Course: Life Sciences
Specialisation:
Environmental Biotechnology

(Credit Based Semester and Grading System with effect from the academic year 2013-2014)

M.Sc. Life Sciences Syllabus
Credit Based and Grading System
To be implemented from the Academic year 2013-2014

SEMESTER III

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
PSLSCEBT301	I	Biomathematics	4	
	II	Research Methodology		
	III	Biostatistics		
	IV	Population Biostatistics		
PSLSCEBT302	I	Foundations of Environment and Ecology	4	
	II	Ecosystems		
	III	Natural Resources		
	IV	Current global environmental issues		
PSLSCEBT303	I	Air pollution	4	
	II	Water pollution		
	III	Land and Noise pollution		
	IV	Radiation, Thermal pollution, Oil Pollution and Electronic waste		
PSLSCEBTT304	I	Environmental degradation	4	
	II	Environmental toxicology		
	III	Environmental microbiology, diversity and systematic		
	IV	Biotechnological methods to control pollution		
PSLSCEBTP301	Biomathematics and Biostatistics		2	
PSLSCEBTP302	Environment and Natural Resources		2	
PSLSCEBTP303	Environmental Pollution		2	
PSLSCEBTP304	Dissertation on Literature Review		2	

SEMESTER IV

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
PSLSCEBT401	I	Bioinformatics – I	4	
	II	Bioinformatics – II		
	III	Intellectual Property Rights		
	IV	Bioethics		
PSLSCEBT402	I	Environmental Biotechnology	4	
	II	Fermentation in environmental biotechnology		
	III	Environmental monitoring		
	IV	Agricultural biotechnology		
PSLSCEBT403	I	Biotechnology for industrial and municipal wastes	4	
	II	Liquid waste management		
	III	Solid waste management		
	IV	Biological Degradation Of Hazardous Wastes		
PSLSCEBT404	I	Sustainable technology and biotechnology	4	
	II	Biofuels		
	III	Natural resource recovery		
	IV	Biotechnology of marine environment		

PSLSCEBTP401	Bioinformatics	**2**	
PSLSCEBTP402	Environmental Monitoring	**2**	
PSLSCEBTP403	Waste water analysis and isolation of industrially important microorganisms	**2**	
PSLSCEBTP404	Dissertation on Project	**2**	

M.Sc. Part – II Life Sciences Syllabus
Credit Based and Grading System
To be implemented from the Academic year 2013-2014

SEMESTER III DETAILED SYLLABUS

Course Code	Title	Credits
PSLSCEBT301	**Biomathematics / Research methodology / Biostatistics (60L)**	**4**
Unit I: **Biomathematics** **(15L)** Binomial Theorem (without infinite series) Determinants, Matrices, Rank of Matrices by Diagonalisation method Limit and derivatives, Differentiation (including differentiability), Successive Differentiation, Integration – Definite and Indefinite (ordinary, method of substitution, special trigonometric function, partial fraction) Application of integration to find area, Differential equations --homogeneous and Linear ODE's and its simple applications to biological problems		
Unit II: **Research Methodology** **(15L)** Meaning of Research, Objectives of research, motivation in research; Types of research – Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, Empirical and Other Types of Research; Research Approaches; Research Methods vs. Methodology; Research and Scientific Method; Research Process: Steps of research process; Criteria of Good Research; Sampling, Sample size determination, Plan for data collection, Methods of data collection, Plan for data processing and analysis; Ethical considerations during research		
Unit : III **Biostatistics** **(15L)** **Basics:** Introduction, scope, applications and uses of statistics, census and sampling surveys, **Data, graphical presentation of data:** collection and tabulation and graphical representation of data, frequency distribution **Practice of statistical methods** in biological research, Measures of central tendency (grouped and ungrouped data), samples and populations; Central tendency measures: Arithmetic mean, median, dispersion and its measures: variance and standard deviation, coefficient of variation. Standard error, Confidence limits Skewness and kurtosis		

