NAGALAND UNIVERSITY

(A Central University Established by an Act of Parliament 1989)

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BIOTECHNOLOGY

D.C. COURT JUNCTION: DIMAPUR-797112, NL, Website: www.nagalanduniversity.ac.in, Email: biotech@nagalanduniversity.ac.in

Course structure for Bachelor of Technology in Biotechnology
Year - 2022
Total Credit: 169, Total Marks: 6700

Total Marks:6700			Total Credit: 169	
Semester	**Course No**	**Course Name**	**Credit**	**Marks**
I	G1T01	Engineering Mathematics-I	4	100
	G1T02	Engineering Physics-I	3	100
	G1T03	Technical English	3	100
	G1T04	Basic Electrical Engineering	3	100
	G1T05	Engineering Chemistry	3	100
	G1T06	Engineering Graphics	1	100
	G1L01	Engineering Physics-I Lab	1	100
	G1L02	Engineering Chemistry Lab	1	100
	G1L03	Engineering Graphics Lab	1	100
			21	900
II	G2T01	Engineering Mathematics-II	4	100
	G2T02	Engineering Physics-II	3	100
	G2T03	Fundamentals of Computing	3	100
	G2T04	Basic Electronics	3	100
	G2T05	Engineering Mechanics	3	100
	G2T06	Environmental Science	0	100
	G2L01	Workshop Practice	2	100
	G2L02	Basic Electronics Lab	1	100
	G2L03	Fundamentals of Computing Lab	1	100
	G2L04	Engineering Physics-II Lab	1	100

	AU102	Sports and Yoga	0	100
			21	1100
III	BTB301	Biostatistics	3	100
	BTB302	Biochemistry	3	100
	BTB303	Microbiology	3	100
	BTB304	Thermodynamics and Kinetics	3	100
	CSB302	Data Structures & algorithm	3	100
	BTB305	Engineering Economics	2	100
	BTB311	Biochemistry Lab	2	100
	BTB312	Microbiology Lab	2	100
	CSB312	Data Structures & algorithm Lab	1.5	100
			22.5	900
IV	BTB401	Cellular Metabolism and Metabolic Engineering	3	100
	BTB402	Plant Biotechnology	3	100
	BTB403	Cell & Molecular Biology	3	100
	BTB404	Genetics	3	100
	BTB405	Green Biotechnology and Pollution Abatement	3	100
	BTB406	Structural Biology	3	100
	BTB411	Molecular Biology Lab	2	100
	BTB412	Plant Biotechnology	2	100
			22	800
V	BTB501	Bioinformatics & Computational Biology	3	100
	BTB502	Enzyme Technology	3	100
	BTB503	Immunology & Immunotechnology	3	100
	BTB504	PROFESSIONAL ELECTIVE COURSE[PE]-I	3	100
	BTB505	OPEN SUBJECT-I	3	100
	BTB505	Entrepreneurship and Startups	2	100
	BTB511	Bioinformatics & Computational Biology Lab	2	100
	BTB512	Immunology & Immunotechnology	1.5	100

		Lab		
	BTB513	Training	2	100
			22.5	900
VI	BTB601	Recombinant DNA Technology and Applications	3	100
	BTB602	Bioseparation Engineering	3	100
	BTB603	Synthetic & Systems Biology	3	100
	BTB604	Animal Biotechnology	3	100
	BTB605	PROFESSIONAL ELECTIVE COURSE[PE]-II	3	100
	BTB606	OPEN SUBJECT-II	3	100
	BTB611	Bioseparation Engineering Lab	2	100
	BTB612	Recombinant DNA Technology Lab	2	100
			22	800
VII	BTB701	Intellectual Property Rights (IPR) & Regulatory	3	100
	BTB702	Bioprocess Engineering	3	100
	BTB703	PROFESSIONAL ELECTIVE COURSE[PE]-III	3	100
	BTB704	OPEN SUBJECT-III	3	100
	BTB705	Synthetic & Systems Biology	3	100
	BTB706	Analytical Techniques	3	100
	BTB711	Bioprocess Engineering Lab	2	100
	BTB712	Project-I	2	100
	BTB713	Colloquium	1	100
			23	900
VIII	BTB801	Constitution of India*	0	100
	BTB802	PROFESSIONAL ELECTIVE COURSE[PE]-IV	3	100
	BTB803	OPEN SUBJECT-IV	3	100
	BTB811	Project-II (Biotech Industrial or Biotech In-house Project or Bio-	9	100

		Entrepreneurship)		
			15	400

* Student may opt offline/online course

PROFESSIONAL ELECTIVE COURSE*[PE]:

Group	Subjects	Remarks
I	● Big Data Analytics ● Genome Editing ● Biosimilars Technology	Any one from each group of subjects May be opted from MOOCs/ NPTEL/offered by concerned or other Dept. of the University
II	● Machine Learning ● Waste Management & Upcycling ● Stem-Cell Technology	
III	● Gene Expression and Transgenics ● Rational Drug Discovery ● State-of-the-art Imaging	
IV	● Precision Medicine & Wellness ● Tissue Engineering ● Nano Biotechnology	

OPEN SUBJECTS [OS]*

Group	Subjects	Remarks
I	● 3D Printing & Design ● Internet of Things ● Image Processing ● Biomaterials	Any one from each group of subjects May be opted from MOOCs/ NPTEL/offered by concerned or other Dept. of the University
II	● Artificial Intelligence ● Quantum Computing ● Cyber Security ● Design Thinking	

III	• Robotics • Virtual Reality • Data Sciences • Food and Nutrition Technology	
IV	• Block Chain • Bioterrorism and National Security	

Programme Outcomes:

Upon completion of this course student will be able to:

1. Acquire knowledge of basic sciences, engineering, and biological sciences (basic and advance).

2. Address problems and find solutions to the complex issues of agriculture, environment, and human health through application of biotechnological tools and techniques.

3. Identify the relevant researchable issues/topics based on literature survey, formulate a proposal and analyze complex biological problems for arriving at substantiated conclusions using an integrated approach considering public health and safety, societal, and environmental implications.

4. Perform their duties effectively as an individual and as a member or leader in diverse teams in multidisciplinary settings for carrying out challenging tasks and providing acceptable solutions involving views of members for increased productivity.

Programme Specific Outcomes:

1. Students will know how to solve some biological problems using computational tools and algorithms.
2. Acquire knowledge in the biotechnology domain that enables their application s in industry and research.
3. Students will be able to clone DNA insert into a vector for overexpression of protein.
4. Students can perform protein purification by affinity chromatography techniques.
5. Students will have some basic training about literature review, journal publications, quality journals etc. which will help the student in his/her future research programme.

Course Outcomes

Semester	Course No	Course Name	Course Outcome
I	G1T01	Engineering Mathematics-I	Student will gain fundamental knowledge in mathematics and its applications relevant to various streams of Engineering and Technology.
	G1T02	Engineering Physics-I	Student will gain fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology.
	G1T03	Technical English	Student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.
	G1T04	Basic Electrical Engineering	Students will learn different applications of commonly used electrical machinery.
	G1T05	Engineering Chemistry	Student will learn the basic phenomenon/concepts of chemistry, the student faces during the course of their study in the industry and Engineering field.
	G1T06	Engineering Graphics	The student will learn: ● Introduction to engineering design and its place in society. ● Exposure to the visual aspects of engineering design. ● Exposure to engineering graphics standards.
	G1L01	Engineering Physics-I Lab	
	G1L02	Engineering Chemistry Lab	
	G1L03	Engineering Graphics Lab	
II	G2T01	Engineering Mathematics-II	
	G2T02	Engineering Physics-II	
	G2T03	Fundamentals of Computing	
	G2T04	Basic Electronics	
	G2T05	Engineering Mechanics	
	G2T06	Environmental Science	
	G2L01	Workshop Practice	

	G2L02	Basic Electronics Lab	
	G2L03	Fundamentals of Computing Lab	
	G2L04	Engineering Physics-II Lab	
	AU102	Sports and Yoga	
III	BTB301	Biostatistics	
	BTB302	Biochemistry	Students will able to know properties of biological molecules, their biosynthesis and metabolism
	BTB303	Microbiology	Students will able to know the growth and control of microbes as well as different techniques involved in microbiology.
	BTB304	Thermodynamics and Kinetics	
	CSB302	Data Structures & algorithm	
	BTB305	Engineering Economics	
	BTB311	Biochemistry Lab	
	BTB312	Microbiology Lab	
	CSB312	Data Structures & algorithm Lab	
IV	BTB401	Cellular Metabolism and Metabolic Engineering	
	BTB402	Plant Biotechnology	Student will be able to understand the concepts and principles of Plant tissue culture.
	BTB403	Cell & Molecular Biology	
	BTB404	Genetics	Students will acquire a broad understanding of current molecular genetics and genomics
	BTB405	Green Biotechnology and Pollution Abatement	Students will gain knowledge about how to maintain the environment. They will also gain the knowledge to use biotechnology for waste management, bioremediation, and green energy.
	BTB406	Structural Biology	Students will gain an understanding of the basic science of Protein and Nucleic Acid (DNA and RNA) structure, including first principles of physical interactions that maintain proteins and the mechanisms

			that make them intact.
	BTB411	Molecular Biology Lab	
	BTB412	Plant Biotechnology	
V	BTB501	Bioinformatics & Computational Biology	Students will develop computational skills relevant to solving problems in bioinformatics
	BTB502	Enzyme Technology	
	BTB503	Immunology & Immunotechnology	
	BTB504	PROFESSIONAL ELECTIVE COURSE[PE]-I	
	BTB505	OPEN SUBJECT-I	
	BTB505	Entrepreneurship and Startups	
	BTB511	Bioinformatics & Computational Biology Lab	
	BTB512	Immunology & Immunotechnology Lab	
	BTB513	Training	
VI	BTB601	Recombinant DNA Technology and Applications	Student will come to know about application of rDNA technology for the production of vaccines and protein therapies such as human insulin, interferon and human growth hormone.
	BTB602	Bioseparation Engineering	The students will learn how to separate and purify to homogeneity molecules and biological macromolecules of interest using different technologies. The course will also introduce how to scale up the separation in a cost effective manner.
	BTB603	Synthetic & Systems Biology	Students will learn the concept of synthetic biology and its widespread applications in research and industry. They will be able to assemble DNA and genes into biological circuits to make a biosensor or even engineer organisms.
	BTB604	Animal Biotechnology	
	BTB605	PROFESSIONAL ELECTIVE	

		COURSE[PE]-II	
	BTB606	OPEN SUBJECT-II	
	BTB611	Bioseparation Engineering Lab	
	BTB612	Recombinant DNA Technology Lab	
VII	BTB701	Intellectual Property Rights (IPR) & Regulatory	
	BTB702	Bioprocess Engineering	
	BTB703	PROFESSIONAL ELECTIVE COURSE[PE]-III	
	BTB704	OPEN SUBJECT-III	
	BTB705	Synthetic & Systems Biology	
	BTB706	Analytical Techniques	At the end of the course, student would be able to understand and apply modern analytical techniques used in biotechnology.
	BTB711	Bioprocess Engineering Lab	
	BTB712	Project-I	
	BTB713	Colloquium	
VIII	BTB801	Constitution of India*	
	BTB802	PROFESSIONAL ELECTIVE COURSE[PE]-IV	
	BTB803	OPEN SUBJECT-IV	
	BTB811	Project-II (Biotech Industrial or Biotech In-house Project or Bio-Entrepreneurship)	Students will have some basic training about literature review, journal publications, quality journals etc. which will help the student in his/her future research programme.

