

M.Tech – Biotechnology

CT	BIO-MATHEMATICS	3	1	0	4
1.	Ordinary Differential Equations : Ordinary Differential Equations of the 1 st order, Exactness and Integrating Factors, Variation of Parameters.				9 3 0
2.	Ordinary Linear Differential Equations : Ordinary Linear Differential Equations of n-th order, solution of Homogeneous and Non-homogeneous Equations, Operator Method, Methods of Undetermined Coefficients and Variation of Parameters.				9 3 0
3.	Sequence and Series : Power Series methods for Linear Ordinary Differential Equations.				9 3 0
4.	laplace transform : Laplace Transform and its Applications. Fourier series and Fourier Transform and applications in Biomedical Engineering.				9 3 0
5.	Partial Differential Equations : Models in Physiology, Introduction to Solution Techniques such as Variable Separation, Product Method and Laplace Transform Method.				9 3 0
Total 60 hrs					

References :

1. G. Eason, C.W. Coles, G. Gittinby, "Mathematics and Statistics for the Biosciences", Ellis Horwood, 1980.
2. J.G. Defares, I.N. Sneddon, "The Mathematics of Medicine and Biology", North Holland, 1971.
3. E. Kreyszig, "Advanced Engineering Mathematics", 5th Edition, Wiley Eastern, 1991.

CT	BIO-PROCESS ENGINEERING	4	0	0	4
1.	Introduction to Biological Systems : Proteins and Nucleic Acids, Enzymes. Introduction to key Bio-technical Processes; Metabolism and Characteristic properties of Microorganisms; Mathematical Modelling of Cell Growth and Metabolism, Engineering Principles, Downstream Processing, Genetically Engineered Organisms, Multidimensional Laminar Flow Problems, Turbulence, Boundary Layer Theory. Bioreactor considerations for Bacterial, Yeast, Plant, and Mammalian Cells.				15 0 0
2.	Introduction to Chemical Engineering Process : Basic principles and methods for the Design of Chemical Processes, Estimation of the Optimal Design Conditions. Process Engineering Operations - Size Reduction, Filtration, Evaporation, Crystallization, Drying, Humidification, De-humidification.				15 0 0
3.	Heterogeneous Catalysis : Decomposition of Methanol, Hydration of Ethylene - Discontinuous and Continuous Stirred Tank Reactors - Cascade of Stirred Tanks - Tubular Reactor; Mass Transfer Gas/Liquid - Programming Problem.				7 0 0
4.	Application of Molecular Genetics : Application of Molecular Genetics to Transcription Control Mechanisms - Gene Expression - Molecular Cloning and Applications to Biotechnology - Study of Microbial Organisms in Industrial Processes.				8 0 0
5.	Instrumental Analysis : Instrumental Analysis of Proteins, Nucleic Acids, Carbohydrates, and Lipids. Methods to Include Ultra-centrifugation; Gradient Separation of Proteins and Nucleic Acids; UV/Visible Spectroscopy.				15 0 0
Total 60 hrs					

References :

1. Shuler, M. L. and F. Kargi. Bioprocess Engineering, Basic Concepts. Prentice Hall, Inc. NJ 2001.
2. Bailey, J., and D.F. Ollis, "Biochemical Engineering Fundamentals", McGraw Hill, 1986 (Theoretical Courses)
3. Wolf R. Vieth, "Bioprocess Engineering – Kinetics Mass Transport, Reactors and Gene Expression".
4. G.F. Hewitt, J.M. Delhaye, N. Zuber (Eds.), "Multiphase Science and Technology", Hemisphere Publishing Corp., Vol.6/1992.

	BIOTECHNOLOGY BASICS	3	0	0	3
1.	Introduction : Introduction to Biotechnology : Scope and importance – Microbes their role – Sterilization Techniques – Microbial Cultivation – Microbial growth and Nutrition – Microbial Metabolism – Rules and Regulations in Biotechnology				12 0 0
2.	Animal Biotechnology : Animal Tissue Culture - Transgenic Animals - Animal Bioproduction - Hybridomatechnology – Gentic Diseases and Gene Therapy – Human Genome Project.				12 0 0
3.	Plant Biotechnology : Invitro Culture Techniques – Biotech Application of Plant Cell, Tissue, Organ Cultures – Biological Nitrogen Fixation – Biogeo Cycles – Biofertilizers – Biological control of plant Pathogens, Pest & Weeds.				12 0 0
4.	Microbial Biotechnology : Features of Biotechnological - Importance of Microbes – Primary and Secondary Metabolites – Microbial Enzymology – Single Cell Proteins.				12 0 0
5.	Environmental Biotechnology : Biomass Introduction – Biomass Energy – Biodiversity – Pollution-Biological Control – Biopyramids – Food Chain - Other aspects.				12 0 0
					Total 60 hrs

References :

1. Pelczar, Jr, M.J., Chan, E.C.S., Krieg, R.Noel., and Pelczar Merna Foss, "Microbiology". 5th Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 1996.
2. Gerhardt, et. Al, "Methods for General Molecular Bacteriology", ASM Press, 1994.
3. Grierson and S.N. Covey, "Plant Molecular Biology", Blackie, 1988.
4. A. Puller (Ed), "Genetic Engineering in Animals".

