Syllabus M.Tech. Biotechnology Programme

Section I Technology/Engineering Stream

Part A (Basic Engineering and Technology, Pharmacology)

i) Basic Engineering and Technology

Basic concepts/principles in mechanical engineering, chemical & biochemical engineering, electrical and electronics engineering:

Chemical Engineering: Computer applications in chemical engineering- chemical process industries instrumentation methods of chemical analysis, thermodynamics- laws of conservation of mass and energy, First and Second laws of thermodynamics, reversible and irreversible processes, internal energy, enthalpy, Kirchoffs equation, heat of reaction, Hess law, heat of formation, Applications of first law to close and open systems, Second law and Entropy Thermodynamic properties of pure substances: equation of state and departure function, free energy, and work function. Gibbs-Helmholtz equation, Clausius-Clapeyron equation, free energy change and equilibrium constant, Troutons rule, properties of mixtures: partial molar properties, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; Azeotrope and eutectic mixtures, and ideal gas mixtures, Third law of thermodynamics, stoichiometry, fluid dynamics, mechanical operations, heat and mass transfer operations- chemical kinetics/reaction engineering- process instrumentation dynamics and control- process equipment design. Material and Energy Balances: Laws of mass conservation, heats of reactions, law of mass action, Correlation, linear regression and analysis; degree of freedom analysis.

Chemical Reaction Engineering : Basic laws of chemical kinetics, chemical rate equations, parallel, sequential and other complex system kinetics, differential and integral kinetics analysis, CSTR and Plug Flow reactors, ideal and nonideal reactors, tank-in-series and APDF models, residence time distribution concept, homogeneous and heterogeneous catalysis.

Fluid Mechanics: Fluid statics, Newtonian and non-Newtonian fluids, Bernoulli equation and its application, energy balance, flow through pipeline systems (laminar and turbulent flows, friction factor), flow meters, pumps and compressors, packed and fluidized beds, size reduction and size separation; free and hindered settling;

centrifuge and cyclones; thickening and classification, filtration, mixing and agitation; conveying of solids. Relation between stress and strain rate for Newtonian fluids.

Heat and Mass Transfer: Conduction, convection and radiation, heat transfer coefficients, steady and unsteady heat conduction, boiling, condensation and evaporation; types of heat exchangers and evaporators. Fick's laws, Diffusion of fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption.

Principles of Biochemical Engineering: Enzyme catalysis (Michaelis Menton Kinetics) and reactor design. Material & energy balances of fermentation processes. Kinetics of microbial growth and product formation (Monad modelLeudeking-Piret model). Nature of fermentation processes. Transport phenomena in biochemical reactors- Mass transfer in immobilized enzyme systems and Oxygen transfer in submerged fermentation process, examples of primary metabolites, secondary metabolites and enzymes. Bioreactor operation and design, reactor sterilization. Batch, fedbatch and continuous culture process and cell recycle processes. Modelling of non-ideal behavior in bioreactors. Novel bioreactors, air-lift reactors, membrane bioreactors and fluidized bed reactors. (Filtration and membrane based separations, centrifugation, extraction, absorption and chromatography – to be removed).

(ii) Pharmaceutical Sciences & Bioprocess technology, and Pharmacology

Physiology, Pharmacology & Biochemistry: Basic physiology and biochemistry pertaining to all the systems in the body. Classification, mode of action, pharmacological effects, side effects, toxicity and posology of drugs acting on the CNS, ANS, CVS, gastrointestinal system, endocrine system. Principles of chemotherapy, chemotherapeutic agents, anticancer drugs, vitamins and minerals.

Industrial Pharmacy : Pharmaceutical processing - mixing, milling, drying, powder compression, clarification, filtration, Rheology, sterilization, sterility testing, disinfection, Pharmaceutical dosage forms : Formulation, manufacture and evaluation of solid, semisolid, liquid, aerosols and parentrals. Chemistry of natural products, SAR and Chemistry of analgesics, anticancer, CVS drugs, drugs acting on the CNS, GIT, chemotherapeutic agents, vitamins, hormones. classification, identification, extraction and isolation of active principles of commonly used medicinal plants.