Population parameters and sample statistics, sampling techniques: simple random sampling; stratified random sampling, systematic sampling, standard error estimation: point & interval, Estimators of population mean & proportion (without proof), confidence intervals for population mean & proportion. Regression and correlation and its application in biology; types of correlation, correlation coefficient	
Unit : IV **Population Biostatistics** **(15L)** Concept of probability, Theories of Probability – additive and multiplicative theory Random variable and its distribution, Probability distributions – Binomial, Poisson and Normal; Tests of statistical significance, **Testing of hypothesis:** Hypothesis and its types (Null hypothesis, Alternative hypothesis), Errors and its types (Type 1 and Type 2 error), Levels of significance, one-tailed and two-tailed tests, tests for single mean and single proportion, equality of the two population means and two population proportions , Critical region. Difference between parametric and non-parametric statistics; confidence interval, critical region, Levels of significance, t-test; Z-test; X^2 test; **Analysis of variance (ANOVA**), one-way ANOVA, Tukey's post hoc test, two-way ANOVA Basic introduction to Muetrovariate statistics, etc. Bivariate data, scatter diagram and interpretation, calculation and interpretation of Karl Pearson's correlation coefficient, equation of the lines of regression and properties of regression lines	

Practicals:

PSLSCEBTP301	**<u>Biomathematics and Biostatistics</u> (60L)** 1. Mathematical sums to be solved in biomathematics and biostatistics 2. Formation of frequency distribution and calculation of descriptive measures – mean, median, mode, variance, standard deviation and standard error 3. Large n small sample tests for sample mean and proportion 4. Calculation of correlation and regression, coefficients and tests of significance 5. ANOVA – one way and two way classification; Estimation of genetic components and heritability from ANOVA data	**2**	**04**

Course Code	**Title**	**Credits**
PSLSCEBT302	**Environmental Sciences (60L)**	**4**
Unit I: **Foundations of Environment and Ecology (15L)** **Environment**: Definitions, Components and Inter-relationships, Parts of environment, Ecology and Ecosystems, Interconnections in nature examples. **Man Environment relationship and impact of technology**: Early man and the environment (agriculture revolution and its impact on the environment; traditional ways of nature conservation, ecosystem imbalance); Change in Man-environment relationship (idea of progress and disappearing tradition of nature conservation); Impact of sciences and technology on the environment. **Ecology and ecosystem:** Structure and boundaries of ecosystem, evolution of an ecosystem, value of ecosystem and ecosystem services. **Food and energy:** First law of thermodynamics and second law of thermodynamics; Producers photosynthesis, consumers and decomposers, role played by decomposers; Food chains and food webs; Ecological pyramid, Pyramid of biomass and disruption of food chain		
Unit II: **Ecosystems (15L)** **Classification of ecosystems** – different biomes in different region, distribution of biomes, tropical rain forests, temperate forests, coniferous forests, arctic tundra, grasslands and deserts **Aquatic ecosystems** – oceans, marine ecosystems and open sea, coastal		

zones, coral reefs and their importance, mangroves, estuaries and coastal wetlands, freshwater life zones Impact of human activity on the marine ecosystems **Evolution of an ecosystem** – habitat and ecological niche, ecosystem as sustainers of life, value of ecosystems and its services. **Biogeochemical cycles:** Cycling elements, water cycle, carbon cycle, nitrogen cycle, phosphorus cycle, sulphur cycle. Impact of human activity on the cycling elements	
Unit : III **Natural resources** **(15L)** **Natural resources**: renewable and non-renewable natural resources, destruction and conservation of resources Geographical spread of biodiversity and extinction of species, Convention on biodiversity, Biodiversity in India, and Conservation of India's biodiversity. Endangered, Threatened and extinct species of the world **Water resources:** Availability of water resources, water needs, annual supply of water, water-shortage (reasons and its impact), Water scarcity and its management. Water use – irrigation, domestic, industrial, and miscellaneous; Methods of water conservation **Forest resources:** classification of forests, forest resources, destruction of forests – natural and manmade, International initiatives in forest conservation, State of forests in India, Local communities and forest conservation in India; Forest (Conservation) Act, 1980 **Energy resources:** Source of our energy, Pattern of global energy use, non-renewable fossil fuels (coal reserves, natural gas, nuclear power), Concerns regarding depletion of oil resources, renewable sources (solar, wind, hydropower, biofuel, fuel cells), Conserving and using energy efficiently. **Mineral resources:** Characterisation of mineral resources, formation of mineral resources, mining and its environmental impact, mineral resources and sustainability issues, environmental concerns of the depleting resources; Conservation, reuse and sustainable mining.	
Unit : IV **Current global environmental issues** **(15L)** Ozone layer depletion (Montreal protocol), El Nino, Acid rain - causes and effects, Green House Effect global climate change – GHG and green house effect, global warming – effect on oceans, coastline and marine ecosystem, impact of global warming on India. Response to global warming – Kyoto protocol and its outcome **Population and habitation:** Population explosion – Malthusian theory, distribution and growth of world population, Growth pattern of India's population. Scale of urbanisation in the world – migration and its implication, growth of worlds large cities, environmental implication of population growth and urbanisation in India. International initiatives on population related issues. **Environmental laws:** The Environment Protection Act, 1986;	