CT	BIO-SYSTEMS AND EQUIPMENT	3	0	0	3
1.	Introduction : Study of Psychometrics - Heat and Mass Transfer - Physiological Requirements for livestock and Bio-products - Analysis and Design of Food Processing Equipment and Plants.				5 0 0
2.	Bio-reactors : Principles and Operation of Bio-reactors - Elements of a Bio-reactor, special types of Bio-reactors, Sterile Operation, Aeration, Measurement and Control.				10 0 0
3.	Membrane and Separation Systems : Design and operation of the most important membrane modules for micro, ultra, nano-filtration, reverse osmosis and pre-evaporation, influence of hydrodynamics on module, General principles of separation processes, gas extraction; membrane processes, foam fractionation, reactive extraction, process chromatography (especially supercritical fluid chromatography-SFC), solving separation problems.				20 0 0
4.	Application of Instrumentation : Application of instrumentation and sensor concepts to measurement and control of environmental, biological, and mechanical parameters. Sensors and non-destructive principles (e.g., computer vision, spectroscopy, imaging, fiber optic sensing) for Bio-production and processing applications.				20 0 0
5.	Scanning Electron Microscopy : Theory and practical application of scanning electron microscopy. Emphasis on specimen preparation and operation of the microscope characteristics.				5 0 0
					Total 60 hrs

References :

1. E. Staude, "Membranen und Membranprozesse", VCH-Verlag, Weinheim, 1992.
2. R. Rautenbach, R. Albrecht, "Membrane Processes", John Wiley & Sons, Chichester, 1989.
3. M. Mulder, "Basic principles of Membrane Technology", 2nd ed., Kluwer, Dordrecht, 1996;
4. H. Strathmann, "Membranes and Membrane Separation Processes", Ullman's Encyclopedia, Vol. A 16, 1991.

CT	BIO-THERMODYNAMICS	3	0	0	3
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1. **Chemical Thermodynamics** : Conservation of Mass, Conservation of Energy and The Second Law of Thermodynamics, as well as material property relations that relate to heat, work, energy and Second Law analysis. 12 0 0
 2. **Introduction to the Thermodynamics of Multi-component Systems** : Introduction to the Thermodynamics of Multi-component Systems with and without Chemical Reactions, Kinetics Reactions. 12 0 0
 3. **Biological Thermodynamics** : Non-classical aspects of Small Systems and Non-equilibrium Thermodynamics, their importance in Biological Processes, Statical Thermodynamics, Gibbs Free Energy Theory and Applications. 12 0 0
 4. **Application of Thermodynamics to Life Processes** : Application of Thermodynamics to life processes at the Molecular Level and at the level of Organisms Interacting with their Environment. 12 0 0
 5. **Applications** : Application of Thermodynamic Principles to Ecosystem Analysis and Evolution. Some Conventional Engineering Applications and Comparison of Biological and Non-biological Energy Conversion Mechanisms. 12 0 0
- Total 60 hrs**

References :

1. Shuler and Kargi, , "Bioprocess Engineering, Prentice Hall, 2nd Edition, 1999.
2. L. Stryer, "Biochemistry", Prentice Hall, 2nd Edition, 2001.
3. B. Alberts, et. Al, "Bio-Thermodynamics", PHI, 2000.
4. G. Stephanopoulos, "Metabolic Engineering : Principles and Methodologies", Wiley,1996.

	BIO-CHEMICAL TECHNOLOGY				
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1. **Bio-Chemistry Basis** : Physiochemical properties of Life, Various types of Chemical Bonds – Functional Groups – Acid-base Theory – Buffer Systems – Oxidation reductions – Osmosis – Diffusion etc. 12 0 0
 2. **Biomolecules** : The Structure, Properties, Reactions, Classifications of Carbohydrates, Lipids, Amino acids, Proteins, Nucleic acids – Biological Membranes – Transport Mechanisms – Signal Transduction. 12 0 0
 3. **Biological Oxidation** : Glycolysis – Catabolism of Hexose's – Citric Acid Cycle – Oxidative Phosphorylation – Oxidation of Fatty Acids – Oxidation of Amino Acids – Photo oxidation. 12 0 0
 4. **Biomolecular Synthesis** : Carbohydrate Biosynthesis – Lipid Biosynthesis – Amino Acid Biosynthesis – Nucleotide Biosynthesis and other related aspects. 12 0 0
 5. **Importance of Bio-Chemical Technology** : Hormones and Vitamins – Their Role – Bio-Chemical Diseases – Regulation of Metabolism – Primary and Secondary Metabolism and Applications. 12 0 0
- Total 60 hrs**

References :

1. A.L.L. Lehninger, D.L. Nelson, M.M. Cox, "Principles of Bio-Chemistry", Worth Publications.
2. L. Stryer, "Bio-Chemistry", Prentice Hall, 2nd Edition, 2001.
3. Zubay, "Bio-Chemistry", Macmillan Publishing House.
4. Hortons, "Principles of Bio-Chemistry", Prentice Hall Publications.

CT	TISSUE ENGINEERING	4	0	0	4
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- Plant Cell Technology** : Special features and organization of plant cells; totipotency, regeneration of plants, concept of totipotency, examples of regeneration from leaves, roots, stem etc; Plant products of industrial importance; Biochemistry of major metabolic pathways and products; Cell suspension culture development, characterization, Kinetics of growth, production formation, examples. **12 0 0**
 - Large Scale Production of Secondary Metabolites** : Large scale production of secondary metabolites from suspension cultures- Nutrient optimization, Cell growth regulators, Biological and technological barriers; Mutation, somaclonal variation, genetic engineering of plant cells; Plant cell reactors-types of reactors, Comparison of reactor performances, Immobilized plant cell reactors; Novel design concepts. **12 0 0**
 - Animal Cell Technology** : Animal cell metabolism, regulation and nutritional requirement; Animal cell growth characteristics and kinetics; Nutrient, substrate and product transport through mammalian cell; Micro carrier attached growth; Cell culture in continuous, perfusion and hollow-fiber reactor; Mass transfer in mammalian cell culture; Scale-up of cell culture processes; Case studies. **12 0 0**
 - Bioseparation** : Characteristics of bioproducts; Flocculation and conditioning of broth; Mechanical separation; Cell disruption; Protein precipitation and its separation; Aqueous two phase extraction; Adsorption-desorption processes. **12 0 0**
 - Chromatographic Methods** : Chromatographic methods of separation based on size, charge hydrophobic interactions, biological affinity methods etc.; Membrane based separation; Electrophoresis; and Electro dialysis; Crystallization; Case studies. **12 0 0**
- Total 60 hrs**