Immunological preparations, genetic engineering, fermentation, Biopharmaceutics, Pharmacokinetics-drug absorption, distribution, metabolism and elimination- general principles. Basic concepts of analysis of drugs.

Biologicals and Biopharmaceuticals: Antibodies: polyclonal and monoclonal antibodies, catalytic antibodies, diagnostic antibodies; production of antibodies, vaccines: types, production and applications; Therapeutic proteins and peptides: Insulin, erythropoietin, interleukins, hormones, sterilization methods for biopharmaceuticals, biosimilars, blood plasma products, Cohn fractionation, recent examples of biopharmaceuticals.

Food Science and Technology: Food chemistry and analysis, microbiology and biochemistry of fermented food products, food spoilage and food borne diseases, Food additives and ingredients, Chemistry and technology of various food commodities like cereals, legumes and oil seeds, fruits and vegetables, meat, fish and poultry, plantation crops, milk and dairy products, confections, beverages etc., Food processing and preservation, Food packaging, Use of enzymes in food industry, Human nutrition, Nutraceuticals and functional foods, Food safety and Food laws.

Agricultural Biotechnology: Production of value added products (biofuel, secondary metabolites, natural products, bioplastics, etc.) from agricultural waste, traditional crop improvement vs biotechnological interventions, secondary agriculture, post-harvest technologies.

Fermentation Technology: Introduction to fermentation processes, Isolation, preservation and improvement of industrially important microorganisms, Optimization of media and culture conditions, Bioreactor design and operations, Modes of culture – batch, fed batch, perfusion, continuous, chemostat etc., Types of bioreactors, Scale up of microbial and animal cell based processes with case studies related to applications in biopharma, biochemical, food and agroindustries, Bioprocess considerations for animal & plant cell cultures. Applications of cell culture technology for production of vaccines, growth hormones; interferons, cytokines and therapeutic proteins; hybridoma technology and gene knockout; stem cells and its application in organ synthesis; gene therapy; transgenic animals and molecular pharming, strategies for improving yield and productivity.

Downstream Processing: Centrifugation, liquid-liquid extraction, solid-liquid extraction, sedimentation & flocculation, Cell disruption- physical, chemical, mechanical and enzymatic methods, Concentration methods, Purification by adsorption,

chromatographic and membrane (microfiltration, ultrafiltration, nanofiltration, plate and frame filters, hallow fibers, cassette filters) techniques including charge based, size based and affinity based processes, drying; Process design of industrial bio-products such as proteins & enzymes, peptides, antibiotics, vitamins, natural products, polysaccharides & biopolymers, oils and Oleochemicals, enzyme immobilization, methods of controlling bioburden in biopharma and biological products and food products. Cell Culture Techniques: Cell culture materials and tools, growth conditions and other requirements for establishment and maintenance of plant and animal cells, cell lines and tissues, micro propagation, virus free plants, protoplast & haploid culture, synthetic seeds, hairy root culture. Animal cell cultivation: primary culture, growth kinetics, biology and characterization of cultured cells

Section I :- Technology/Engineering

Stream Part - B (Physics, Chemistry and Mathematics)

Mathematics: Calculus - Differential Equation- Complex numbers- Complex integration- Power series- Three Dimensional GeometryAlgebra.

Physics:

- **Mechanics:** Kinematics- Newton’ s laws - work and mechanical energy- dynamics of rotary motion- fundamentals of special theory of relativity- gravitation- motion in non-inertial frames.
- **Thermodynamics:** Ideal gases- Ist law of thermodynamics- Kinetic theory of gases- 2nd law of thermodynamics -real gases.
- **Electricity and Magnetism:** Electrostatics- Coulomb’ s law- electric field potential- capacitance- dielectrics in an electric field- energy of an electric field- direct current- magnetic field of direct current- - eletromagnetic induction.
- **Waves and Optics:** Free harmonic oscillators- elastic waves- electromagnetic waves- interference, diffraction, scattering and polarisation of light- thermal radiation.
- **Modern Physics:** Structure of matter and basic solid state physics - elementary nuclear physics- elementary quantum mechanics- structure of atom.