No of courses having employability/entrepreneurship/skill development

Course Code	Name of the Course	Activities/Content with direct bearing on Employability/ Entrepreneurship/ Skill development	Year of introduction
G2L01	Workshop Practice	Content with direct bearing on Employability	2007
CSB302	Data Structures & algorithm	Content with direct bearing on Employability	2019
CSB312	Data Structures & algorithm Lab	Content with direct bearing on Employability	2019
BTB412	Plant Biotechnology-Lab	Content with direct bearing on Employability	2017
BTB501	Bioinformatics & Computational Biology	Content with direct bearing on Employability	2022
BTB505	Entrepreneurship and Startups	Content with direct bearing on Employability	2022
BTB511	Bioinformatics & Computational Biology Lab	Content with direct bearing on Employability	2022
BTB504	Big Data Analytics	Content with direct bearing on Employability	2022
BTB605	Machine Learning	Content with direct bearing on Employability	2022
BTB703	State-of-the-art Imaging	Content with direct bearing on Employability	2022
BTB505 (1)	Internet of Things	Content with direct bearing on Employability	2022
BTB505 (2)	Image Processing	Content with direct bearing on Employability	2022
BTB606 (1)	Artificial Intelligence	Content with direct bearing on Employability	2022
BTB606 (3)	Cyber Security	Content with direct bearing on Employability	2022
BTB803	Block Chain	Content with direct bearing on Employability	2022

Syllabus
for
B.Tech in Biotechnology

3rd Semester

BTB301 - Biostatistics	**(3 – 0– 0 – 3)**
Unit - I	Introduction to Biostatistics: Definition, types of data and Application, data collection, random and non random, Data representations, Bar, Histogram, Frequency Polygon, frequency curve, relative frequency curve, pie chart (with merits and demerits). Descriptive Statistics: Introduction to basic quantities methods, Measure of central tendency, mean , mode, median, Harmonic mean, Geometrical mean, Partitions, measure of dispersion, Range, Quartile deviation, mean deviation, standard deviation and, coefficient of variation, Lorentz's curve, difference between dispersion and skewness, measures of skewness and kurtosis (with merits and demerits).
Unit - II	Probability Distributions: Introduction to probability and types of probability with applications in biostatistics, expected value of a random variable (discrete and continuous). Probability Distributions function, moment of generating function, properties and application of binomial, poisson and Normal distributions.
Unit - III	Sampling: Introduction to sampling, Types of sampling, errors, standard error, confidence limits, large sample test, single probability test, deference of probability, single mean difference of mean difference of standard deviation, tests of significance of small samples, Student's t-distribution (applications only), Chi-square test of goodness of fit, comparisons of several means: A prior tests, Posteriori tests two ways Variance. Anova and Nonparametric Test: Introducing to F-test, Z-test, Introduction, Types of Anova-one way, two ways, Nonparametric methods, Advantages and Disadvantages of Non parametric and parametric method.
Unit - IV	Correlation and regression: Introduction to correlation, Rank's Correlation methods, Introduction to regression lines, linear and nonlinear fitting (least squares methods). Multiple regressions. Advantages and disadvantages of Correlation and regression.
	Books: 1. Mathematical Statistics: S C Gupta and V K Kapoor, Sultan Shand & Sons 2. Fundamentals of Biostatistics: Bernard A. Rosner, Published by Thomson Brooks/ Cole 3. Statistics-An Introductory Analysis: Taro Yamane, Harper and Row Publisher. 4. Biostatistical Methods: J H Zar.
BTB302 –Biochemistry(3 – 0 – 0 – 3)	
Unit - I	STEREOCHEMISTRY Concept of asymmetric carbon atom, Enantiomers, Diastereiosmers, Stereogenic atom/center, Chirotopic/Achirotopic Centre, Chirality and asymmetricity in relation to biomolecules. Stereochemical nomenclature, RS, EZ, DL, Erythro and Threo designation of enantiotropic atoms. Fischer, Newman, Sawhorse and Wedge structures and their interconversion. Nomenclature of bicyclic and spiro compounds.
Unit - II	CONCEPT OF ACIDS AND BASES Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water, Ionization of weak acids and bases, pH scale, common ion effect, Theory of acid-base indicators, Buffer solutions.
Unit - III	AMINO ACIDS, PEPTIDES AND PROTEINS Amino acids: Dipolar Nature, Isoelectric point and Electrophoresis. Preparative Methods (Strecker synthesis, using Gabriel's phthalimide synthesis.). Reaction with –COOH group, acetylation of –NH2 group, complexation with Cu2+ ions, ninhydrin test. Peptides : The Peptide Linkage, Peptide Synthesis, Structure of Polypeptides. Proteins : General Characteristics, Classification, Structure, colour tests.

Unit - IV	CARBOHYDRATE Classification, and General Properties, glucose and fructose: open chain and cyclic structure, reactions, mutarotation. Epimerisation, Chain lengthening and shortening in aldoses. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose).
Unit - V	Nucleic Acids History, Sugars and bases; Conformation of sugar-phosphate backbone; hydrogen bonding by bases; the double helix; A, B, and Z double helices; Stability of Double Helix ; DNA intercalators; Chemical synthesis of DNA; Catalytic RNA, siRNA; micro RNA.
Unit - VI	LIPIDS Definition, distinction between fats and oils, structure of lipids (fatty acids, glycerolipids sphingolipids).
Unit - VII	BIOCHEMICAL TECHNIQUES A preliminary idea about principle and use of chromatography (paper, thin layer, GC, HPLC), colorimetry and spectrophotometry (UV-Vis, IR, NMR), ultracentrifugation.
	Books: 1. Lehninger's Principles of Biochemistry by Nelson & Cox 2. T. W. Graham Solomons. Organic Chemistry, John Wiley and Sons 3. Bahl A and Bahl BS. Advanced Organic Chemistry. S. Chand. 4. Eliel EL. Stereochemistry of Carbon Compounds, Tata McGraw Hill. 5. Finar L. Organic Chemistry (Vol. I & II), E. L. B. S. 6. Morrison RT and Boyd RN. Organic Chemistry, Prentice Hall.
BTB303 - Microbiology	**(3 – 0 – 0 – 3)**
Unit - I	Introduction to Microbiology: Basic microbiology- Landmark achievements in 20th century: Refutation of abiogenesis: Major contribution of scientists. Cell structure and sub cellular organelles of bacteria– Slime layer, capsule, cell wall, flagella, pili, fimbriae, nucleoid, plasmid and episome (F, R, Ti as example) ribosome, cytoplasmic inclusions (inorganic and organic), endospores. Archibacteria (importance- structure- reproduction), Moulds (importance- structure-reproduction), yeast (structurereproduction), algae (importance- structure-reproduction). Virology- General classification of virus, (structure, nucleic acid, cultivation of bacteriophage, coliphage), animal viruses plant viruses, TMV). Importance of viruses, life cycle of viruses, lytic cycle (T4) and lysogenic (lambda). Taxonomy- The five kingdom classification, criteria for classification, bacterial phylogeny, numerical approach, new approaches – taxonomic implications of DNA base composition.
Unit - II	Basic Principles of Microbiology: Microscopy- Principles and applications, dark field, bright field, resolving power, numerical aperture, chromatic aberration, phase contrast microscopy, fluorescent microscopy, inverted microscopy, stereo microscopy, electron microscopy, TEM and SEM. Cultivation of bacteria– Types of growth media (natural, synthetic, complex, enriched, selective- definition with example), pure culture methods (streak plate, spread plate, pour plate, stab culture, slant culture). Anaerobic (thioglycolate, anaerobic chamber, Robertson's media, microaerophilic), liquid shake culture of aerobic bacteria. Control of microbes- Sterilisation, disinfection, antiseptic, tyndallisation, pasteurization: Physical-dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, Chemical
Unit - III	Microbial Growth and Metabolism Growth of bacteria- Definition, growth phases, kinetics of growth, direct and indirect measurement of growth, The mathematical nature and expression of growth. growth principles of nutrition, influence of environmental factors-pH, temperature, oxygen, Heavy metals and Other compounds. Bacterial metabolism-Aerobic and anaerobic respiration (definition, examples), fermentation (alcoholic, mixed acid, acetic acid, lactic acid), Entner Duodruffs pathway, bacterial photosynthesis (green and purple bacteria), biochemical nitrogen fixation– non-symbiotic, symbiotic (definition and examples), basic concept of nif –genes. Mod genes, nitrogenase complex, legheamoglobin.

Unit - IV	**Microbiology of Air, Water and Soil:** Air microbiology- Microorganisms in the air, sampling techniques, air borne pathogens. Microbiology of water-Microbiology of fresh water and wastewater (sewage), Important water borne diseases– cholera, typhoid, (name of pathogen, preventive measures). Outlines of method for detection of microorganisms in drinking water (presumptive, confirmatory and completed tests). Distinction between fecal and non-fecal coliforms. Soil microbiology- Soil microorganisms, different kinds of association between soil microflora, between micro and macro organisms.
	Books: 1. R.C Dubey and D. K Maheshwari -A Text Book of Microbiology, 3rd ed, S. Chand and Company. 2. C.B Powar and H.F Daginawala- General Microbiology (Vol I & II) 3rd ed, Himalaya Publishing House. 3. Stanier R. –General Microbiology, 5thed, Macmilan Press ltd. 4. M. Pelczar, E.Chan, N.Kreig, Microbiology, 5thed, MGH 5. Salle.A.J- Fundamental Principles of Bacteriology, Tata Mcgraw Hill
BTB304 -Thermodynamics and Kinetics	**(3 – 0 – 0 – 3)**
Unit - I	Basic Concepts of Thermodynamics: The Ideal Gas, Review of first and second laws of thermodynamics, PVT behaviour of Pure Substances, Virial Equation of State, Application of the Virial Equations, Cubic Equations of State. The Vapour-Compression Cycle, the Choice of Refrigerant, Absorption, Refrigeration and liquefaction: Low temperature cycle: Linde and Claude.
Unit - II	Thermodynamics and its Applications: The Chemical Potential and Phase Equilibria Fugacity and Fugacity Coefficient:for pure species and solution; The Nature of Equilibrium, the Phase Rule, Duhem's Theorem, Simple model's for Vapour/Liquid Equilibrium, Roult's Law, Henry's law, Modified Raoult's Law.
Unit - III	Kinetics: Rate of chemical reaction; Effect of Temperature on Rate Constant, Arrehnius equation, Collision Theory, Transition State Theory, Order and Molecularity of a Chemical reaction,Elementary Reactions, First, Second and Third order reactions, Non Elementary Reactions, Pseudo-first order reaction, Determination of rate constant and order of reaction, Half life method, Fractional order reactions.
Unit - IV	Applications of Kinetics: Interpretation of batch reactor data for simple and complex reactions. Kinetics of Enzyme catalyzed reactions for free and immobilized enzymes.– derivation of Michaelis-Menten equation, Briggs-Haldane relationship, the determination and significance of kinetic constants, Lineweaver-burk and Eadie-Hofstee plot, principles of enzyme inhibition – Competitive, noncompetitive and uncompetitive.
	Books: 1. Smith & Vanness, Thermodynamics for Chemical Engineers, MGH 2. Richardson, J.F., Peacock, D.G.Coulson & Richardson's Chemical Engineering- Volume 3 3. ed., First Indian ed. Asian Books Pvt. Ltd. 1998 4. Levenspiel.O., Chemical Reaction Engineering, Wiley Eastern Ltd. 5. Bailey & Olis,Biochemical Engg. Fudamentals, MGH, 1990 6. Physical Chemistry: Castellan, Narosa Publishing. Physical Chemistry, ;Moore, PHI BT
CSB302 - Data Structures and algorithms	**(3 – 0 – 0 – 3)**
Unit - I	Basic concept of data structures, mathematical preliminaries-big oh notation, notion of space and time complexity, simple algorithms and illustration of their complexity,
Unit - II	Elementary data structures: arrays and its representation. Stacks: prefix, infix and postfix conversion. Queues, link list.
Unit - III	Trees: Basic terminology, Binary trees, Binary tree representation, traversal, threaded binary tree, Counting Binary Tree, Huffman coding using binary trees.
Unit - IV	Graphs: Representation, traversal, connected components, shortest path andtransitive closure, topological sort, BFS and DFS.Dijkstra's Algorithm, Floyd Warshall's Algorithm, Minimum Spanning Tree Definitions. Eulerian and Hamiltonian graphs – Characterization of Eulerian graphs - Sufficient conditions for Hamiltonian graphs.
Unit - V	Sorting- Bubblesort, selection sort, insertion sort, Shell sort; Quicksort; Heapsort;Mergesort; Radix sort; Analysis of the sorting methods. Selecting the top k elements.Lower bound on sorting.