References :

- Robert P. Lanza, "Principles of Tissue Engineering", Elsevier S&T, 2nd Edition, May 2000.
- Bernhard Palsson, Robert Plonsey, Jeffrey A. Hubbell, "Tissue Engineering", PHI, March 2003.
- Thomas M. Chang, "Blood Substitutes : Principles, Methods, Products & Clinical Trials: Tissue Engineering", Elsevier S&T, October 1997.

CT	GENETIC ENGINEERING	3	0	0	3
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- Recombinant DNA Technology Concept** : Recombinant DNA Technology Concept and purpose, basic methodology, use of plasmids, Type I, II and III restriction modification systems, type II restriction endonucleases, nomenclature and sequence recognition, mcr and mrr genotypes, linkers, adaptors, blunt end ligation, homopolymeric tailing, methods in screening recombinant DNA. **12 0 0**
- Labelling of DNA** : Nick translation, random priming, use of Klenow enzyme, T4 DNA polymerase, bacterial alkaline phosphatase, polynucleotide kinase, hybridization techniques, northern, Southern and colony hybridization. **12 0 0**
- Restriction Maps and Mapping Techniques** : cDNA cloning in plasmids. maximizing gene expression Construction of prokaryote expression vectors, deletion mapping, linker scanning. Cloning in M13 mp vectors, application to DNA sequencing site-directed mutagenesis, S-nuclease mapping. **12 0 0**
- Dideoxy Sequencing** : chemical sequencing of DNA, RNA sequencing. Lambda vectors, insertion and replacement vectors, selection and screening recombinant phage, in vitro packaging, genomic libraries and cDNA cloning. Cosmid vectors. Yeast transformation, yeast cloning vectors. Cloning and expression in mammalian cells, methods of selection and screening. **12 0 0**

5. **Specialised Topics** : Transgenic animals, polymerase chain reaction DNA footprinting. DNA fingerprinting, RFLP Applications of recombinant DNA technology in medicine, agriculture, veterinary sciences. **12 0 0**

Total 60rs

References :

1. W. Old and Primrose, "Principles of Gene Manipulation", S.B. University Press, Cambridge 1985.
2. T. Maniatis, E.F. Fritsch, J. Sambrook, "Molecular Cloning : A Laboratory Manual", Cold Spring Harbor Laboratory Press, 1982.
3. D.M. Glover, "DNA Cloning", Volume 1-A Practical Approach, IRL Press Ltd. 1985.

	MOLECULAR BIOTECHNOLOGY				
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1. **Introduction** : Principles of Classical Genetics – Mendalian Genetics – Identification of Genetic Material – Organisation of Genomes – Chromosomes and Types – Molecular organisation of DNA and its Structure. **12 0 0**
2. **DNA Replication and Repair** : Types of Replication of DNA – Molecular Mechanism of Replication – Enzymology of Replication – Damage of DNA by various agents – Mechanism of DNA repair- Reverse Transcriptase Mechanism. **12 0 0**
3. **Biosynthesis of RNA** : Types of RNA and their role – Transcription Mechanisms, RNA Polymerases – Introns and Exons – Promoters and Enhancers – Splicing Mechanisms – Factors affecting Transcription. **12 0 0**
4. **Biosynthesis of Proteins** : Central Dogma Theory – Flow of Genetic Information – Genetic Code – Wobble Hypothesis – Structure of Ribosomes - Events in Protein Synthesis (Activation, Initiation, Elongation and Termination) – Post-Translational modification of Proteins – Inhibitors of Translation. **12 0 0**
5. **Molecular Processes** : Mutagenesis – Types of Mutagens – Molecular Mechanism of Mutations – Types of Genes – Operon Concepts – Tumerogenesis – Bacterial Recombination – Plasmids – Transposable Elements – Other related aspects. **12 0 0**

Total 60 hrs

References :

1. Baltimore and Lodish, "Molecular Cell Biology", Freemans Company.
2. T.A. Brown, "Genetics – A Molecular Approach", PHI.
3. S.R. Maloy, J.E. Cronan and D. Friefelder, "Microbial Genetics", Jones and Bartlett Publishers, 1994
4. Old and Primrose, "Molecular Biotechnology", Blackwell Scientific Company Ltd.

CT	BIOINFORMATICS	3	0	0	3
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1. **Introduction** : Databases - Mapping, Sequence, Structure, Non-redundant; Sequence Alignment Pairwise and Multiple; Phylogenetics. **12 0 0**
2. **Structure Prediction Methods** : Homology, Threading, Abinitio. **12 0 0**
3. **Sequence Analysis** : Class and Secondary Structure Prediction - Motifs – PROSITE. **12 0 0**
4. **Detecting Functional Sites** : Detecting Functional Sites in DNA; ORFinder. **12 0 0**
5. **Computer Science Perspective** : Pattern Recognition, Hidden Markov Models; Neural Networks. **12 0 0**

Total 60 hrs

References :

1. A.D.Baxevanis & B.F.F.Ouellette, (eds.), "Bioinformatics", Wiley Interscience, 1998.
2. S.L.Salzberg, D.B.Searls, S.Kasif (eds.), "Computational Methods in Molecular Biology", Elsevier, 1998.
3. R.F.Doolittle, "Computer Methods for Macromolecular Sequence Analysis", Academic Press, 1996.
4. M. Bishop, "Guide to Human Genome Computing", Academic Press, 1998.
5. Irfan Akhan & Atiya Khanum, "Emerging Trends in Bioinformatics", Ukaaz Publications, 2002.