Chemistry:

- **Inorganic chemistry:** Electronic structure of atoms, periodic table and periodic properties. General characteristics, structure and reactions of non-transition elements and transition elements. Coordination compounds, structure, crystal field and ligand field theories, spectral and magnetic properties.
- **Organic chemistry:** Synthesis, reactions and mechanisms of alkenes, alkynes, arenes, alcohols, phenols, alde-hydes, ketones, carboxylic acids and their derivatives, halides, nitro compounds and amines. Structure and properties of biomolecules, carbohydrates, oils, oleochemical, amino acids and proteins.
- **Physical chemistry:** Chemical equilibrium, first law, thermochemistry, second law and entropy, free energy, properties of dilute solutions. chemical kinetics, rates of reactions and factors affecting rates of reactions.
- **Analytical techniques in Biotechnology:** Principle and applications of spectroscopy, principles of UV- visible and IR spectroscopy, analytical chromatography such as HPLC, GC, TLC, HPTLC, FPLC, ion chromatography, Gelpermeation chromatography (GPC) etc., hyphenated techniques such as LC-MS and GC-MS, thermo-gravimetric analysis (DSC, TGA), Karl fisher titration, fluorescence spectroscopy, dynamic light scattering (DLS) techniques, Immunological techniques: Immunodiffusion, immunoelectrophoresis, RIA and ELISA techniques, southern & western blotting, gel Electrophoresis (PAGE, SDS-PAGE) and capillary electrophoresis, PCR & Q-PCR, AFM, SEM, TEM, EDX, X-ray diffraction, Zetasizer, acid-base titrations, common methods of organic and inorganic analysis, validation of analytical methods as per ICH guidelines, characterization of biotech products as per regulatory guidelines & pharmacopoeial guidelines, Pharmacopoeial assay, LAL-Test, BET Test, Principles and methods of microbial assay of pharmacopoeia, filter integrity test, sterility testing of biopharmaceuticals, methods of analysis of for proteins,.

Section I:- Technology/Engineering Stream

Part C (Fundamentals of Life Sciences, Chemical Sciences and Informatics)

Life Sciences: Organization of unicellular organisms, invertebrates and vertebrates. Ultrastructure of plant and animal cells. Nucleic acids, protein synthesis, Mendalian genetics. Morphology of angiosperms. Biotechnology, Physiology.

Information Technology: Introduction to www.Networking:
Basics-modem-hub-switch-commands to transfer filesremote login. Elements of

languages used on the Internet JAVA- Perl. Elements of databases- Relational databases.

Genetics and Genetic Engineering: Genotype and Phenotype, nucleic acid structure, Cell division, crossing over and mapping, Mutations and their role in evolution, Genetic Disorders, Enzymes in Genetic Engineering, Cloning Vehicles, gene cloning strategies, mutagenesis, Cloning & expression of transgenes in Prokaryotic & Eukaryotic systems, DNA sequencing, PCR technologies, gene transfer in plant and animals, molecular markers, Applications and impact of DNA technology.

Molecular Biology: Central dogma of molecular biology, Gene structure in prokaryotes and eukaryotes, Coding and non-coding DNA & RNA, Gene regulation, Molecular mechanisms of recombination, Transposons and rearrangement of DNA, DNA damage and repair, Post transcriptional and post-translational modification. Concept of system and synthetic biology.

Bioenergy biosciences: Types of biofuels, Biomass characterization and processing, biodiesel, biogas and biohydrogen production, algal biofuels (microalgae and macroalgae cultivation, harvesting, processing and value addition). Application of enzymes in biofuels.

Chemistry and chemical equilibria: Ionic and covalent bonding, M.O. and V.B. approaches for diatomic molecules, VSEPR theory and shape of molecules, hybridisation, resonance, dipole moment, structure parameters such as bond length, bond angle and bond energy, hydrogen bonding, van der Waals interactions. Ionic solids, ionic radii, lattice energy (Born-Haber Cycle). Identification of functional groups by chemical tests. Acids and bases, electronic and steric effects, optical and geometrical isomerism, tautomerism, conformers, concept of aromaticity. Reaction kinetics: Rate constant, order of reaction, molecularity, activation energy, zero, first and second order kinetics, catalysis and elementary enzyme reactions. Colligative properties of solutions, ionic equilibria in solution, solubility product, common ion effect, hydrolysis of salts, pH, buffer and their applications in chemical analysis, equilibrium constants for homogeneous reactions. Zeta potential and electronic double layer.