	Books: 1. E. Horowitz and S. Sahani, " Fundamentals of Data Structures", GalgotiaBooksource Pvt. Ltd. 1999. 2. R.L.Kruse, B.P. Leung, C.L. Tondo, " Data Structure and program design in 3. C",PHI,2000. 4. Schaum's outline series, " Data Structure", TMH, 2002. 5. Y.Langsamet. Al., " Data Structures using C and C++", PHI,1999. 6. Yashwantkanethkar, " Data Structure through C", BPB, 2005. AV Aho, J hopcroft, JD Ullman, "Data Structures and Algorithms", Addison-Wesley

BTB305:Engineering Economics (2-0-0-2)	
Unit I	Introduction: Definition – Nature – Scope and Significance of Economics for Engineers. Demand and Supply: Demand – Types – Determinants – Law of Demand – Elasticity of Demand – Types – Significance – Supply – Market price determination – Case Study in Demand Forecasting –- Meaning – Methods – Consumer Survey – Trend Projections Moving average.
Unit II	Cost and Revenue: Concepts – Classifications – Short run and long run cost curves – Revenue – Concepts – Measurement of Profit (Case Study). Market Structure: Perfect Competition – Characteristics – Price and output determination in short run and long run – Monopoly – Price Discrimination – Monopolistic Competition – Product Differentiation – Oligopoly and Duopoly.
Unit III	Market Failure: Causes – Type of Goods – Rivalrous and Non-rivalrous goods – Excludable and Non-excludable goods – Solutions – Government Intervention. Money and Banking: Money – Functions – Quantity theory of money – Banking – Commercial Banks – Functions – Central Bank (RBI) – Functions – Role of Banks in Economic Development.
Unit IV	Foreign Exchange: Balance of Payments – Exchange rate determination – Methods of foreign payments – International Institutions – IMF, IBRD. Business Cycle and National Income: Meaning –Phases of business cycle – Inflation Causes – Control measures - Deflation - National Income – Concepts – Methods of calculating national income – Problems in calculating national income.
Books	1. Premvir Kapoor, "Sociology & Economics for Engineers", Khanna Publishing House, 2018. 2. Dewett. K.K., Navalur M. H., "Modern Economic Theory", S. Chand and Company Ltd, New Delhi, 24thEdn., 2014. 3. Lipsey& Chrystal, "Economics", Oxford University Press, 2010.

BTB311 - Biochemistry Lab	**(0 – 0 –4 – 2)**
	Experiments: 1. Spectrophotometry: Verification of Lambert-Beer's law 2. Estimation of sugars: Enzymatic method (GOD method) 3. Separation of amino acids/ sugars/ steroids/ vitamins/ alkaloids/antibiotics - Thin layer 4. chromatography/ Paper chromatography (at least one adopting both methods). 5. Determination of specific activity of an enzyme (α and ß amylase/SDH/alkaline 6. phosphatase) 7. Enzyme Kinetics - (Determination of Km and Vmax) of a enzyme 8. Determination of temperature and pH optima of an enzyme 9. Enzyme Inhibition – determining the nature of inhibition 10. Separation of proteins by Polyacrylamide Gel Electrophoresis (PAGE). Chemical estimation of DNA /RNA (by spectroscopy).

BTB312 - Microbiology Lab	**(0 – 0 –4 – 2)**

	Experiments: 1. Sterilization techniques 2. Media preparation 3. Microscopy and Micrometry 4. Isolation, enumeration and purification of microbes from a given sample 5. Staining Techniques (Simple, Gram staining, spore staining) 6. Biochemical Characterization of Bacteria Oxidation/Fermentation Test Catalase, Oxidase and Urease Tests IMViC test Hydrogen Sulfide Test and Nitrate Reduction Test. Casein and Starch Hydrolysis 7. Antibiotic Assay - Antimicrobial Sensitivity Test (Disc Diffusion Method) 8. Growth Kinetics (Bacterial Growth Curve)
CSB312 - Data Structures and algorithms Lab	**(0 – 0 – 3 – 1.5)**
	Experiments: 1. Implementation of Array Operations: (using C/C++ languages) 2. Stacks and Queues: Adding, Deleting elements, Circular Queue: Adding and Deleting elements, Merging 3. Problem. 4. Implementation of linked lists: Inserting, Deleting, Inverting a Linked List. Sorting and 5. Searching 6. Algorithms. Prim's, Kruskal's and Dijkstra's Algorithm.

4th Semester

BTB401 Cellular Metabolism and Metabolic Engineering	**(3 – 0 – 0 – 3)**
Unit - I	Introduction to Enzyme & Carbohydrate Metabolism: Enzymes: Basic concept of enzyme-substrate reaction, Classification and nomenclature, Enzyme active site, Regulation of enzyme activity, allosteric regulation. Generation and utilization of ATP. Metabolic pathways of carbohydrates and their regulation: glycolysis, TCA cycle, pentose phosphate pathway, Entner-Doudoroff pathway and Cori cycle.Oxidative phosphorylation: electron transport chain, ATP synthesis, regulation of oxidative phosphorylation; gluconeogenesis, glycogen (glycogenolysis and glycogenesis). Photosynthesis: Photophosrylation, Calvin cycle. Disorder/diseases of carbohydrate metabolism.
Unit - II	Metabolism of Amino acid, Protein: Catabolism and Anabolism, Catabolism of amino acids, general metabolism of amino acids. catabolism of Tyrosine, Leucine, Glutamic acid and Arginine Glucogenic amino acids, ketogenic amino acids. urea cycle and its regulation, protein degradation and turnover. Disorder/ diseases of amino acids metabolism.
Unit - III	Metabolism of lipid, nucleic acid and vitamin: Oxidation of Fatty acid: Beta oxidation and omega oxidation of fatty acids – saturated and unsaturated fatty acids –even and odd numbered. Catabolism of phospholipids. Biosynthesis of fatty acids, phospholipids, cholesterol and steroid, Disorder/ diseases of lipid metabolism. Nucleic acid metabolism: nucleotide metabolism, purine and pyrimidine degradation, De Novo and Salvage Pathways. Disorder of purines and pyrimidines metabolism. Metabolism of Vitamins, Brief description of animal and plant hormones.
Unit - IV	Cell Signaling: Cell signaling and signal transduction pathways: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, second messengers, regulation of signaling pathways, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins.
Unit - V	Introduction to metabolic engineering and its importance: Introduction to metabolism, catabolism, anabolism. Key differences between metabolic controls of prokaryotes and eukaryotes. Stoichiometry of cellular reactions, enzyme kinetics, reaction rates, dynamic mass balance, yield coefficients and linear rate equations, the black box model, elementary balance, heat balance different models for cellular Reactions-Induction-Jacob Monod Model and its regulation, differential regulation by isoenzymes, concerted or cumulative feedback regulation. Regulation in branched pathways, permeability and transport of metabolites.

	Books: 1. Lehninger's Principles of Biochemistry by Nelson & Cox 2. Molecular Biology of the Cell by Bruce Alberts, 4th ed, Garland Science Publishers, 2002 3. Lubert Stryer, Bio chemistry, Freeman & Co, NY 4. Voet & Voet, Fundamentals of Biochemistry, John Willey & Sons 5. Harper's Illustrated Biochemistry - R.K.Murray et al. (McGraw Hill) 6. Outline of Biochemistry - Conn & Stump (John Willey & Sons)
BTBT04 - Plant Biotechnology	**(3 – 0 – 0 – 3)**
Unit - I	Introduction and scope of plant biotechnology, introduction to plant tissue culture-plasticity and totipotency, various media formulations, plant growth regulators, callus and suspension cultures.
Unit - II	Micropropagation, organogenesis and somatic embryogenesis, haploid and triploid production and homozygous lines, embryo culture and rescue.
Unit - III	Protoplast isolation, culture. Somatic hybridization and cybrid production, selection of hybrid cells, regeneration of hybrid plants, production of virus free plants, synthetic seeds.
Unit - IV	Architecture of plant nuclear, chloroplast and mitochondrial genomes, structural aspects of plant genes, rubisco synthesis and assembly, coordination, regulation and transport of proteins, regulation of gene expression, Genetics of *nif* genes, Molecular mechanism of nitrogen fixation.
Unit - V	Introduction to plant genetic engineering and manipulation of phenotypic traits; strategies of molecular cloning and manipulation of plant genes, various methods of plant genetic transformation, *Agrobacterium*-mediated genetic transformation of plants (Ti and Ri-plasmid vectors), Viral Vectors: Gemini virus, cauliflower mosaic virus, viral vectors and its benefits, direct transformation of plants, molecular markers, Transgene stability and gene silencing, introducing resistance to herbicides, virus, pest and fungal pathogens.
Unit - VI	Introduction to secondary metabolites, plant cell culture techniques for production of secondary metabolites & other important compounds, cryopreservation and conservation of germplasm.
	Books: 1. A. Slater, N. Scott and M. Fowler, *Plant Biotechnology: The genetic manipulation of plants*, Oxford University Press, 2003. 2. S. S. Bhojwani and M. K. Razdan, *Plant Tissue Culture: Theory and Practice*, Elsevier, 1996. 3. J. Hammond, P. McGarvey and V. Yusibov, *Plant Biotechnology: New Products and Applications*, Springer Verlag, 1999. 4. P. Jones, P. J. Jones and J. M. Sutton, *Plant Molecular Biology: Essential Techniques*, John Wiley & Sons, 1997. 5. Potrykus and G. Spangenberg, *Gene Transfer to Plants*, Springer Verlag, 1995. 6. Primrose, S.B., Twyman, R.M., *Principles of Gene Manipulation and Genomics*, 7th Edition, Blackwell Publishing (2006)
BTB403 - Cell & Molecular Biology	**(3 – 0 – 0 – 3)**
Unit - I	Introduction to Molecular Biology, Replication & repair: Introduction: Double Helix model of DNA by Watson and Crick. A, B, Z Forms of DNA; Supercoiling of DNA, Nucleosome bead, Chromatin structure.. Replication in prokaryotes and eukaryotes: Mechanism, Model, structure and function of different Enzymes in DNA replication. Initiation, Elongation & Termination of replication; Inhibitors of DNA replication; RNA replication. DNA Repair in Prokaryotes and Eukaryotes: Nucleotide excision repair, base excision repair, mismatch repair, photo-reactivation repair, recombination repair and SOS repair. Repair defects and human diseases, Central Dogma of molecular biology.
Unit - II	Gene expression; Transcription: Components of transcriptional machinery in prokaryotes and eukaryotes: Structure of mRNA, promoter, RNA polymerases and transcription factors, terminators. Process of transcription in prokaryotes and eukaryotes: Initiation, Elongation & Termination of transcription (Rho dependent and independent). Post transcriptional processing of RNA: capping, splicing (different types), polyadenylation and RNA editing. mRNA stability. Inhibitors of transcription. Reverse transcription. Ribozyme.