CT	FOOD PROCESSING ENGINEERING	4	0	0	4
1.	Food Engineering Fundamentals : Heat and Mass Transfer in Food Processing – Food Rheology – Freezing of Foods – Food Dehydration – Extraction – Kinetics of Chemical Reactions in Foods – Thermal Process Calculations.				12 0 0
2.	Food Processing : The Rationale and History of Food Processing – Organizing Unit Operations – The Maintenance of Food Quality including Food Palatability and Nutritive Value – Separation Technology including Initial Operations – Size Reduction and Screening – Mixing – Filtration – Centrifugation and Crystallization.				12 0 0
3.	Preservation Methods : Including Fresh Food Storage – Low Temperature and High Temperature Methods – Preservation methods including Drying – Additives – Asepsis – Modified Atmosphere Storage – Fermentation and Irradiation – Preparation (assembly) Methods including Emulsification – Homogenization and Extrusion.				12 0 0
4.	Food Safety and Sanitation : Including Laws and Regulations – Good Manufacturing Practices.				9 0 0
5.	Advanced Food Process Engineering Technology : Process calculations for Food Processing Methods such as Canning, Aseptic Processing, Ohmic Heating, Microwave Processing and Pulsed Energy Processing – Extrusion Techniques in Food Processing – Discussion of New Food Processing Techniques and Safety Implications.				15 0 0
					Total 60 hrs

References :

1. Byong H. Lee, "Fundamentals of Food Biotechnology", December 1995.
2. Romeo T. Toledo, "Fundamentals of Food Process Engineering", October 2001.
3. R. Paul Singh, Dennis R. Heldman, "Introduction to Food Engineering", August 2001.

CT	IMMUNOLOGY	3	0	0	3
1.	History and Scope of Immunology : Types of Immunity – Innate – Acquired – Passive & Active – Specific and Non-Specific – Physiology of Immune response – MI and CMI specificity and Immune memory.				12 0 0
2.	Lymphoid Tissues : Primary and Secondary Organs of Immune System – Thymus – Spleen – Lymph Nodes, Bursa Fabricus, Differentiation of Lymphocytes – Neutrophils – Macrophages – Plasma Cells – Eosinophils – Basophils – Microbes – Host Relationships – Blood Groups.				12 0 0
3.	Antigen-Antibodies : Types of Antigen and its Structure – Specificity – Antigenic Determinants – Haptens – Nature and Formation – Classification of Immunoglobulins – Primary and Secondary Responses – Antigen-Antibody Reactions – In Vitro Serological Tests.				12 0 0
4.	Immune System : Humoral Immunity – Cell mediated Immunity – Complement Fixation – Hyper Sensitivity – Immune Tolerance – Immune Diseases – Immunopathology – Major Histocompatibility – Tumor Immunology.				12 0 0
5.	Immuno Technology : Production of Vaccines – Production of Polyclonal Antibodies, Monoclonal Antibodies, Collection and Preservation of Antisera – Transplantation Immunology – Hybridoma Technology.				12 0 0
					Total 60 hrs

References :

1. I.M. Roitt, J. Brostoff & D.K. Male, "Immunology".
2. Charles Janeway (Editor), Paul Travers, J. Donald Capra, Mark J. Walport, "Immunobiology : The Immune System in Health and Disease", 4th Edition, Garland Publication, 1999.
3. John Jr., Ph.D. Cloney, James Morgan (Eds), "Basic Concepts in Immunology", 1st Edition, McGraw Hill Text, 1998.
4. Julius M. Cruse, Robert E. Lewis (Eds), "Atlas of Immunology", CRC Press, 1998.
5. William E. Paul (Editor), "Fundamental Immunology", LWW Publishers, 1998.
6. Lauren M. Sompayrac, "How the Immune System Works", 1st Edition, Blackwell Science Inc., 1999.

Microbial Technology					
1.	Introduction : Isolation – Screening – Culturing – Strain Improvement – Nutritional Requirements – Growth of Economically Important Microbes – Media Formulation – Maintenance and Preservation of Microbes.				12 0 0
2.	Sterilization : Media Sterilization – Filtration – Batch and Continuous Sterilization – Radiation – Chemical Sterilization – Thermal Death Kinetics of Microbes.				12 0 0
3.	Industrial Biotechnology : Production of Biomass, Bio-energy – Primary and Secondary Metabolites – Extra cellular Enzymes – Important Intracellular Products – History and Development of Fermentation Industry – Solid State Fermentation.				12 0 0
4.	Economical Bio-products : Antibiotics : Penicillin, Streptomycin, Tetracycline – Other Antibiotics – Organic Acids – Lactic Acids – Citric Acids – Acidic Acids – Gluconic Acids etc. – Alcoholic Beverages : Ethanol – Production and Purification – Beer, Wine and related beverages – Industrial Enzymes - Vitamins.				12 0 0
5.	Food Technology : Bakers Yeast – Rannet and other Proteolytic Enzymes – Cheese – Dairy Products – Bio-fertilizers – Bio Fuels : Methane, Bio production of Hydrogen etc.				12 0 0
					Total 60 hrs

References :

1. Stanier, et. al, "General Microbiology", Macmillan Publications.
2. Prescott, "Industrial Microbiology".
3. Casida, "Industrial Microbiology".
4. P.F.Stanbury and A. Whitaker, "Principles of Fermentation Technology".
5. J.E. Bailey, D.F. Ollis,, "Biochemical Engineering Fundamentals", Mc Graw Hill Publications.