The Water (Prevention and Control of Pollution) Act, 1974; The Air (Prevention and Control of Pollution) Act, 1981; The Forest Conservation Act, 1980; The Wildlife Preservation Act, 1982; The Wildlife (Protection) Act, 1972; The Biological Diversity Act, 2002; The Biodiversity Rules, 2004; The Prevention of Cruelty to Animals Act, 1960	

Practicals:

PSLSCEBTP302	**<u>Environment and Natural Resources - I</u> (60L)** 1. Determination of total organic matter in soil. 2. Determination of pH value of different types of soil. 3. Determination of water holding capacity of soil. 4. To quantify hydrological cycle in different land use types in or around specified premises.	**2**	**04**

Course Code	**Title**	**Credits**
PSLSCEBT303	**Pollution (60L)**	**4**
Unit I: **Air pollution** **(15L)** Natural and anthropogenic sources of pollution, Primary and secondary pollutants transport and diffusion of pollutants, Effect of air pollution, control measures for air pollution; Methods of monitoring and control of air pollution - SO_x, NO_x, CO, SPM, PAN; Level of air pollution in India. Ambient air quality in India Bhopal Gas tragedy, Acid rains		
Unit II: **Water pollution** **(15L)** **Types and sources of water pollution:** marine, fresh and ground water; consequences of water pollution; Physiochemical and bacteriological sampling, analysis of water quality, sewage and waste water treatment, state of rivers in India – pesticide contamination of fresh water; status of world Sanitation and ecological sanitation. **Water quality and standards** **Marine pollution:** environmental effect of oil spills and oil leaks. Coastal pollution, international initiatives to control marine pollution Eutrophication and monitoring eutrophication; algal blooms		

Unit : III **Land and Noise pollution** **(15L)** **Soil pollution:** Sources of pollution – water logging, soil salinity, desertification, mining, pollution by plastic, dumping of hazardous and toxic waste. Recycling solid waste and restoring soil condition Industrial waste effluents and heavy metal – their interactions with soil components; managing of urban waste in India Chemical and bacteriological analysis of soil sample, soil sampling methods and procedures **Noise pollution:** Basic properties of sound waves – plane and spherical waves, sound pressure, loudness and intensity levels, decibel; Sources of Noise Pollution–Measurement and analysis of sound, Measures to control noise pollution.	
Unit : IV **Radiation, Thermal pollution, Oil Pollution and Electronic waste (E-waste)** **(15L)** **Radiation pollution:** Radioactive decay; Interaction of radiation with matter; Biological impact and health hazards associated with radiation, Units of radioactivity and radiation dose; Protection against ionizing isotopes and their applications in waste water and air pollution analysis and treatment; Radioactive waste disposal. **Thermal pollution:** Definition and sources, Chemical and biological effects of thermal pollution, Effect on marine life, bacteria and water quality and other aquatic biota; Thermal pollution from power plants and their control Methods for minimization and control of thermal pollution **Oil Pollution:** Oil pollution and marine ecology, sources of oil pollution, factors effecting fate of oil after spillage movement, spreading, evaporation, emulsification, dispersion, remote sensing in water quality monitoring **Electronic waste (E-waste):** Sources and types and constituents of E-wastes and its environmental consequences.	

Practicals:PSLSCEBTP303	**<u>Environment and Natural Resources - II</u> (60L)** 1. Determination of mechanical composition of soil by Pipette method. 2. To study the soil profiles for their height, color, texture and electrical conductivity. 3. Determination of total nitrogen value of the soil by Kjeldahl's method 4. Determination of SAR value of soil. (Sodium Absorption Ratio)	**2**	**04**