Unit - III	Gene expression; Translation: Components translational machinery in prokaryotes and eukaryotes: structure and function of ORF, tRNA, rRNA, aminoacyl synthetases, Ribosomes, RBS). Process of Translation in prokaryote and eukaryote: Initiation, Elongation & Termination. Concept of genetic code and Wobble hypothesis. Post translational modifications of protein, Protein folding, Protein targeting and degradation, Inhibitors of translation.
Unit - IV	Regulation of Gene Expressions: Molecular structure of genes and its nomenclature. Principle of gene regulation: negative and positive regulation, inducer, repressor, co-repressor, activators, co-activators, silencers, insulators, enhancers, DNA binding protein-protein interacting domain of gene regulatory protein. Gene regulation in prokaryote: concept of operon model, (*lac*, *trp* and *ara* operon), Phage regulatory strategy and antitermination in lambda phage. Gene regulation in eukaryotes: DNA looping model, hormonal control of gene expression (steroid and non steroid), regulations at level of translation, riboswitch, gene silencing.
	Books: 1. Molecular Biology of the Gene – by Watson 2. Gene IX by B. Lewin. 3. Essentials of molecular Biology, by Malacinski and Freifelder Jones and Bartlelt 4. Publishers. 5. Molecular and Cellular Biology- by Stefen Wolfe 6. Genomes, by T. A. Brown, John Wiley and Sons PTE Ltd. 7. Cell and molecular Biology, Concepts and experiments by Gerald Karp, John Wiley and Sons

BTB404 - Genetics	**(3 – 0 – 0 – 3)**
Unit - I	**Classical Genetics & its exceptions:** Mendelian inheritance; multiple alleles, pseudoallele, gene interaction, complementation, Codominance, incomplete dominance, linkage, pleiotropy; recombination and chromosome mapping, sex determination; extrachromosomal inheritance, special types of chromosomes; Alterations of chromosomes: euploidy and aneuploidy, deletion, duplication, inversion and translocation their genetic implications; pedigree analysis, lod score for linkage testing, karyotypes.
Unit - II	**Gene Mutation and Cancer:** Gene Mutation: Induced and spontaneous mutation**,** mutation Types, causes and detection, mutant types. Molecular basis of genetic diseases. Applications of genetic disorders: Cancer Genetics: Genetic rearrangements in progenitor cells, oncogenes; proto-oncogenes; tumour suppressor genes – p53, RB and others, virus-induced cancer, cancer and the cell cycle
Unit - III	**Microbial Genetics :** Biochemical genetics. Bacterial Genetics: plasmids, transposon; Gene transfer: transformation, transduction, conjugation; recombination and complementation analysis; gene mapping. Viral genetics: genetics of animal virus: polio, HIV and adenovirus, Bacteriophage: genetics of lambda, M13, T4 and T7;
Unit - IV	**Population Genetics:** Population genetics: Hardy-Weinberg equilibrium, changes of gene frequency, continuous variation; extensions of H-W equilibrium. Polygenic inheritance, heritability and its measurements, QTL mapping.
	Books: 1. Concepts of Genetics, 7th edition, (Low Price edition) M.R. Cummings, A.W. Klug. Pub: Pearson Education. Cengage Learning India (P) Limited 2. M.W.Strickberger: Genetics, Pearson 3. Introduction to Genetic Analysis, 8th edition, Anthony J. F. Griffiths, Jeffrey H. Miller, David T. Suzuki, Richard C. Lewontin, and William M. Gelbart. Pub: W.H. Freeman & Co. 4. Principles of Genetics, 5th edition. D. Peter Snustad, Arthur J. Simmons. Pub: John 5. Wiley & Sons. 6. iGenetics: a Conceptual Approach, 3rd edition, Peter J. Russell. Pub: WH Freeman & Co. 7. Microbial Genetics, 2nd edition, Stanley R. Maloy, John E. Cronan, David Freifelder. Pub: Jones and Bartlett Publisher Inc. Genetics: Principles and Analysis, 4th edition. D.L. Hartl, D.W. Jones. Pub: Jones and

BTB405 -Green Biotechnology and Pollution (3 – 0 – 0 – 3)	
Unit-I	**Biological wastewater treatment:** Principles and design aspects of various waste treatment methods with advanced bioreactor configuration: Solid waste management: landfills, recycling and processing of organic residues, minimal national standards for waste disposal.
Unit-II	**Biodegradation of Xenobiotic Compounds:** Xenobiotic compounds– Definition, examples and sources. Biodegradation- Introduction, effect of chemical structure on biodegradation, recalcitrance, co metabolism and biotransformation. Factors affecting biodegradation, microbial degradation of hydrocarbons.
Unit-III	**Biotransformations and Biocatalysts:** Basic organic reaction mechanism- Common prejudices against enzymes, advantages & disadvantages of biocatalysts, isolated enzymes versus whole cell systems, biocatalytic application, catalytic antibodies; stoichiometry.
Unit-IV	**Bioremediation and Biorestoration:** Introduction and types of bioremediation, bioremediation of surface soil and sludge, bioremediation of subsurface material, In situ and Ex-situ technologies, phytoremediation- restoration of coal mines a case study. biorestoration: reforestation through micropropagation, use of mycorrhizae in reforestation, use of microbes for improving soil fertility, reforestation of soils contaminated with heavy metals.
Unit-V	**Eco-Friendly Bioproducts from Renewable Sources:** Fundamentals of composting process: scientific aspects and prospects of biofuel production: bioethanol, biohydrogen and biodiesel; biofertilizers and biopesticides.
Unit-VI	**Biotechnology in Environment Protection:** Current status of biotechnology in environment protection and its future, release of genetically engineered organisms in the environment.
	Books 1. Environmental Processes I-III, J. Winter, 2nd ed., Wiley Publications 2. Introduction to Wastewater Treatment- R. S. Ramalho, Academic Press. 3. Elements of Water Pollution Control Engineering – O.P. Gupta, Khannabooks. 4. Energy Technology – O.P. Gupta, Khannabooks, 2018. 5. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd. 6. Environmental Biotechnology, B.C. Bhattacharya & Ritu Banerjee, Oxford Press, 2007. 7. Environmental Biotech, Pradipta Krimar, I.K. International Pvt. Ltd., 2006. 8. Environmental Microbiology & Biotechnology, D.P. Singh, S.K. Dwivedi, New Age International Publishers, 2004. 9. Biodegradation and Bioremediation 1999 (2nd edition). Martin Alexander, Elsevier Science & Technology. 10. Environmental Biotechnology by Bruce Rittmann and Perry McCarty.

BTB406-Structural Biology	(3 – 0 – 0 – 3)
Unit-I	**Protein structural biology**: Protein sequences, sequence alignment; basic polypeptide stereochemistry, hierarchy in protein folds: secondary structure, tertiary structure, quaternary structure. Chaperones assisted protein production, Thermodynamics of protein stability. Effect of amino acid on protein structure.
Unit-II	**Protein structure and analysis**: Principles of soluble and membrane protein purification, Phase diagram and separation, crystallization, Use of robotics in crystallization, Space groups and symmetry, structure determination; NMR sample preparation, Sample preparation for Cryo EM, Structure validation and best practices on the use of protein structures from protein data bank; Protein fold-function relationships, Protein Data Bank (PDB) and EM Data Bank, BioMagResBank (BMRB).
Unit-III	**Methods for atomic-resolution structure determination**: X-ray crystallography, solution- and solid-state NMR spectroscopy, Single particle Cryo Electron Microscopy, X-Ray Free-Electron Laser (XFEL). Anisotropy? Use of Circular Dichroism, Steady-state and time-resolved fluorescence spectroscopy, FRET, Single molecule fluorescence, Electron Paramagnetic Resonance spectroscopy.
Unit-IV	**DNA and RNA structures**: DNA and RNA secondary structures (duplex, triplex, quadruplexes and aptamers), RNA secondary structure prediction.
Unit-V	**Structure of Sugars and lipids**
Unit-VI	**Structural dynamics**: Dynamics of Protein-RNA complexes; Structure and organization of genomes.
Unit-VII	**Simulations**: Protein functional dynamics, Protein dynamics studies by MD simulations; Protein dynamics studies by biophysical techniques.
Books	1. Biophysical Chemistry vol I, II and III by Charles R. Canter and Paul R. Shimmel. 2. Structure and Mechanism in Protein Science by Alan Fersht. 3. Proteins: Structures and Molecular Properties, by Thomas E. Creighton. 4. Introduction to Protein Structure by Branden and Tooze, Garland Science; 2nd edition 1999. 5. Principles of nucleic acid structure, by Stephen Neidle. 6. RNA Sequence, Structure, and Function: Computational and Bioinformatic Methods by Walter L. Ruzzo, Jan Gorodkin, Springer 2014. 7. Crystallography made crystal clear by Gale Rhodes. 8. NMR of Proteins and Nucleic Acids by Kurt Wüthrich. 9. The Art of Molecular Dynamics Simulation by D. C. Rapaport Cambridge University Press; 2nd edition 2004.

BTB411-Molecular Biology Lab	(0 – 0 – 4 – 2)
	Experiments:
1.	Isolation of Genomic DNA from blood, plant cell and bacteria (any one)
2.	Isolation of RNA
3.	Isolation of Plasmids
4.	Spectroscopic analysis of DNA/RNA
5.	Preparation of Agarose Gel

	6. Formaldehyde gel electrophoresis of RNA 7. Induced mutation by: (a) Chemical (b) Ultraviolet light 8. Phage Titration **9. PCR**
BTB412 - Plant Biotechnology Lab	**(0 – 0 – 4 – 2)**
	Experiments: 1. Explant selection sterilization and inoculation 2. Various media preparations: MS, B5. 3. Callus and cell suspension culture; induction and growth parameters 4. Chromosomal variability in callus culture 5. Plant regeneration from embryo, meristem culture. 6. Androgenesis: Anther and pollen culture. 7. Somatic embryogenesis-study of different stages of cells.

5th Semester

BTB501-Bioinformatics &Computational Biology	**(3 – 0 – 0 – 3)**
Unit - I	Definition and application bioinformatics to biological research and a general view about application relating biological research. NCBI different modules: GenBank; OMIM, Taxonomy browser, PubMed;. A brief introduction of gene prediction: Prediction of ORF, Promoter.
Unit - II	Sequence analysis: Introduction to sequence analysis, local and global alignment, pair wise and multiple alignment,sequence alignment algorithm: Needleman and Wunsch algorithm, Smith-Waterman, BLAST, FASTA. Substitution Matrix :PAM and BLOSUM.
Unit - III	MATLAB programming with bioinformatics application. Introduction to the idea about phylogenetics analysis through multiple sequence alignment: CLUSTALW.
Unit - IV	Protein Secondary and tertiary structure prediction : Chou Fasman method, Hidden markov model and neural network, Homology Modelling, Motif identification- Pfam, Prosite. Structure visualization methods (eg: RASMOL, CHIME) Introduction to energy minimization ,QSAR and their relation in drug design.
	Books: 1. Xiong.J, Essential Bioinformatics, Cambridge University Press 2. Ghosh and Mallick, Bioinformatics-Principles and applications Oxford University 3. Press. 4. James Tisdall, Beginning Perl for Bioinformatics, SPD 5. Cynthia Gibas and Per Jambeck, Introduction to Bioinformatics computer Skills, 2001 6. SPD 7. Atwood, Introduction to Bioinformatics, Person Education Smith, D.W, Biocomputing : informatics and Genome Project,.,1994, Academic 8. Press, NY. Baxevanis, A.D, Quellette. B.F.F, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, , John Wiely & Sons. Andrew Leach, Molecular Modelling: Principles and Applications,Pearson Education.