Enzyme Technology					
1.	Introduction : Enzymes, Nature, Nomenclature, Classification – General properties of Enzymes – Extraction – Assay and Purification of Enzymes – Free and Immobilized Enzymes.				12 0 0
2.	Enzyme Kinetics : Steady State Kinetics – Michaelis-Menten Kinetics – Line Weaver – Burke – Kinetics for Reversible Reactions – Km Value – Enzyme Inhibitors – Pre Steady State Kinetics – Enzyme Deactivation – Micro Environmental effects on Enzyme Kinetics.				12 0 0
3.	Enzyme Reactions : Enzyme Specificity – Enzyme Substrate Complex – Evidences – Nucleophilic and Electrophilic Attach – Role of Metal Ions – Design and Analysis of Enzyme Reactors – Ideal Reactors – Reactor Dynamics.				12 0 0
4.	Enzymatic Interactions : Allosteric Interactions – Product Inhibition – Membrane Bound Enzymes – Intra-particle Diffusion – Internal and External Mass Transfer Effect – Immobilized Enzyme Reactors – Effect of Fluidity on Enzyme Activity.				12 0 0
5.	Applications : Applications in Industrial, Medical, Analytical, Chemical, Pharmaceutical and Food Sectors – Co-Enzymes Associated with Vitamins – Isolation and Purification of Enzymes.				12 0 0

References :

1. James M. Lee, "Bio-Chemical Engineering", Prentice Hall, 1992.
2. A. Lehninger, "Principles of Bio-Chemistry", 1987.
3. Dixon and Webb, "Enzymes".
4. H.R. Mahler and E. Cordes, "Biological Chemistry", 1986.
5. J.E. Bailey, D.F. Ollis, "Biochemical Engineering Fundamentals", Mc Graw Hill Publications.

CT	BIOLOGICAL WASTE TREATMENT	3	0	0	3
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1. **Introduction :** Definition of waste, Physical, Chemical and Biological characteristics of waste water, BOD, COD and TOD- their estimation and correlation; BOD progression curve and kinetics; Effect of reaction rate constant on short term BOD, Determination of BOD rate constants; Effect of temperature on BOD. **12 0 0**
2. **Nitrification and Denitrification :** Nitrification and Denitrification and their kinetics; Activated sludge process (ASP), Biological solid retention time, Mixing regime in ASP, Kinetic model of ASP, Sludge volume index (SVI); relation between recycle ratio and biological solid retention time in ASP, minimum biological an solid retention time, Aeration system in ASP, Step aeration, extended aeration, contact stabilization, Loading criteria, excess sludge production, sludge viability, O₂ requirement in ASP, nutrient requirement in ASP. **12 0 0**
3. **Solid Liquid Separation :** Solid liquid separation in secondary clarifier, Mass balance in secondary clarifier, evaluation of kinetic parameters in ASP, nitrification and biological denitrification in ASP. **12 0 0**
4. **Anaerobic Treatment of Wastes :** Anaerobic treatment of wastes, Fundamental microbiology, Process kinetics; Rate limiting step approach, Gas production, process design consideration, case study. **12 0 0**
5. **Growth of Biological Treatment Process :** Attached growth of biological treatment process, Trickling filter, Anaerobic digestion, kinetic relationships, sludge characteristics and design considerations, process modeling and control, case study; Aerobic digestion – kinetic relationships and design consideration, case study. **12 0 0**

Total 60 hrs**References :**

1. Theory and Practice of Water and Wastewater Treatment, R. L. Droste, John Wiley and Sons, 1997.
2. Grady Daigger and Lim, "Biological Wastewater Treatment", 2nd Edition, 2000.
3. "Std Handbook of Hazardous Waste Treatment and Disposal", Freeman, 2nd Edition, 2001.

CT	ENVIRONMENTAL MICROBIOLOGY	4	0	0	4
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1. **Introduction :** Microorganisms - Classification, Prokaryotic and Eukaryotic Cells, Structure, Characteristics, Nucleic Acids, DNA and RNA, Replication. Recombinant DNA - Genetic Engineering. **12 0 0**
2. **Metabolism of Microorganisms :** Environmental Factors, Nutrition and Metabolism, Growth Phases, Enzymes, Carbohydrate, Protein, Lipids Metabolism, Respiration, Fermentation, Glycolysis, Krebs's Cycle, Hexose Monophosphate Pathway, Significance of Energetics. **12 0 0**
3. **Microbiology of Drinking Water :** Distribution of Microorganisms, Indicator Organisms, Coliforms - Fecal Coliforms - E.coli, Streptococcus Fecalis and Clostridium Welchii, Differentiation of Coliforms - Significance - MPN index, M.F. Technique, Standards. Virus-concentration Techniques. Algae in Water Supplies - Problems and Control. **12 0 0**

4. **Microbiology of Wastewater Treatment** : Biodegradation of Toxic Pollutants - Alpha Oxidation, Beta Oxidation, Electron Transport System and Oxidative Phosphorylation Mechanism, Microbiology of Biological Treatment Process. 12 0 0
 5. **Aquatic Microbiology** : Ecotoxicology - Toxicants and Toxicity - Factors Influencing Toxicity, Effects, Acute, Chronic, Concentration Response Relationships, Test Organisms, Toxicity Testing Bio-concentration – Bio-accumulation - Bio-magnification - Bioassay – Bio-monitoring. 12 0 0
- Total 60 hrs**

References :

1. Pelczar, Jr, M.J., Chan, E.C.S., Krieg, R.Noel., and Pelczar Merna Foss, "Microbiology". 5th Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 1996.
2. Stainer, R.Y., Ingraham, J.L., Wheelis, M.C. and Painter, P.R. " General Microbiology", Mac Milan Ltd., London, 1989.
3. Pichai, R. and Govindan, V.S., Edn., "Biological Processes in Pollution Control", Anna University, Madras, 1988.