Course Code	**Title**	**Credits**
PSLSCEBT 304	**Environmental degradation / toxicology and Biotechnological methods to control pollution (60L)**	**4**
	Unit I: **Environmental degradation (15L)** **Impact of anthropogenic activities of environment:** Land, Water, Air, Forest, Oceans and the coasts; Biodiversity destruction (flora and fauna); Disturbance of ecological balance United Nations Millennium ecosystem assessment **Exponential growth:** Four spikes and the reason for spikes, impact and significance of exponential growth, Sustainability of exponential growth, Ecological balance and ecological footprint	
	Unit II: **Environmental toxicology (15L)** Toxic chemicals in the environment (air and water) – their effects and biochemical interactions; Pesticides in water, biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, ozone and PAN pesticide Mode of entry of toxic substance, its breakdown and detoxification; biotransformation of xenobiotics, Carcinogens in environment, chemical carcinogenicity, mechanism of carcinogenicity, environmental carcinogenicity testing. Insecticides, MIC effects; Major, trace and rare earth element (REE) imbalance and its effects Epidemiological issues of toxic compounds and metal poisoning – goitre, fluorosis, arsenic poisoning, Minamata, etc.	
	Unit : III **Environmental microbiology, diversity and systematic (15L)** **Environmental microbiology**: Microorganisms in nature and their importance, sampling, culture and cultivation of microorganisms; Microorganisms involved and used in service of nature and humans; GMO	

	and their uses in environmental management Environmental Problems and environmental monitoring through microorganisms; Microbiology of water, air and soil Influence of microorganisms on Earth's environment and its inhabitants; Rhizosphere, Phyllosphere, microbial interactions - Competition, Rumen microbiology, Biofertilizers, Biological N2 fixation, Symbiotic N2 fixation (*Rhizobium Frankia*) Non-symbiotic N2 fixation (*Azotobacter* and *Azospirillum Mycorrhizae*) ecological impacts of microbes; Role of microorganisms in natural and artificial ecosystems **Microbial diversity:** Classic and modern method Domain and Kingdom classification of microorganisms; Classification of bacteria according to Bergey's manual; Molecular methods of identification of microorganisms – DGGE, TGGE, ARDA, T-RFLP, 16S rDNA sequencing and Database project	
	Unit : IV **Biotechnological methods to control pollution (15L)** Biofilters, Bioremediation, Biotransformation Biodegradation and Phytoremediation: In situ and Ex situ bioremediation; Evaluating Bioremediation; Bioremediation of VOCs. Factors affecting process of biodegradation; Methods in determining biodegradability; Contaminant availability for biodegradation; Use of microbes (bacteria and fungi) and plants in biodegradation and Biotransformation; Phytoremediation: Waste water treatment using aquatic plants; Root zone treatment.	

Practicals:

PSLSCEBTP304	**Dissertation in Literature Review (60L)** 1. Project dissertation of literature review	**2**	**04**

SEMESTER IV DETAILED SYLLABUS

Course Code	Title	Credits
PSLSCT401	**Bioinformatics and IPR and Bioethics (60L)**	**4**
	Unit I: **Bioinformatics – I** **(15L)** **Introduction to Bioinformatics:** Definition and History of Bioinformatics, Internet sources for Bioinformatics, Introduction to Data Mining, Bioinformatics Problems and data mining solutions **Biological databases:** Introduction to variety of data sources. Population, sample, Classification and modeling of Data. Quality of data, Private and public data sources. Example Databases: (a) Nucleic acid databases (NCBI, DDBJ, and EMBL). (b) Protein databases (Primary, Composite, and Secondary) (c) Specialized Genome databases: (SGD, TIGR, and ACeDB) (d) Structure databases (CATH, SCOP, and PDBsum) **Alignment problem and solutions** Alignment: Basics and techniques, Local alignment and Global alignment Pairwise sequence alignment: NEEDLEMAN and Wunsch algorithm, Smith and Waterman algorithm, The Dot Plot, Dynamic Programming Algorithm. Multiple Sequence Alignment (MSA): Definition, Objective, Consensus, Methods for MSA: Heuristic approach, Dynamic programming approach and their combinations. Complexity analysis. Phylogenetic Analysis: Molecular-Phylogenetics, Phylogenetic-trees, Terminology of tree-reconstruction, rooted and un-rooted trees, gene vs species trees and their properties. Algorithms /methods of phylogenetic analysis: UPGMA, Neighbor-Joining Method.	
	Unit II: **Bioinformatics – II** **(15L)** **Protein structure analysis and prediction**: Identification/assignment of secondary structural elements from the knowledge of 3-D structure of macromolecule using DSSP and STRIDE methods , Prediction of secondary structure: PHD and PSI-PRED method Tertiary (3-D) Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology Modeling, fold recognition, threading approaches, and ab-initio structure prediction methods **Genomics**: Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays **Drug discovery and Development** : - Introduction to Drug Design and	