BTB501 – Immunology& Immunotechnology	**(3 – 0 – 0 – 3)**
Unit - I	Introduction to Immunology: The origin of Immunology: History and evolution of immune system; Innate immunity; Acquired immunity; Humoral and cell-mediated immunity; Passive transfer of immunity; Primary and secondary lymphoid organs; Structure and function of Antigen; Concept of Epitope, B cell and T cell: Biogenesis or Maturation; Macrophage and other Antigen Presenting Cells (APCs).

Unit - II	Molecular basis of Immunology: Structure and function of Antibody; Concept of Isotype, Allotype and Idiotype; Molecular basis of antibody diversity: DNA rearrangements; variations arising out of V,D,J joining; somatic hypermutation; Class switching; Primary and secondary immune response; Polyclonal and monoclonal antibody; Complement; Antigenantibody reaction, Basic concepts of Immunodiffusion, RIA and ELISA.
Unit - III	Major Histocompatibility Complex(MHC): Antigen processing and presentation; synthesis of antibody and secretion; HLA; laws of graft rejection; graft versus host reaction; Development of Inbred mouse strain; Blood group classification and Rh factor, Cytokines and other co-stimulatory molecules.
Unit - IV	Immune response and tolerance: Regulation of immune response; Immune tolerance; T cell anergy and T cell elimination;Hypersensitivity; Autoimmunity with respect to Myasthenia gravis and Rheumatoid arthritis; AIDS and immunodeficiency; Tumour immunology; vaccines.
	Books: 1. Roitt, Immunology, 6th ed 2001, Mosby Publications. 2. Immunology and Immune Technology by A. Chaktraborty, Oxford Univ. Pub. 3. Immunology: An Introduction. Tizard Cengage Learning India (P) Limited 4. Essential Immunology, Roitt, I.M., 9th Ed. (1997), Blackwell Scientific, Oxford, UK 5. Immunology, Kuby, J. 3rd Ed. (1997), Freeman, W.H,Oxford,UK 6. Weir, Immunology, 8th ed, W.B. Saunders& Co. 7. K.A. Abbas, Immunology, 4th ed, W.B. Saunders& Co.
BTB502 -Enzyme Technology	**(3 – 0 – 0 – 3)**
Unit - I	Introduction to enzymes, mechanism of enzyme action, strategies of purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes. . Kinetics of Enzymecatalyzed reactions for free and immobilized enzymes.– derivation of Michaelis-Menten equation, Briggs-Haldanerelationship, the determination and significance of kinetic constants, Lineweaver-burk and Eadie-Hofstee plot, principlesof enzyme inhibition – Competitive, noncompetitive and uncompetitive.
Unit - II	Immobilized enzymes and cells: Economic argument for immobilization, methods of immobilization, kinetics of immobilized enzymes, effect of solute partition and diffusion on the kinetics of immobilized enzymes, use of immobilized enzymes, bioreactors using immobilized enzyme.
Unit - III	General uses of biocatalysts: advantages of enzymes vs chemical catalysis, enzyme vs fermentation, application of biocatalysts, industry medicine and analysis, enzyme business in India abroad.
Unit - IV	Large scale uses of enzymes: enzymes used in detergents, use of proteases in food, leather and wool industries , production of glucose syrup from the starch using starch hydrolyzing enzymes, production of syrup containing maltose, enzymes in sucrose industry, glucose from cellulose, lactose in diary industry, glucose oxidase and catalase in food industry, medical application of enzymes. Enzyme engineering: The design and construction of novel artificial enzymes
	Books: 1. Fundamentals of enzymology by Nicolas C. price and Lewis stevens . Oxford 2. University Press 3. Enzymes by Trevor palmer, East west Press 3. Enzyme Technology by Messing Atkinson.B and Marituna.F, Biochemical Engineering and Biotechnology 4. Handbok,The Nature Press, Macmillan Publ. Ltd.4 Enzymes : Dixon and Webb.(IRL Press) Enzyme technology by Chaplin and Bucke. 5. Cambridge Univerity Press Biochemical engineering fundamentals, second edition. James E Bailey, David F., Ollis, McGraw Hill Intl. Edition

BTB504- PROFESSIONAL ELECTIVE COURSE[PE]-I	

BTB505- OPEN SUBJECT-I	

BTB505- Entrepreneurship and Startups	
Unit-I	**Introduction to Entrepreneurship and Start – Ups** • Definitions, Traits of an entrepreneur, Intrapreneurship, Motivation • Types of Business Structures, Similarities/differences between entrepreneurs and managers.
Unit-II	**Business Ideas and their implementation** • Discovering ideas and visualizing the business • Activity map • Business Plan
Unit-III	**Idea to Start-up** • Market Analysis – Identifying the target market, • Competition evaluation and Strategy Development, • Marketing and accounting, • Risk analysis
Unit-IV	**Management** • Company's Organization Structure, • Recruitment and management of talent. • Financial organization and management
Unit-V	**Financing and Protection of Ideas** • Financing methods available for start-ups in India • Communication of Ideas to potential investors – Investor Pitch • Patenting and Licenses
Unit-VI	**Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy.**

S. No.	Title of Book	Author	Publication
1	The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company	Steve Blank and Bob Dorf	K & S Ranch ISBN – 978-0984999392
2	The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses	Eric Ries	Penguin UK ISBN – 978-0670921607
3	Demand: Creating What People Love Before They Know They Want It	Adrian J. Slywotzky with Karl Weber	Headline Book Publishing ISBN – 978-0755388974
4	The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business	Clayton M. Christensen	Harvard business ISBN: 978-142219602

BTB511 -Bioinformatics &Computational Biology Lab	(0 – 0 – 2 – 1)
	Experiments: 1. Handling of Biological databases eg: NCBI, EMBL, PDB, 2. Pair wise sequence alignment (EMBOSS and BLAST) and multiple sequence alignment (CLUSTALW) and phylogenetic analysis (CLUSTAL W) 3. Prokaryotic gene prediction 4. Prediction of secondary and tertiary structure of proteins ; structure viewer and analysis. 5. Basic introduction to molecular modeling, 6. Perl programming,
BTB512-Immunology & Immunotechnology Lab	**(0 – 0 – 2 – 1)**
	Experiments: 1. Staining of Blood film 2. Blood grouping. 3. Preparation of O and H antigen 4. Quantitative VIDAL test 5. Immunodiffusion in Agar gel 6. ELISA- qualitative 7. Western blot technique.
BTB513	**Training**

6th Semester

BTB601- Recombinant DNA Technology and Applications	(3 – 0 – 0 – 3)
Unit - I	Tools of Recombinant DNA technology: Restriction & modification enzymes (Restriction enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase,Polynucleotide kinase, Alkaline phosphatase); Cloning Vectors: plasmid, M13 vectors, cosmids, Phagemids,YAC, BACand MAC; Expression vectors: pET vectors, Baculovirus vectors.
Unit - II	Techniques Recombinant DNA technology: DNA labelling (radioactive and non radioactive method); DNA sequencing (Maxum & Gilbert, Sangers, pyro-sequencing,shotgun sequencing method)'; Protein sequencing; RNA sequencing; Southern and northern and western blotting; In-situ hybridization; Site-directed mutagenesis; DNA fingerprinting (RAPD; RFLP, AFLP).
Unit - III	Gene Cloning Methods Isolation of DNA, mRNA and total RNA; Polymerase chain reactions (PCR) and modified PCR. Genomic and cDNA libraryies; Gene isolation; Gene cloning; screening & Expression of cloned gene; Transposons and gene targeting.
Unit - IV	Gene transfer technologies, production of insulin, human growth factor; gene therapy (antisense and ribozyme technology), Human genome project and its application. Large scale Gene expression analysis (Microarray for DNA and protein). strategies for genome sequencing. Biosafety.
	Books: 1. Old and Primrose, Principles of Gene Manipulation, 3rd Ed, Blackwell 2. ScientificPublishers.2 3. Genetic Engineering by S. Rastogi and N. Pathak, Oxford Univ. Pub. 4. Recombinant DNA Technology: Setubal: Introduction to computational Molecular Biology. Cengage Learning India (P) Limited 5. D.M. Glover, Genetic Engineering, Cloning DNA, Chapman and Hall, New York, 1980 6. B. R. Glick and J.J. Pasternak ; Molecular Biotecnology: Principles and Applications of Recombinant DNA, ASM press 7. Watson, J.D., Gilman, M., Witkowski, J., Zoller, M. - Recombinant DNA, Scientific American Books, New York, 1992. 8. H.K. Das, Text Book of Biotechnology, 1st ed, 2004, Wiley Publishers 9. Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 10. D. M. Glover and B.D. Hames; DNA cloning: A Practical Approach, IRL Press. Brown TA, Genomes, 3rd ed. Garland Science 2006

BTB602- Bioseparation Engineering	
Contents	Introduction to separation of biomolecules and its importance in Biotechnology, Working principles of centrifugation, centrifugation-based methods for separation of the cell organelles and biomolecules (DNA, RNA, Proteins and secondary metabolites), Separation of different types of DNA from cells, Separation of the different types of RNA from biological samples, Basics of chromatography and its use in separation of biomolecules, TLC, HPLC, GC etc., Methods for separation of the proteins based on size, charge and chemical nature of the proteins, Isolation and separation of biolipids, Membrane and Rotating Membrane in Bioseparation, TCL for separation of the lipids, Ultrafiltration methods and separation of biomolecules, Polymer beads for immobilization of biomolecules, Magnetic Beads for Bio-separation, Cell Sorting, Microfluidics based separation.
Books	1. Molecular Cloning - Sambrook Russel - Vol. 1, 2, 3. 2. Fat Detection: Taste, Texture, and Post Ingestive Effects. Montmayeur JP, le Coutre J, editors. Boca Raton (FL): CRC Press/Taylor & Francis; 2010. 3. Biochemistry. 5th edition. Berg JM, Tymoczko JL, StryerL. New York: W H Freeman; 2002.