CT	PROTEIN ENGINEERING	3	0	0	3
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1. **Protein Structure and Folding** : Protein Synthesis, Protein structure and folding; Mechanism of folding, chaperonins and other proteins, shape size and conformation; motifs of protein structure, Electrophoresis. 12 0 0
 2. **Alpha - Beta Domain** : Alpha domain, Beta domain and Alpha/Beta domain; XRay analysis of proteins: Mathematical principles, Bragg's Law, NMR. 12 0 0
 3. **Strategies for Protein Engineering** : Strategies for protein engineering : Random, site directed, catalytic effectivity: Structure prediction and modeling or proteins: Structure prediction and modeling or proteins. 12 0 0
 4. **Molecular Graphics** : Molecular graphics in protein engineering, Dynamics and mechanics; Drugs-protein interactions and Design; 12 0 0
 5. **Benefits of Protein Engineering** : Protein engineering benefits: Industry, Medicine; Engineering Antibodies. 12 0 0
- Total 60rs**

References :

1. Stephen H. White, "Membrane Protein Structure – Experimental Approaches", Oxford University Press, 1994.
2. A. J. Wilkinson, P. C. Moody, "Protein Engineering : In Focus", March 1991.
3. Jeffery L. Cleland, "Protein Engineering : Principles & Practice", January 1996.

CT	PESTICIDES – PROBLEMS AND SOLUTIONS	3	0	0	3
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1. **Fundamentals of Pests** : What are Pests? – Classification Pests – Microbes as Pest – Insects as Pest – Animal as Pest – Plants and Weeds. 12 0 0
 2. **Pest Control Methods** : Factors related to Pests – Means of Pest Control – Biological, Chemical Methods of Pest Control – Natural Methods of Pest Control. 12 0 0
 3. **Pesticide – Chemistry and Bio-chemistry** : Pest – Pesticide – Host Interaction. 12 0 0
 4. **Environmental Considerations** : Environmental Considerations in Pest Control. 12 0 0
 5. **Pesticide Toxicology and Legal Aspects** : Biotechnology Targets for Pest Control – Legal Aspects of Pest Control. 12 0 0
- Total 60 hrs**

References :

1. G.S. Dhaliwal , et. al, "Pesticides and Environment", Commonwealth, New Delhi, 2000.

2. Pesticides, Man and Biosphere/edited by O.P. Shukla, Omkar and A.K. Kulshretha. 1998, xviii, 424 p., figs., tables, \$54. Details No. 13677
3. Balwinder Singh, et. al, "Pesticides : Their Ecological Impact in Developing Countries", 1993.
4. B.C. Sabata, et. al, "Planet Protection : Biodiversity, Conservation, Environmental Education & Degradation and Socio-Economic Development", Mittal, New Delhi, 1997.

PR	ENVIRONMENTAL MANAGEMENT SYSTEM	3	0	0	3
1.	Introduction : The Greening of Business – Need of the Hour – Awareness - Commercial Aspects of Green Competitiveness Environment Review - Physical Environment of Business: Resources, Effluents, Waste.				12 0 0
2.	Environmental Concerns : Science/Technology/Academia, Media, Environmental Groups, Local Communities, Green Bench in India - International Agencies, Political Area - Government Regulation - National - International - ISO 14000 Series.				12 0 0
3.	Environmental Review & Audit : Environmental Impact Assessment (EIA) - Environmental Survey - Eco Auditing – Eco Labeling - Supplier Audit - Local Authorities - External Audit.				12 0 0
4.	Life Cycle Analysis & Assessments : Concepts and Methods				12 0 0
5.	Waste Minimisation : R&D and Investment in Cleaner Technologies - Control of Energy Costs - Cost of Waste - Package & Recycling. Issues in Green Marketing and Management.				12 0 0
					Total 60 hrs

References:

1. Linda .J, Speeding, "Environmental Management for Business", John Wiley & Sons, England, 1996.
2. Forest .L Reinhard & Richard .H.K Vietor, "Business Management and The Natural Environment", South Western College Publishing, Ohio, USA, 1996.
3. Suzanne Pollack, "Improving Environmental Performance", Routledge London, 1995.
4. Gray, "Accounting for The Environment", The Chartered Association of Certified Accountants, London, 1993.
5. John .F Wasik, "Green Marketing & Management", Black Well, Cambridge, USA, 1996.
6. George Winter – "Blue Print for Green Management", McGraw Hill, England, 1995.