Development, Drug targets, Lead Identification and Modification, Computer-Aided Drug Design, Drug Delivery, Pre-clinical and Clinical Testing **Applications of Bioinformatics**: Pharmaceutical industries, immunology, agriculture, forestry; Legal, ethical and commercial ramifications of bioinformatics; Bio-sensing	
Unit : III **Intellectual Property Rights** **(15L)** Introduction to IPR; Types of Intellectual property – Patents, Trademarks, Copyrights and related rights; Traditional vs. Novelty; Importance of intellectual property rights in the modern global economic environment, Importance of intellectual property rights in India; IPR and its relevance in biology and environmental sciences; Case studies and agreements - Evolution of GATT and WTO and IPR provisions under TRIPS; Madrid agreement; Hague agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970) **Patents:** Definition, patentable and non-patentable inventions; types of patent application – Ordinary, Conventional, PCT, Divisional, and Patent of addition; Concept of Prior Art; Precautions while patenting - disclosure / non-disclosure; Time frame and cost; Patent databases, Searching International databases; Patent licensing and agreement; Patent infringement – meaning, scope, litigation, case studies. Patenting rules – European Scenario, US Scenario, Australia Scenario, Indian Scenario, Non Patentable IP and Patentable IP in Indian Patent Act	
Unit : IV **Bioethics** **(15L)** Bioethics: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; Basic Approaches to Ethics; Posthumanism and Anti-Posthumanism; Bioethics: legal and regulatory issues; Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research Bioethics and cross-cultural bioethics – Autonomy, Rights, Beneficience, Do No Harm, Justice, Confidentiality, Animal Rights, Environmental ethics, Decision-Making Perceptions of Ethical Biotechnology 'Moral' is not the same as Ethical, Mixed Perception of Benefit & Risk, Reasoning behind Acceptance or Rejection of Genetic Manipulation, Concerns about Consuming products of GMOs. Past and Present 'Bioethical Conflicts' in Biotechnology- Interference with Nature , Fear of Unknown, Regulatory Concerns, Human Misuse	

Future 'Bioethical Conflicts' in Biotechnology - Changing perception of Nature, Human Genetic Engineering	

Practicals

PSLSCEBTP401	**Bioinformatics (60L)** 1. Introduction to (Open office / Libre office version) Use of worksheet to enter data, edit data, copy data, move data. Use of in-built statistical functions to compute means, S.D., correlation (you may require to add correlation and regression in the theory part of statistics), regression coefficients etc. Use of bar diagram, histogram, scatter plots, etc. graphical tools for presentation of data. 2. Searching PubMed , Introduction to NCBI, NCBI data bases, BLAST BLASTn, BLASTp, PSI-BLAST, Sequence manipulation Suite, Multiple sequence alignment, Primer designing, Phylogenetic Analysis, SRS, Entrez,Pubmed. 3. Secondary Structure Prediction 4. Homology Modeling, Fold recognition, Abinito methods – SWISS-MODEL, MODELLER, GenTHREADER, ROSETTA. 5. Identification of Disease Genes 6. Ligand-Protein Docking 7. Case study of various Applications of Bioinformatics	**2**	**04**

Course Code	Title	Credits
PSLSCEBT402	**Biotechnology in Environmental Science (60L)**	**4**
Unit I: **Environmental Biotechnology (15L)** Role of environmental biotechnology, Scope for use, Market for environmental biotechnology, modalities and local influences, Integrated approach in environmental biotechnology; Immobilisation, Degradation or Monitoring of Pollutants from a Biological Origin, Metabolic Pathways of Particular Relevance to Environmental Biotechnology,		