Section II :- Science Stream Part A

Life Sciences

Biochemistry and Microbiology: Cell structure and function; protein synthesis; genetic code; DNA & RNA; carbohydrate, protein and lipid metabolism, clinical biochemistry; In born erros of metabolism; hormones and their function. Enzymes- classification, nomenclature, kinetics etc., Metabolism & regulation of: carbohydrates, proteins, fats & nucleic acids, Metabolic disorders, Classification and taxonomy of microorganisms; Growth and physiology; Laboratory cultivation of microbes, Methods of microbial enumeration; Microbial metabolism, photosynthesis, fermentation, aerobic & anaerobic respiration, Pathogenic microorganisms, Microbial genetics, Microbes in industry, Endotoxins, viruses (enveloped and non-enveloped).

Molecular biology & recombinant DNA technology: Properties of nucleic acids, chromosomes, DNA replication, damage and repair, gene manipulation, cloning vectors, gene libraries, screening of libraries, gene cloning, applications of recombinant DNA technology, PCR, RFLP, Western, Northern and Southern blotting. microarray technology, DNA fingerprinting and recombinant DNA technology; prokaryotic and eukaryotic expression systems; Vectors: plasmids, phages and cosmids. Gene mutation: Types of mutation; UV and chemical mutagens; Selection of mutants; Ames test for mutagenesis; Bacterial, yest, cyanobacteria, fungi genetic system: transformation, conjugation, transduction, recombination, transposons genome shuffling, electroporation; DNA repair and chromosomal aberrations, synthetic biology for production of biochemicals and biotech products.

Immunology : Cells of the immune system, lymphoid tissues, complement, antibodies, hybridoma technology, applications of monoclonal antibodies, antigen recognitioin, processing and presentation, cell mediated immunity, cytokines, hypersensitivity, vaccines & vaccine technology, auto-immunity, transplantation, immune responses t various infections, Immunotechnology, B-cells and T-cells, Antibody structure, function and diversity, T-cell receptors, Antigen-antibody Reaction, Complement system and Cytokines, Hyper-Sensitivity, MHC and HLA, Hybridoma, Immunodeficiency diseases.

Section II: Science Stream

Part B (Physics and Chemistry)

Physics:

- **Mechanics:** Kinematics- Newton’ s laws - work and mechanical energy- dynamics of rotary motion- fundamentals of special theory of relativity- gravitation- motion in non-inertial frames.
- **Thermodynamics:** Ideal gases- Ist law of thermodynamics- Kinetic theory of gases- 2nd law of thermodynamics -real gases.
- **Electricity and Magnetism:** Electrostatics- Coulomb’ s law- electric field potential- capacitance- dielectrics in an electric field- energy of an electric field- direct current- magnetic field of direct current- - eletromagnetic induction.
- **Waves and Optics:** Free harmonic oscillators- elastic waves- electromagnetic waves- interference, diffraction, scattering and polarisation of light- thermal radiation.
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- **Organic chemistry:** Synthesis, reactions and mechanisms of alkenes, alkynes, arenes, alcohols, phenols, alde-hydes, ketones, carboxylic acids and their derivatives, halides, nitro compounds and amines. Structure and properties of biomolecules, carbohydrates, oils, oleochemical, amino acids and proteins.
- **Physical chemistry:** Chemical equilibrium, first law, thermochemistry, second law and entropy, free energy, properties of dilute solutions. chemical kinetics, rates of reactions and factors affecting rates of reactions.

Section II:- Science Stream

Part C (Mathematics, Computer and Information Sciences)

Mathematics: Vectors- Trignometry- Differentiation & Integration- Matrices

Information Sciences: Introduction to www. Networking: Basics-modem-hub-switch-commands to transfer filesremote login. Elements of languages used on the Internet JAVA- Perl. Elements of databases- Relational database.

Computer Application: Basics of computers- hardware-components of a computer. Operating systems- windowslinux- simple commands. Elementary Boolean arithmetic-substraction- addition- multiplication. Applications- word processing- spread sheets. Elementary basic programming commands and syntax.