PR	CLEANER PRODUCTION TECHNIQUES	3	0	0	3
1.	Cleaner Production : Introduction - Industrial and Commercial Sector Development and Related Energy and Environmental Issues. Cleaner Production(CP) Definition and Role in Industrial and Commercial Sector – Link with Sustainable Production and Consumption Concepts – Life Cycle Analysis – Extended Producer Responsibility – Pollution Prevention Vs Pollution Control – Overview on Cleaner Production – Explanation of What is Pollution Control and the Technologies associated with it – Approaches and means of Pollution Prevention.				12 0 0
2.	Energy and Environmental Parameters / Concepts for CP : Basic Technology, Units, Measurement Techniques, Significance etc. (BOD, COD, TSS, TDS, Colour, etc.) Waste and Energy Audit Methodologies – Application of Mass and Energy Audit Methodologies. Application of Mass and Energy Balance in Energy of and Environmental Audit – Sankey Diagram.				12 0 0

3. **Major Industrial Processes Considering Energy and Environmental Points of View** : Identification of Major Unit Processes Associated with Energy Consumption and Pollution Generation. 12 0 0
4. **Pollution Prevention Through Process Integration (Energy & Environment)** : Process Optimization by Integrating both Energy and Environmental Aspects – Energy Management Concepts and Measures to improve Energy Efficiency. Energy and Water Pinch : An Efficient Waste minimization Tool - Occupational Health and Safety -Quality of Product and other aspects of CP. 12 0 0
5. **Financial Analysis of CP Options** : Cash Flow - Payback Period – Net Present Value – Internal Rate of Return – Profitability Index – Depreciation etc. Environmental Pollution and Resource Use : Design for Recycling – Life Studies – LCA Package. 12 0 0

Total 60 hrs

References :

1. Rossiter .A.P, "Waste Minimization through Process Design", McGraw Hill, ISBN : 007053957, 1995.
2. Nemerow .N.L, "Zero Pollution for Industry – Waste Minimization through Industrial Complexes", John Wiley & Sons, ISBN : 0471121649, 1995.
3. Paul .L Bishop, "Pollution Prevention : Fundamentals and Practice", McGraw Hill, ISBN : 0-07-116058-2, 2000.
4. Modak .P, Viswanathan .C & Parasnis .M, "Cleaner Production Audit", Review No. 32, ENSIC, AIT, 1997.
5. "United Nation Environment Programme", "Cleaner Production Training Manual", 1996.
6. "United Nations Environment Programme, Industry and Environment, Company Environmental Reporting, A Measure of the Progress of Business & Industry towards Sustainable Development", 1994.
7. "UNEP/IE, Audit and Reduction Manual for Industrial Emissions and Wastes", Tech. Report No. 7, 1991.

CT	BIO-CONVERSION AND PROCESSING OF WASTE	3	0	0	3
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1. **Fundamentals** : Production of biomass, photosynthesis. Broad classification. Agro and forestry residues utilisation through conversion routes : biological, chemical and thermochemical. 12 0 0
2. **Bioconversion Mechanism** : sources of waste undergoing bio-treatment, biogas. Energetics and rate processes of major biological significance. 12 0 0
3. **Bioconversion of Substrates** : Bioconversion of Substrates into alcohols, organic acids, solvents, amino acids, antibiotics etc. 12 0 0
4. **Thermochemical Conversion** : Thermochemical conversion of bio-mass. Energy balance. Conversion to solid, liquid and gaseous fuels, pyrolysis, gasification and their economics. 12 0 0
5. **Chemical Conversion Process** : hydrolysis and hydrogenation, solvent extraction of hydrocarbons. 12 0 0

Total 60 hrs

References :

1. P.C. Trivedi and K.C. Sharma, "Biodiversity Conservation", Aavishkar Pub., Jaipur, 2003.
2. B.N. Pandey, R.K. Choudhary and B.K. Singh, "Biodiversity Conservation, Environmental Pollution and Ecology", APH Pub., New Delhi, 2002.
3. T.I. Khan and Y.S. Shishodia, "Biodiversity Conservation and Sustainable Development", 1998.
4. Ashish Dutta, "Biodiversity and Ecosystem Conservation", Kalpaz, Delhi, 2001.

ME	TOTAL QUALITY MANAGEMENT	3	0	0	3
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1. **Concepts of TQM** : Philosophy of TQM, Customer Focus, Organisation, Top Management Commitment, Teamwork, Quality Philosophies of Deming, Crosby and Muller. 12 0 0
2. **TQM Process** : QC Tools, Problem Solving Methodologies, New Management Tools, Work Habits, Quality Circles, Bench Marking, Strategic Quality Planning. 12 0 0
3. **TQM Systems** : Quality Policy Deployment, Quality Function Deployment, Standardisation, Designing for Quality, Manufacturing for Quality. 12 0 0

4. **Quality System** : Need for ISO 9000 System, Advantages, Clauses of ISO 9000, Implementation of ISO 9000, Quality Costs, Quality Auditing, Case Studies, ISO 9001:2000 Quality Management System (QMS) – Manual – Implementation – IQA Certification Processes. 12 0 0
 5. **Implementation of TQM** : Steps, KAIZEN, 5S, JIT, POKAYOKE, Taguchi Methods, Case Studies. Total Productive Maintenance (TPM) : Philosophy and Implementation – Benchmarking – Type - Applications 12 0 0
- Total 60 hrs**

References :

1. John Bank, "The Essence of Total Quality Management", PHI, 1993.
2. Rose, J.E, "Total Quality Management", Kogan Page Ltd. 1993.
3. Greg Bounds, Lyle Yorks et al, "Beyond Total Quality Management", McGraw Hill, 1994.
4. Takashi Osada, "The 5S", The Asian Productivity Organisation, 1991.
5. Masaki Imami, "KAIZEN:", McGraw Hill, 1986.
6. Seiichi Nakagima, "Introduction to Total Productive Maintenance", Productivity Press (India) Pvt. Ltd., 1993.