BTB603- Synthetic &Systems Biology	
Module 1:	**Introduction to Synthetic biology & Systems biology** Introduction to synthetic biology. Background of Gene Regulatory Mechanisms (Gene Parts- Gene Structure, Promoters, Terminators, Enhancers, Inducers, Repressors, Transcription Factors, Co-factors, transcriptional and post-transcriptional regulation, post-translational modifications). Genetic Engineering and Genome Editing Various Omics & role in systems biology - genomics, proteomics, transcriptomics, metabolomics
Module 2:	**Elements of synthetic biology - Tools, circuits, BioBricks** Gene shuffling for large scale pathway assembly and engineering; Choices for microbial hosts for industrial applications– bacteria, yeast, insect. Gene editing methods – CRISPR/ Cas; Gene sequencing – Pyrosequencing, Nanopore sequencing. Bacterial circuits: feed-back, feed-forward, toggle switch, signal propagators and band filter, synchronized oscillators. Introduction to Bio Bricks & its applications. Microarrays & systems biology - a basic introduction
Module 3:	**Mathematical modelling & simulation** Noise in Gene Expression.Mathematical Modeling and Simulation. Biosensors. Application of software tools for modelling gene expression. Various markup languages used in systems biology. Introduction to various metabolic pathway databases
Module 4:	**Commercial Applications** Biomedicine, Biomaterials, Biofuels and Bioremediation; Production of artemisinin as case study. Building the new bio-economy. Introduction to Biofoundries & circuits. Role of automation and robotics in biofactories; Green chemistry - use of plants for engineering biologics & small molecules. Biosurfactants as an example of microbial cell factory based production. Global events & competitions- iGEM, synbiobeta.
Module 5:	**Regulations & ethics**. Safety & bioethics, legal & IP elements involved in synthetic biology applications for human, animals and plants.
Text Books/References	1. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC (2006). 2. Eric Davidson, The Regulatory Genome: Gene Regulatory Networks In Development And Evolution, Academic Press (2006). 3. Hamid Bolouri, Computational Modeling of Gene Regulatory Networks - A Primer, Imperial College Press (1st edition) (2008). 4. Freemont, P.S and Kitney, R.I. (2012). Synthetic Biology – a Primer. World Scientific Publishing Co pte Ltd 5. Singh, V and P.K. Dhar. (2015). Systems and Synthetic Biology. Springer publishing, Netherlands 6. Fu, P and Panke, S (2009). Systems Biology and Synthetic Biology. Wiley Publishing. 7. Covert, M.W. (2014). Fundamentals of Systems Biology: from Synthetic Circuits to Whole Cell Models. CRC Press 8. Konopka, A. K. (2006). Systems Biology: Principles, Methods, and Concepts. CRC Press. 9. Church, G and Regis, E. (2012). Regenesis: How Synthetic Biology will Reinvent Nature and Ourselves. Basic Books. 10. Standards for Plant Synthetic Biology - http://onlinelibrary.wiley.com/doi/10.1111/nph.13532/full 11. Synthetic and Systems Biology for Microbial production of Commodity Chemicals - http://www.nature.com/articles/npjsba20169. 12. Biotechnology and Synthetic Biology Approaches for Metabolic Engineering of Bioenergy Crops - https://www.ncbi.nlm.nih.gov/pubmed/27030440. 13. Microarray Data Analysis: Gene Expression Data Analysis. A Beginner's Guide by: Helen Causton (Imperial College), J Quackenbush and AlvisBrazma (The European Bioinformatics Institute).

	14. A Practical Approach to Microarray Data Analysis (Hardcover) by Daniel P. Berrar (Editor), Werner Dubitzky (Editor), Martin Granzow (Editor).

BTB604 - Animal Biotechnology	**(3 – 0 – 0 – 3)**
Unit - I	History of animal cell culture and development, Development of primary culture, Development of cell line by enzymatic disaggregation, Culture media and growth conditions. Cell type and characterization, origin of animal cell line, Differentiation of cancerous cells and role of protooncogenes; cryopreservation; Common cell culture contaminants. Marker gene characterization, Cell cloning and selection; Transfection and transformation of cells. Application of animal cell culture in: Cytotoxicity and viability assays; production of human and animal viral vaccines and pharmaceutical proteins. Stem cell: types, properties and their applications in animal cloning, therapeutics.
Unit - II	Animal cell growth characteristics and kinetics; Cell culture reactors; Scale-up in suspension; Scale and complexity; Mixing and aeration; Rotating chambers; Perfused suspension cultures; Fluidized bed reactors for suspension culture; Scale-up in monolayers; Multisurface propagators; Multiarray disks, spirals and tubes; Roller culture; Micro-carrier attached growth; Cell culture in continuous, perfusion and hollow fibre reactor; Microencapsulation; Growth monitoring; Mass transfer in mammalian cell culture.
Unit - III	Animal breeds; Embryo transfer: Artificial insemination, Superovulation, Embryo transfer, In vitro fertilization-Pregnancy diagnosis-Sexing of embryos, Embryo splitting; Cryopreservation of embryo; Transgenic animal production; Methods of transgene delivery; Integration of foreign genes and their validation; Gene targeting; Methods and strategies; Improving transgene integration efficiency; transgenic animals and stem Cells; Transgenesis and Xenotransplants, Transgenic fish;
Unit - IV	Organ culture technology; Tissue engineering and its application –production of complete organ - kidney – eyes - heart –brain; Immune system in health and disease, tissue and organ transplant, Vaccinology, Regenerative medicine.Biotechnology in animal production: Manipulation of Growth hormone - somatotropic hormone-Thyroid hormone;Probiotics as growth promoters-Ideal characteristics of probiotics, Mode of action-uses of probiotics-Manipulation of lactation –Lactogenesis galactopoiesis- Manipulation of wool growth-Manipulation of rumen microbial digestive system.
	Books:
1.	Davis.J.M Basic Cell Culture Second Edition, Oxford University Press. (First Indian Edition, 2005)
2.	Animal cell culture by R.I. Freshney
3.	Animal Biotechnology by P.Ramadas
4.	In vitro cultivation of Animal cells by Dr.C.K.Leach, Butterworth and Heinnmamm Ltd.1994.
5	Balasubramanian, Bryce, Dharmalingam, Green and Jayaraman (Eds.), Concepts in Biotechnology, University Press,1996
6.	Das.H.K. Text Book of Biotechnology, First Edition 2004,Wiley Dreamtech.
7.	B. Hafez and E.S.E Hafez, Reproduction in farm animals, 7th Edition, Wiley Blackwell, 2000
8.	G.E. Seidel, Jr. and S.M. Seidel, Training manual for embryo transfer in cattle (FAO Animal Production and Health Paper-77), 1st Edition, W.D. Hoard and sons
9.	FAO, 1991
10.	I. Gordon, Laboratory production of cattle embryos, 2nd edition, CAB International, 2003.
	Louis-Marie Houdebine, Transgenic Animals: Generation and Use 5th Edition, CRC Press, 1997.

BTB605- PROFESSIONAL ELECTIVE COURSE[PE]-II	

BTB606- OPEN SUBJECT-II	

BTB611- BioseparationEngineering Lab
1. Isolation of the plant cell organelles using centrifugation methods. 2. Isolation and separation of the DNA, RNA and proteins using centrifugation and biochemical methods. 3. Separation of the proteins with suitable chromatography methods. 4. Apply filtration and ultrafiltration method for separation of proteins. 5. Use TLC for separation of the biolipids. 6. Isolation of the photosynthetic pigments using centrifugation methods.

BTB611- Recombinant DNA Technology Lab	
	Experiments:
1.	Restriction enzyme digestion of plasmid DNA or lambda DNA
2.	Gel purification of RE digested DNA
3.	Ligation of DNA fragments with cloning vector pUC18 or pBR322.
4.	Preparation of competent cells and Transformation into E.coli with recombinant vector.
5.	Isolation of recombinants and confirmation of insert DNA in vector.
6.	Primer design for PCR and amplification of DNA by PCR.
7.	Southern Hybridisation (Demonstration only).

7th Semester

BTB701- Intellectual Property Rights (IPR) & Regulatory	(3 – 0 – 0 – 3)
Unit - I	Bioethics: Introduction to ethics and bioethics, roots of honours and integrity in science; the responsible conducts of biotechnological research; research with human beings; societal obligation of a biotechnologist; Ethical l e g a l s o c i a l issues (ELSI) in biotechnology: Biotechnology/ biomedicine application – ethical consideration; ethics and the natural world: environmental ethics (protecting public health and environment; genetically modified foods – the ethical and social issue. ELSI in genetic engineering. / biomedical science, eugenic enhancement, eugenic genetic engineering., genetic information – use and abuse; patenting human genes – ethical and policy issue, ethics in cloning, genetic testing and screening, human gene therapy and genetic modification – ethical and public consideration, legal implication of somatic cell, gene therapy-germ line gene therapy.

Unit - II	Intellectual Property Rights (IPR), Patents and protection: IPR: Jurisprudential definition and concept of property rights, duties and their correlations, history and evaluation of IPR – like patent design and copy right. Distinction among the various forms of IPR, requirements of a patentable invention like novelty, inventive step and prior art and state of art procedure; Rights/ protection, infringement or violation, remedies against infringement, civil and criminal, Indian patent act 1970 (2 0 0 0) international convention in IPR, major changes in Indian patent system as post TRIPS-GATT-International conventions effects. Contents of patent specification and procedure for patents: a) obtaining patents, b) geographical indication c) WTO. Detailed information on patenting biological products, Biodiversity and farmer rights, Budapest treaty. Case studies on - Patents (basmati rice, turmeric, neem, etc.)
Unit - III	Biosafety-Regulatory Framework In India & International Level: Biosafety: The legal and socioeconomic impact of biotechnology, public education of the process of biotechnology involved in generating new forms of life for informed decision making, biosafety regulation and national & international guidelines, r-DNA guidelines, experimental protocol approvals, levels of containment, levels of safety. Regulations on ethical principles in biomedical/ biotechnological practice: The Nuremberg code, declaration of Helsinki; the Belmont report, cooperational guidelines – WHO, guidelines of DBT (India), Guidelines of an informed consent. Different regulatory bodies in India (RDAC), (IBC), (GEAC), (SBCC), (DLC). Convention of Biological Diversity (1992) – Cartagena Protocol on Biosafety
Unit - IV	Principles of Laboratory Biosecurity: Biosecurity introduction, Case study, Risk management Methodology, Developing a Biosecurity Program, Countering biorisk, Elements of a Biosecurity Program, Bioterrorism
	Books: 1. Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection- Oxford and IBH Publishing Co. ND. 2. Sasson A, Biotechnologies and Development, UNESCO Publications. 3. Singh K, Intellectual Property rights on Biotechnology, BCIL, New Delhi 4. Regulatory Framework for GMOs in India (2006) Ministry of Environment and Forest, Government of India, ND. 5. Cartagena Protocol on Biosafety (2006) Ministry of Environment and Forest, Government of India, New Delhi. 6. P.K. Gupta, Biotechnology and Genomics, Rastogi Publications 7. Patent Strategy For Researches & Research Manegers- Knight, Wiley Publications. 8. Agriculture & Intellectual & Property Rights, V. Santaniello & R E Evenson, UniversityPress. 9. Intellectual Property Protection & Sustainable Development, Phillipe Cullet, Ldexix Nexis Butterworths. 10. Biotechnology & Safety Assessment, Thomas, Ane/Rout Publishers. 11. Biotechnology, IPRs and Biodiversity - By M.B. Rao and Manjula Guru (Pearson Education)

BTB702- Bioprocess Engineering	
Contents	Microbial growth kinetics, substrate utilization, and product formation kinetics, stoichiometry, principles of enzyme catalysis, enzyme kinetics, immobilized enzymes, bioreactors- batch, fed-batch or continuous bioreactors, Immobilized cell systems, solid-state fermentations, energy balance and mass transfer, operation and control of bioreactors (aeration, agitation, heat transfer, scale-up and scale-down), Bioprocesses for the production of antibiotics, proteins, polysaccharides, aroma etc. Instrumentation and monitoring, sterilization, process modeling, downstream processing, plant/mammalian cell culture reactors, examples of industrial bioprocesses
Text Books/References:	1. Michael Shuler, Fikret Kargi, Matthew DeLisa, Bioprocess Engineering: Basic Concepts, 3rd Edition 2. Pauline Doran, Bioprocess engineering principles 3. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition,