Unit II: **Fermentation in environmental biotechnology** **(15L)** Importance of fermentation in environmental biotechnology Types of bioreactor, design of bioreactor; Microbial growth kinetics and yield constants; Monod kinetics; Types of fermentation: Batch, Continuous and Fed-batch system; Batch culture and kinetics; Continuous culture – types, multistage systems, feedback systems; Comparison of batch and continuous culture – biomass productivity, metabolite productivity, continuous culture and biomass productivity, Fed-batch culture – types and applications Strain improvement: Methods of strain improvement in fermentation. Chemical and molecular methods of strain improvement, Random and site direct methods of mutagenesis; use of molecular biology for the development of strain to be utilised for fermentation examples with respect to environmental biotechnology	
Unit : III **Environmental monitoring** **(15L)** Definition and environmental monitoring process; Sampling – land (site) sampling, water sampling, air sampling, Analysis – physical, chemical and biological analysis methods and process Use of microbial population for environmental monitoring – recombinant DNA technology and proteomics Monitoring pollution; Bioindicators; Biomarkers – biochemical indicators, immunochemistry, genetic indicators; Toxicity testing using biological material – example Algae, luminescent organisms, Ames test, Molecular biology biomarkers; Biosensors – mechanism, principle and working Environment Impact Assessment: EIA complete process, Importance of EIA	
Unit : IV **Agricultural biotechnology** **(15L)** Application of biotechnology in agriculture – Detection and diagnostics, Micropropagation; Somatic cell genetics – production of callus and suspension cultures, production of protoplasts, somaclonal variation, protoplast fusion, haploid production Transgenic plants: Production of transgenic plants – complete process, vectors used, transformation methods used; Types of GM Plants and Products obtained from GM Plants, Biopharming, Safety of transgenic crops Transgenic animals: Production – process, disease control, germplasm and biodiversity	

Practicals:

PSLSCEBTP402	**Environmental Monitoring (60L)** 1. Estimation of total solids 2. Estimation of volatile solids 3. Estimation of cellulose 4. Estimation of starch 5. Estimation of hemicelluloses 6. Determination of cellulose, hemicelluloses and lignin – detergent extraction method 7. Estimation of organic carbon – Walkely and Black's method 8. Estimation of Potassium 9. Estimation of phosphate	**2**	**04**

Course Code	Title	Credits
PSLSCEBTT403	**Biotechnology in Waste management (60L)**	**4**
Unit I: **Biotechnology for industrial and municipal wastes (15L)** Waste classification and characterisation, Waste material suitable for Biological treatment, Wastewater Treatment, BOD Removal, Types of Biological Processes, Municipal Wastewater, Activated Sludge Process, Sludge, Tapered Aeration, Step Feed Aeration, Contact Stabilization, Complete Mix, Extended Aeration, Oxidation Ditch, Anaerobic Digestion **Sludges,** Desulfurization, Nitrification/Denitrification, Nitrification, Suspended Growth Systems, Attached Growth Systems, Aquatics		
Unit II: **Liquid waste management (15L)** Waste-treatment system, Sewage-treatment methods; Design of bioreactors for liquid waste management – activated sludge process, trickling filters, rotating biological contactors, anaerobic treatment of waste water; Modification of existing processes, removal of nitrogen and phosphorus, sludge removal and disposal, agricultural waste treatment		
Unit : III **Solid waste management organisms (15L)** Solid waste management – Introduction, Treatment processes for solid wastes, thermal conversion process, biological conversion process, Landfill and landfill bioreactor for solid waste treatment Bioremediation: Process of bioremediation; Bioremediation of synthetic compounds, petrochemicals, inorganic wastes; Bioremediation strategies, Bioremediation techniques *in situ*,		

	Bioremediation techniques *ex situ*, Phytoremediation and Phyto-technology Metals bioremediation, Gaseous bioremediation, Biochemical pathways of bioremediation	
	Unit : IV **Biological Degradation Of Hazardous Wastes (15L)** Introduction Abiotic Treatment Techniques: Wastewater Treatment, Liquids-Solids Separation, Chemical Treatment, Physical Methods, Incineration, Wet Air Oxidation, Solidification Techniques, Biological Control Methods: Land Treatment, Composting, Liquids/Solids Treatment Systems (LSTS) , Soil Biofilters, Wastewater Treatment, Activated Sludge Process, Trickling Over Process, Stabilization, Degradability: Basis for Biodegradation, Genetics, Testing for Recalcitrance, Aerobic Tiered Testing, Anaerobic Tiered Testing; Testing for Recalcitrance; Biochemical pathways of hazardous waste remediation: Pilot studies – PCB Biodegradation, Methyl Ethyl Ketone, Landfill Leachate; TCE Degradation, Examples of biodegradation – Polycyclic Aromatic Hydrocarbon Ring Fission, Phenanthrene Degradation, Chlorophenol Degradation, Chlorinated Wastes, p-Nitrophenol Degradation, Benzenes, Oil Degradation Coal Gasification Wastewater, Tannery Wastes, Dioxin, PAH Degradation, Selenium, Immobilization of Phenolics	