	KNOWLEDGE MANAGEMENT	3	0	0	3
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1. **Introduction** : Knowledge Management (KM) – Overview – Definition and Scope. Knowledge Model : Components - Construction – Benefits from KM – Human Learning – Organisational Learning. 12 0 0
 2. **Elements of KM System** : KM and New Product Development – KM Strategy – KM in Professional Service Firms – Strategic Planning for Organisational KMS – Building and Implementing a KMS. 12 0 0
 3. **KM System** : Network of Practice – Communities of Practice – Expertise Knowledge Portals, Bringing about Organisational Change – Group Decision Support Systems – KMS Project Review – Organising around Knowledge – Knowledge Architecture. 12 0 0
 4. **Knowledge Engineering** : Introduction, Knowledge representation using Frames, Rules and Semantic Nets – Search Algorithms. 12 0 0
 5. **Knowledge Base Management** : Interface to Information System – Retrieval – Reasoning – Logic Programming – Natural Language Processing – Applications – Case Studies. 12 0 0
- Total 60 hrs**

References :

1. Guus Schreiber, et. al, "Knowledge Engineering and Management", University Press(I) Ltd., 2001.
2. Ganesh Natarajan & Sandhya Sekar, " KM – Enabling Business Growth", TMH(CI), 2000.

	RESEARCH METHODOLOGY	3	0	0	3
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1. **Concepts and Importance of Research Methodology** : Meaning of Research – Objectives – Types and Importance of Research – Research Process for Applied and Basic Research. 12 0 0
2. **Research Design** : Need – Concepts related to Research Design – Different Research Designs – Meaning – Importance and Scale Construction Techniques. 12 0 0
3. **Sample Design and Data Collection** : Criteria for Selecting a Good Sample Design – Random Sample – Sampling Techniques – Probabilistic and Non-probabilistic Samples – Sample Size – Collection of Data –

Primary and Secondary Sources – Selection of Appropriate Methods – Guidelines for Questionnaire Design and Successful Interviewing.	12 0 0
4. Processing and Analysis of Data : Process Operations – Problems in Processing – Types of Analysis – Measures of Relationship – Factor –Cluster – Discriminate Analysis.	12 0 0
5. Hypothesis Testing and Research Report : Basic Concepts and Procedure – Report Writing – The Role of Computers in Research – Use of Internet.	12 0 0
	Total 60 hrs

References :

1. Kothari C.R, "Research Methodology – Methods & Techniques", Wishwa Prakashan, A Division of New Age International Pvt. Ltd.
2. Donald R. Cooper and Ramela S. Schindler, "Business Research Methods", Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2000.
3. Uma Sekaran, "Research Methods for Business", John Wiley & Sons Inc., New York, 2000.
4. Donald H. McBurney, "Research Methods", Thomson Asia Pvt. Ltd., Singapore.
5. Ranjit Kumar, "Research Methodology", Sage Publications, London, New Delhi, 1999.
6. Chandan J.S, Statistics for Business and Economics", Vikas Publishing House Pvt. Ltd., 1998.

PR	EMERGING ENGINEERING TECHNOLOGIES	3	0	0	3
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1. Engineering Technologies & Systems and Critical Technologies : Overview - Micro and Nanotechnologies, MEMS, MOEMS.	10 0 0
2. Interdisciplinary Approach : Engineering, Biology & Medical Technologies - Engineering disciplines & Applications - Biological disciplines & Applications - Medical disciplines & Applications.	12 0 0
3. Genomics : Biotechnologies, DNA, Protein, Tissue Engineering, Bioinformatics.	8 0 0
4. Cognitive Engineering : Nanotechnologies, Nanotubes, Molecular Manufacturing - Molecular Nanotechnology - I.T. - Artificial Intelligence, Robotics, Informatics, Human - Computer interaction, Neural Networks - Smart Materials - Microfabrication – Sensors.	15 0 0
5. Role of Emerging Technologies and its Applications : Energy & Environmental - Defence & Aerospace - Construction & Infrastructure - Information & Electronic Industry - Pharmaceuticals & Medicine - Food & Agricultural Sector.	15 0 0
	Total 60 hrs

References :

1. Nadim Maluf, "An Introduction to Microelectromechanical Systems Engineering", (Artech House MEMS Library) Artech House; ISBN : 0890065810; (December 1999).
2. Sergey Edward Lyshevski, "Nano and Microelectromechanical Systems ; Fundamentals of Nano and Microengineering", CRC Press; ISBN : 0849309166; (September 25, 2000)
3. "Report on Critical Technologies – Overview", NDRF Publication, 2002.

PR	TECHNICAL ENTERPRENURSHIP	3	0	0	3
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1. Introduction : Entrepreneur - Entrepreneurship Concept - Entrepreneurship as a Career.	5 0 0
2. Entrepreneurial Competence : Personality Characteristics of Successful – Entrepreneur - Knowledge and Skills Required for an Entrepreneur.	10 0 0

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| 3. | Entrepreneurial Environment : Business Environment - Role of Family and Society - Entrepreneurship Development, Training and Other Support Organisational Services - Central and State Government - Industrial policies and Regulations - International Business. | 15 0 0 |
| 4. | Business Plan Preparation : Sources of Product for Business - Pre-feasibility Study - Criteria for Selection of Product Ownership - Capital - Budgeting Project Profile Preparation - Matching Entrepreneur with the Project - Feasibility Report Preparation and Evaluation Criteria. | 15 0 0 |
| 5. | Launching and Development Small Business : Finance and Human Resource Mobilization Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching - Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units. | 15 0 0 |
| | | Total 60 hrs |

Reference :

1. Faculty of EDI and External Experts, "A Hand Book for New Entrepreneurs", Entrepreneurship Development Institute of India, Ahmedabad, 1986.
2. Staff College for Technical Education, Manila and Centre for Research and Industrial Staff Performance, Bhopal, Entrepreneurship Development, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1998.
3. Prasama Chandra, "Projects - Planning, Analysis Selection, Implementation and Reviews", Tata McGraw Hill Publishing Company Limited, 1995.
4. P. Saravanavel, "Entrepreneurial Development", Ess Pee kay Publishing House, Chennai, 1997.