	Cambridge University Press, 2001. 4. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003. 5. Bioreaction Engineering, Bioprocess Monitoring (Bioreaction Engineering) by Karl Schügerl

BTB703- PROFESSIONAL ELECTIVE COURSE[PE]-III	
Module 1:	Information Design and Development- Different kinds of technical documents, Information development life cycle, Organization structures, factors affecting information and document design, Strategies for organization, Information design and writing for print and online media.
Module 2:	Technical Writing, Grammar and Editing- Technical writing process, forms of discourse, writing drafts and revising, Collaborative writing, creating indexes, technical writing style and language. Basics of grammar, study of advanced grammar, editing strategies to achieve appropriate technical style. Introduction to advanced technical communication, Usability, Human factors, Managing technical communication projects, time estimation, Single sourcing, Localization.
Module 3:	Self Development and Assessment- Self assessment, Awareness, Perception and Attitudes, Values and belief, Personal goal setting, career planning, Self-esteem. Managing Time; Personal memory, Rapid reading, taking notes; Complex problem solving; Creativity.
Module 4:	Communication and Technical Writing- Public speaking, Group discussion, Oral; presentation, Interviews, Graphic presentation, Presentation aids, Personality Development. Writing reports, project proposals, brochures, newsletters, technical articles, manuals, official notes, business letters, memos, progress reports, minutes of meetings, event report.
Module 5:	Ethics- Business ethics, Etiquettes in social and office settings, Email etiquettes, Telephone Etiquettes, Engineering ethics, managing time, Role and responsibility of engineer, Work culture in jobs, Personal memory, Rapid reading, taking notes, Complex problem solving, Creativity.
Books & References	1. Effective Communication Skills. Kulbhushan Kumar. Khanna Publishing House. 2018. 2. David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004. 3. Diane Hacker, Pocket Style Manual, Bedford Publication, New York, 2003. (ISBN 0312406843). 4. Shiv Khera, You Can Win, Macmillan Books, New York, 2003. 5. Raman Sharma, Technical Communications, Oxford Publication, London, 2004. 6. Dale Jungk, Applied Writing for Technicians, McGraw Hill, New York, 2004. (ISBN: 07828357-4) 7. Sharma, R. and Mohan, K. Business Correspondence and Report Writing, TMH. 2002. 8. Xebec, Presentation Book, TMH New Delhi, 2000.

BTB704- OPEN SUBJECT-III	

BTB705- Synthetic & Systems Biology	
Module 1:	**Introduction to Synthetic biology & Systems biology** Introduction to synthetic biology. Background of Gene Regulatory Mechanisms (Gene Parts- Gene Structure, Promoters, Terminators, Enhancers, Inducers, Repressors, Transcription Factors, Co-factors, transcriptional and post-transcriptional regulation, post-translational modifications). Genetic Engineering and Genome Editing Various Omics & role in systems biology - genomics, proteomics, transcriptomics, metabolomics
Module 2:	**Elements of synthetic biology - Tools, circuits, BioBricks** Gene shuffling for large scale pathway assembly and engineering; Choices for microbial hosts for industrial applications– bacteria, yeast, insect. Gene editing methods – CRISPR/ Cas; Gene sequencing – Pyrosequencing, Nanopore sequencing. Bacterial

	circuits: feed-back, feed-forward, toggle switch, signal propagators and band filter, synchronized oscillators. Introduction to Bio Bricks & its applications. Microarrays & systems biology - a basic introduction
Module 3:	**Mathematical modelling & simulation** Noise in Gene Expression.Mathematical Modeling and Simulation. Biosensors. Application of software tools for modelling gene expression. Various markup languages used in systems biology. Introduction to various metabolic pathway databases.
Module 4:	**Commercial Applications** Biomedicine, Biomaterials, Biofuels and Bioremediation; Production of artemisinin as case study. Building the new bio-economy. Introduction to Biofoundries & circuits. Role of automation and robotics in biofactories; Green chemistry - use of plants for engineering biologics & small molecules. Biosurfactants as an example of microbial cell factory based production. Global events & competitions- iGEM, synbiobeta.

BTB706-Analytical Techniques	
Contents	Light spectroscopy and Microscopy-Absorption, IR, Scattering (Raman and Rayleigh), Resonance Raman, Fluorescence (steady-state and time resolved), confocal microscopy, Multi-photon microscopy, Atomic Force Microscopy, Chromatography-Ion-Exchange, Affinity, Hydrophobic, Size exclusion, FPLC, HPLC, GC. Ultracentrifugation, Electrophoresis, Solution- and solid-state NMR spectroscopy, X-ray crystallography, Mass spectroscopy-MALDI, LC-MS, GC-MS, MS-MS, MALDI-Mass imaging, Proteomics, MS and NMR based Metabolomics, DNA and RNA sequencing for genomics, PCR for transcriptomic, Real time PCR, Droplet PCR, Calorimetry, Surface Plasmon Resonance (SPR), Bio-layer interferometry (BLI), High content screening.
Books & References	1. Biophysical Chemistry, Vol II by Charles R. Canter and Paul R. Shimmel. 2. Protein Purification: Principles and Practice by Robert K. Scopes (Narosa). 3. Principles of Fluorescence Spectroscopy by Joseph R. Lakowicz. 4. Infrared Spectroscopy Fundamentals and Applications by Barbar Stuart. 5. Raman Spectroscopy for Chemical Analysis by RICHARD L. McCREERY. 6. NMR spectroscopy by Harald Gunther (John Wiley). 7. Mass Spectrometry Basics by Christopher G. Herbert and Robert W. Johnstone. 8. Chromatographic methods by A Braithwaite and F. J. Smith (Kluwer Academic Publishers).

BTB711-Bioprocess Engineering Lab	

BTB712-Project-I	

BTB713-Colloquium	

8th Semester

BTB801-Constitution of India*	
BTB802- PROFESSIONAL ELECTIVE COURSE[PE]-IV	

BTB803-OPEN SUBJECT-IV	

BTB811-Project-II (Biotech Industrial or Biotech In-house Project or Bio-Entrepreneurship)	

PROFESSIONAL ELECTIVE COURSES[PE]-

Professional Elective – I

Genome Editing

Course Content: Overview of traditional methods: homologues recombination for gene knockout. RNAi system, Cre-LoxP and Flp-FRT systems. Engineered enzyme systems: Zinc finger nucleases (ZFNs), transcription-activator like effector nucleases (TALEN), meganucleases and the clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system. Design of sgRNA. Multiplex Automated Genomic Engineering (MAGE). Applications in Targeted gene mutation, Gene therapy, creating chromosome rearrangement, Study gene function with stem cells, Transgenic animals, Endogenous gene labeling, targeted transgene addition, GM plants, application is biofuel production and in bioremediation. Ethics, safety and risk of targeted gene editing.

Text Books/References:

1. CRISPR Gene Editing, Methods and Protocols, Editors: Luo, Yonglun (Ed.)
2. Genome Editing and Engineering, From TALENs, ZFNs and CRISPRs to Molecular Surgery. Edited by Krishnarao Appasani.
3. Progress in Molecular Biology and Translational Science Vol 149-Genome Editing in Plants. Edited by Donald P. Weeks and Bing Yang. Academic Press.
4. Precision Medicine, CRISPR, and Genome Engineering, Moving from Association to Biology and Therapeutics, Editors: Tsang, Stephen H. (Ed.). Springer.

Biosimilars Technology

Module 1: Introduction to Biopharma

Generics in Biopharma, definition of biologics, biosimilars, super biologics, differences between chemical genetics and biosimilars, The developmental and regulatory challenges in biosimilar development, Prerequisites for Biosimilar development, Biosimilar market potential.

Module 2: Types of biosimilar drugs

Peptides, proteins, antibodies, Enzymes, Vaccines, Nucleic acid based therapies (DNA, RNA, etc), Cell based therapies (including stem cells)

Module 3: Characterization methods

Aggregation- precipitation, floccule strength, precipitate ageing & kinetics, adsorption of proteins & peptides on surfaces, effect of temperature on protein structure, hydration & thermal stability of proteins - solid powders, suspension on non-aqueous solvents, reversed micelles, aqueous solution of polyols, analytical and spectrophotometric characterization of proteins, protein sequencing and structure determination

Module 4: Bioequivalence studies

Immunogenicity & allergenicity of biosimilars; factors affecting immunogenicity - structural, post-translational modifications, formulations, impurities, manufacturing and formulation methods for biosimilars; types of bioequivalence (average, population, individual), experimental designs & statistical considerations for bioequivalence studies (Non-replicated designs – General Linear Model, Replicated crossover designs),

introduction to “ORANGE BOOK” & “PURPLE BOOK”.

Module 5: Case studies
Indian companies working in this space & their product pipeline (Biocon, Intas, Dr Reddy’s, Reliance, Bharat Biotech, Lupin, Cipla, Shanta, etc); products - Erythropoietin, growth hormone, granulocyte stimulating factors, interferons, streptokinase, monoclonal antibodies.

Text Books/References:

1. Laszlo Endrenyi, Paul Declerck and Shein-Chung Chow, Biosimilar Drug Development, Drugs and Pharmaceutical Sciences, Vol 216, CRC Press.
2. Cheng Liu and K. John Morrow Jr., Biosimilars of Monoclonal Antibodies: A Practical Guide to Manufacturing, Preclinical and Clinical Development, Wiley, Dec 2016.
3. https://www.drugs.com/medical-answers/many-biosimilars-approved-united-states-3463281/

Professional Elective – II *****

Machine Learning

UNIT I: Introduction
Learning – Types of Machine Learning – Supervised Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept Learning Task – Concept Learning as Search – Finding a Maximally Specific Hypothesis – Version Spaces and the Candidate Elimination Algorithm – Linear Discriminants – Perceptron – Linear Separability – Linear Regression.

UNIT II: Linear Models
Multi-layer Perceptron – Going Forwards – Going Backwards: Back Propagation Error – Multi-layer Perceptron in Practice – Examples of using the MLP – Overview – Deriving Back-Propagation – Radial Basis Functions and Splines – Concepts – RBF Network – Curse of Dimensionality – Interpolations and Basis Functions – Support Vector Machines.

UNIT III: Tree and Probabilistic Models
Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Ensemble Learning – Boosting – Bagging – Different ways to Combine Classifiers – Probability and Learning – Data into Probabilities – Basic Statistics – Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithms – Vector Quantization – Self Organizing Feature Map.

UNIT IV: Dimensionality Reduction and Evolutionary Models
Dimensionality Reduction – Linear Discriminant Analysis – Principal Component Analysis – Factor Analysis – Independent Component Analysis – Locally Linear Embedding – Isomap – Least Squares Optimization – Evolutionary Learning – Genetic algorithms – Genetic Offspring: - Genetic Operators – Using Genetic Algorithms – Reinforcement Learning – Overview – Getting Lost Example – Markov Decision Process.

UNIT V: Graphical Models
Markov Chain Monte Carlo Methods – Sampling – Proposal Distribution – Markov Chain Monte Carlo – Graphical Models – Bayesian Networks – Markov Random Fields – Hidden Markov Models – Tracking Methods.

Text Books:

1. Stephen Marsland, — Machine Learning – An Algorithmic Perspective||, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
2. Tom M Mitchell, —Machine Learning||, First Edition, McGraw Hill Education, 2013.
3. Jeeva Jose, - Introduction to Machine Learning using Python||, First Edition, Khanna Publishing House, 2019.