Practicals:

PSLSCEBTP403	**PRACTICAL VII: Genetics Practicals (60L)** 1. Waste water analysis - pH, COD, BOD, Hardness, halides, Total solids, alkalinity and chloride 2. Assessment of point of use water purifiers (Zero B) for removal of bacteria. 3. Detection and isolation of industrially important microorganisms – lipase producers, oil degraders, antibiotic producers 4. Enrichment and isolation of cellulose, lignin & xylanase degraders from mangrove soil 5. Enrichment & isolation of thermophiles from hotsprings /compost heaps & extraction of thermophillic enzymes & determination of its specific activity 6. Bacteriological examination of Water by Multiple Tube Fermentation	**2**	**04**

Course Code	Title	Credits
PSLSCEBT404	**Industrial Environmental Biotechnology (60L)**	**4**
Unit I: **Sustainable technology and biotechnology (15L)** Introduction; Provision of bulk and fine chemicals – plants as a source, microbial production of chemicals, their production process (examples acetic acid, acetone, butanol, citric acid, ethanol, fumaric acid, glycerol, isopropanol, lacticacid, propanediol, acrylamide, biosurfactants); Microbial polymers – process, production and organisms involved; Microbial plastics – process, production and organisms involved; Industrial process and clean technology: extraction and supply of raw materials (eg. Desulphurization and denitrogenation of oils, Desulphurization and coal), processing of raw material (eg. Enzymes, extremophiles), use and disposal of product		
Unit II: **Biofuels (15L)** Finite supply of fossil fuels, emissions from fossil fuels, Greenhouse gases – CO2, Ozone, Sulphur dioxide, their interactions with environment; remediation of the emissions from fossil fuels Alternative non-fossil energy sources; Biological energy sources, Biofuels – generations of biofuels; Combustion of biomass, Biogas, Biodiesel, Ethanol, hydrogen Biofuels from waste: Methods and processes for utilization of waste for production of fuels, economical and social aspects of waste treatment, Community biogas plant, biogas scheme – scope of rural development,		
Unit : III **Natural resource recovery (15L)** Introduction to natural resource recovery **Oil recovery:** Introduction, Enhanced oil recovery (EOR), Microbially enhanced oil recovery (MEOR), Microbial biopolymers used in recovery **Recovery of metals:** Bioleaching – direct and indirect, bioleaching microorganisms, recovery of metals from mining waste; Extraction of – Copper, uranium, gold, etc. Recent developments in natural resource recovery		
Unit : IV **Biotechnology of marine environment (15L)** Introduction, Extreme environmental conditions, Marine life forms Role of microorganisms in ocean processes Biomimetic materials Compounds obtained from marine environment – Pharmaceuticals (new class of pharmaceuticals), industrial products and processes, sea and land based cultivation of these pharmaceutical products, Molecular biology products eg. *Thermus aquaticus*, Polymers – eg Polysaccharides, emulsans, polyhydroxyalkanoates, adhesives and melanins; Microalgae – products obtained from microalgae		

Marine pollution and its control – Biosensors, oil spills and remediation Environmental research in marine environment, Biofouling and bio-deterioration, Marine Genomics and Proteomics	

Practicals:

PSLSCEBTP404	**Dissertation of Research Project (60L)** 1. Project studies: presentation and preparation of report of observations and results	**2**	**04**

REFERENCES

PSLSCEBTT301

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4. Kumar, R., 2005, Research Methodology-A Step-by-Step Guide for for Beginners,(2nd.ed.),Singapore, Pearson Education.
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PSLSCEBT401

1. Fundamentals of Bioinforamtics: Harisha S.
2. Bioinformatics and Molecular Evolution: Higgs & Attwood
3. Bioinformatics: Harshwardhan Pal

PSLSCEBT302, 303, 304, 402, 403 and 404

1. Environmental Sciences: Odum
2. Environmental Biotechnology: Alan Scragg
3. Environmental Biotechnology: Bimal Bhattachraya and Ritu Banerjee
4. Environmental Sciences: Odum
5. Water Analysis: AWWA, APHA
6. Encyclopedia of Bioethics, Stephen G. Post (3rd edition)

7. R. M. Atlas and R. Bartha - 1998 - Microbial Ecology - Fundamentals and applications. AddisonWesley Longman, Inc.
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11. The Metagenomics of soil by *Rolf Daniel,*470/June2005/vol3, ww.nature.com/reviews
12. Metagenomics: DNA sequencing of environmental samples,Susannah Green Tringe and Edward M. Rubin,806**/**November2005/Volume6
13. Brock Biology of microorganisms12th ed Madigan,Martinko,Dunlap,Clara,Pearson Intl Ed
14. Microbial Diversity- Current Perspective and Potential Application--Johri and Satyanarayana
15. Methods in Microbiology Vol 35- Extremophiles (2006) Edited by Fred Rainey, Aharon Oren (Academic press)
16. Environmental microbiology. P. D. Sharma. Alpha Science International 2005 ed.
17. Wastewater engineering: Treatment and reuse. Metcalf and Eddy, Tata McGraw Hill Publishing Co. Ltd. 4th Ed.
18. A textbook of environmental pollution and control. S S. Dara
19. Environmental chemistry A. K. De
20. Environmental pollution control engineering. C. S. Rao. New Age International Publishers.
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23. Water and Wastewater analysis Volume 1. Handbook of methods in environmental studies. S. K. Maiti. ABD Publishers 2004
24. Soil analysis Volume 2. Handbook of methods in environmental studies. S. K. Maiti. ABD Publishers 2004
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27. Environmental management. H. V. Jadhav, Vipul Prakashan , 2002
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OVERALL EXAMINATION AND MARKS DISTRIBUTION PATTERN

Semester III

Course	PSLSCEBTT301			PSLSCEBTT302			PSLSCEBTT303			PSLSCEBTT304			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	**400**
	PSLSCEBTP301			**PSLSCEBTP302**			**PSLSCEBTP303**			**PSLSCEBTP304**			
Practicals	-	50	50	-	50	50	-	50	50	-	50	50	**200**

Semester IV

Course	PSLSCEBTT401			PSLSCEBTT402			PSLSCEBTT403			PSLSCEBTT404			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	**400**
	PSLSCEBTP401			**PSLSCEBTP402**			**PSLSCEBTP403**			**PSLSCEBTP404**			
Practicals	-	50	50	-	50	50	-	50	50	-	50	50	**200**

MODALITY OF ASSESSMENT:

THEORY EXAMINATION PATTERN:

A] Internal Examination for Theory: **40 marks**

No.	Particulars	Marks
1.	Active participation in routine Class instructional deliveries	05
2.	Overall conduct as a responsible learner, Communication & leadership qualities in organizing related academic activities.	05
3.	One seminar based on curriculum to be assessed by the teacher of the institution teaching P.G. learners/ publication of a research paper/ presentation of a research paper in seminar or conference	30
	(a) Selection of the topic, Introduction, write up, references (15)	
	(b) Presentation with the use of ICT (15)	

B] External Examination - 60 % [Semester End Theory Assessment]: 60 marks

1. Duration - These examinations shall be of two and half hours duration.
2. Theory question paper pattern :-
   (a) There shall be **five** questions each of **12** marks. On each unit there will be one question & fifth one will be based on all the four units .
   (b) All questions shall be compulsory with internal choice within the questions. Each question will be of **24** marks with options.
   (c) Questions may be sub divided into sub questions **a, b, c & d only, each carrying six marks OR a, b, c, d, e & f only** each carrying **four** marks and the allocation of marks depends on the weightage of the topic.

PRACTICAL EXAMINATION PATTERN

A] Internal Examination:

There will not be any internal examination/ evaluation for Practicals.

B] External (Semester end practical examination) Per course:

No.	Particulars	Marks
1.	Laboratory work	40
2.	Journal	05
3.	Viva	05

SEMESTER III:

Practical examination will be held at the college / institution at the end of the Semester.

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head of the Department/ Co-ordinator of the department, failing which the student will not be allowed to appear for the practical examination.

Research proposal (Dissertation based on Literature Review): Candidates are required to present duly certified research proposal (as per the BCUD format) with relevant references (minimum 25) and make the power point presentation of the same for the evaluation by the examiner (the research proposal must be included with literature survey of the selected research topic).

SEMESTER IV:

Practical examination will be held at the college / institution at the end of the semester. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head of the Department/ Co-ordinator of the Department, failing which the student will not be allowed to appear for the practical examination.

Research Project work (Dissertation based on Research): Candidates are required t present duly certified dissertation report based on the topic of research along with the laboratory notebook containing raw data and make the poster presentation of the research work for evaluation by the examiner.