References:

1. Peter Flach, —Machine Learning: The Art and Science of Algorithms that Make Sense of Data||, First Edition, Cambridge University Press, 2012.
2. Jason Bell, —Machine learning – Hands on for Developers and Technical Professionals||, First Edition, Wiley, 2014.
3. Ethem Alpaydin, —Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series) ||, Third Edition, MIT Press, 2014.
4. Rajiv Chopra, - Machine Learning ||, Khanna Book Publishing Co. 2019.

Waste Management & Upcycling

UNIT I

Waste management: The definition of waste, and its classification in the context of EU legislation, policy and other drivers for change, including the planning and permitting regime for the delivery of waste management solutions

Liquid waste collection, treatment and disposal systems: Segregation and mixing schemes; Pre-treatment and its role in the industrial wastewater management; Overview of wastewater treatment technologies and development of wastewater treatment schemes; Operation and maintenance of effluent treatment plants; and Case study of an industrial wastewater management system.

Air Pollution management and treatment: Overview of industrial emissions; Air pollution control systems and overview of air pollution control technologies; Development of schemes for the collection, treatment and discharge industrial emissions;

UNIT II

Technologies for Waste treatment technologies: waste incineration and energy from waste, pyrolysis and gasification, anaerobic digestion, composting and mechanical biological treatment of wastes, managing biomedical waste.

UNIT III

Health considerations in the context of operation of facilities, handling of materials and impact of outputs on the environment; Advances in waste recycling and recovery technologies to deliver added value products; Landfill engineering and the management of landfill leachate and the mining of old landfills.

UNIT IV

Interface of waste and resource management and civil engineering in the context of sustainable waste management in global cities and developing countries; and Use of

decision support tools including multi-criteria analysis, carbon foot-printing and life-cycle analysis, as appropriate.

UNIT V

Waster Upcycling, waste reuse, Waste down cycling, waste upcycling a social enterprise, Case study in each area. Innovative technologies for sustainable waste management.

Text Books/References:

1. O.P. Gupta, "Elements of Solid & Hazardous Waste Management", Khanna Publishing House, New Delhi, 2019.
2. George Tchobanoglous et.al., "Integrated Solid Waste Management", McGraw-Hill Publishers, 1993.
3. B.Bilitewski, G.HardHe, K.Marek, A.Weissbach, and H.Boeddicker, "Waste Management", Springer, 1994.

Stem-Cell Technology

Introduction to Stem Cells: Principles and properties of stem cells, types of stem cells, comparison of embryonic and adult stem cells.

Stem Cell Niche: Introduction to stem cell niches in gut epithelium, bone marrow, epidermis, testis and neural tissues.

Cell Cycle and Development: Cell cycle regulators and checkpoints, cell fusion, differentiation of stem cells and their role in self-renewal.

Epigenetic Control: DNA-methylation and histone modifications, genomic imprinting, telomerase regulation, X-chromosome inactivation, reprogramming of cells, induced pluripotent stem cells and their therapeutic applications.

Types and Regeneration: Stem cells derived from amniotic fluid, extra embryonic membrane, germ cells, hematopoietic organs, neurons and kidney, cord blood transplantation, donor selection, HLA matching, patient selection, peripheral blood and bone marrow transplantation, bone marrow and cord blood collection procedures and cryopreservation and their applications.

Experimental Methods: Isolation and differentiation of human adult stem cells, embryonic stem cells and mouse stem cells, stem cell techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging.

Applications: Stem cells applications in cancer, diabetes, heart disease, muscular dystrophy, regeneration of epidermis; stem cell regulations, debate, social and ethical concerns, Organ farming.

Text Books/References:

1. Hematopoietic Stem Cell Transplantation by Treleaven, J., first edition 2009.
2. Essentials of Stem Cell Biology by Lanza, R., second Edition, 2009 Academic Press.
3. Molecular Cell Biology by Lodish et al., sixth Ed., W.H. Freeman & Co. 2008.
4. Stem Cells: From Bench to Bedside by Bongso and Ariff.

*****

Professional Elective – III

Gene Expression and Transgenics

Course Content: Overview of recombinant protein expression vectors and promoters: Vectors with tags His, GST, MBP, GFP. Cleavable tag and non-cleavable tags. Vectors for tag free protein expressions. Over-expression of integral membrane proteins. Over-expression in *E. coli*, *B. subtilis*, Corynebacterium, *Pseudomonas fluorescens*, yeasts like *S. cerevisiae* and *Pichia pastoris*, insect cell lines like Sf21, Sf9 and BTI-TN-5B1-4, Mammalian cell line like Chinese Hamster ovary (CHO) and Human embryonic kidney (HEK), Plant single cell. Chloroplast transformation and protein expression in chloroplasts. Cell free protein Expression-Cell free extracts from *E. coli*, rabbit, wheat germ, insects. Purification of tagged and tag-free proteins. GMP and GLP requirements.
Use of transgenic animals. History, safety and ethics of transgenic animals. Methods for creation of transgenic animals-DNA microinjection, Embryonic stem cell-mediated gene transfer, Retrovirus-mediated gene transfer. Use transgenic animals in medical research, in toxicology, in mammalian developmental genetics, in molecular biology in the pharmaceutical industry, in biotechnology, in aquaculture and in xenografting. Humanised animal models

Text Books/References:

1. Gene Expression Systems, Using Nature for the Art of Expression. Edited by Joseph M. Fernandez and James P. Hoeffler.
2. Regulation of Gene Expression, By Perdew, Gary H., Vanden Heuvel, Jack P., Peters, Jeffrey M. Springer.
3. Prokaryotic Gene Expression. Edited by Simon Baumberg. Oxford Press
4. Transgenic Animal Technology,3rd Edition, A Laboratory Handbook by Carl Pinkert. Elsevier.
5. Ethical Use of Transgenic Animals (English, Paperback, Shah Krunal V). Lambert
6. Transgenic Animals as Model Systems for Human Diseases. Edited E. F. Wagner F. Theuring. Springer.

Rational Drug Discovery

Unit-I Molecular Modelling in Drug Discovery:
Drug discovery process, Role of Bioinformatics in drug design, Methods of computer aided drug design, ligand design methods, drug design approaches, Target identification and validation, lead optimization and validation, Structure and ligand based drug design, modelling of target-small molecule interactions, Molecular simulations. Protein Modelling.

Unit-II Quantum Mechanics and Molecular Mechanics:
Features of molecular mechanics force fields; Bond structure and bending angles – electrostatic, van der Waals and non – bonded interactions, hydrogen bonding in molecular mechanics; Derivatives of molecular mechanics energy function; Application of energy minimization.

Unit-III Molecular Dynamics simulation methods:
Molecular Dynamics using simple models; Molecular Dynamics with continuous potentials and at constant temperature and pressure; Time – dependent properties; Solvent effects in Molecular Dynamics; Conformational changes from Molecular Dynamics simulation and application.

Unit-IV Molecular Docking and lead optimization:
Molecular Docking; Types of Molecular Docking, docking algorithms and programs,

Structure-based methods to identify lead compounds; de novo ligand design; Applications of 3D Databases Searching and virtual Screening; Strategy for target identification and Validation, lead identification, optimization and validation. Combinatorial chemistry and library design, virtual screening, drug likeness and compound filtering, Absorption, distribution, metabolism, excretion and toxicity (ADMET) property prediction, computer based tools for drug design.

Unit-V Pharmacophore and QSAR:
Pharmacophore derivation, 3D pharmacophore prediction and application in drug discovery; QSARs and QSPRs, QSAR Methodology, Various Descriptors used in QSARs: Electronic; Topology; Quantum Chemical based Descriptors. Use of Genetic Algorithms, Neural Networks and Principal Components Analysis in the QSAR equations.

Text Books/References:

1. Computational methods in drug design Fred E. Cohen, Walter Hamilton Moos Publisher: ESCOM Science, 1993.
2. Molecular Modelling for Beginners - Alan Hinchliffe Publisher: John Wiley & Sons Inc, 2008. ISBN: 978-0470513149.
3. Combinatorial Library Design and Evaluation: Principles, Software, Tools, Applications in Drug Discovery – Arup Ghose, Vellarkad Viswanadhan Publisher: CRC Press, 2001. ISBN: 0-8247-0487-8.
4. Molecular Modeling Basics - Jan H. Jensen Publisher: CRC Press, 2010. ISBN 978-1420075267.
5. 3D QSAR in Drug Design: Recent Advances – Hugo Kubinyi, Gerd Folkers, Yvonne C. Martin Publisher: Springer Science & Business Media. ISBN: 0-306-46858-1.
6. Computational Chemistry and Molecular Modeling - K. I. Ramachandran, Gopakumar Deepa, Krishnan Namboori Publisher: Springer – Verlag Berlin Heidelberg. ISBN: 978-3540773023.

State-of-the-art Imaging

Course Content: Overview and limitations of traditional imaging methods. Confocal microscopy, Super-resolution microscopy- Deterministic functional techniques-Stimulated emission depletion (STED), Ground state depletion (GSD), Saturated structured illumination microscopy (SSIM). Stochastic optical reconstruction microscopy (STORM), photo activated localization microscopy (PALM) and fluorescence photo-activation localization microscopy (FPALM), Points accumulation for imaging in nanoscale topography (PAINT), Label-free localization microscopy. Multi-photon imaging systems, Real time imaging, computerized tomography (CT) imaging, Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), Functional MRI (fMRI), Tissue imaging through mass spectroscopy. Image recognitions and artificial intelligence.

Text Books/References:

1. Super-Resolution Microscopy: A Practical Guide, By Udo J. Birk. Wiley
2. Super-Resolution Microscopy, Methods and Protocols,, Editors: Erfle, Holger (Ed.). Springer
3. Super-Resolution Imaging in Biomedicine, By Alberto Diaspro, Marc A. M. J. van Zandvoort. CRC Press
4. Multiphoton Microscopy. Editors: Hartveit, Espen (Ed.). Springer
5. Confocal and Two-Photon Microscopy: Foundations, Applications and Advances By Alberto Diaspro (Editor). Academic Press
6. Basics of PET Imaging, Physics, Chemistry, and Regulations, By Saha, Gopal B.
7. MRI and Spectroscopy in Pharma. & Clinical Research by N. R. Jagannathan
8. Magnetic Resonance Imaging: Physical and Biological Principles, By Stewart C. Bushong. Elsevier
9. Imaging Mass Spectrometry, Protocols for Mass Microscopy. Editors: Setou, Mitsutoshi.

Precision Medicine & Wellness

Course Content: Use of genomics, transcriptomics, proteomics and metabolomics in understanding disease condition. Biomarker identification and validation of a disease state. Human Genome project. Cancer genome project. Different types of genetic and non-genetic variations, Genetic screening and diagnosis: prenatal carrier testing and newborn screening for Mendelian diseases, Pharmacogenomic testing for drug selection, dosing and predicting adverse effects of commonly prescribed drugs, Tumor profiling, Patient data and clinical decisions. Risk assessment through omics approach. Ethical, legal, and social implications of health privacy and policy laws for precision medicine. Ayurveda system of *Prakriti* and *Agni*.

Text Books/References:

1. National Institute of General Medical Sciences. The New Genetics. Bethesda, MD: U.S. Department of Health and Human Services.
2. Genomic and Precision Medicine, Geoffrey Ginsburg and Huntington Willard,
3. The Language of Life: DNA and the Revolution in Personalized Medicine, Francis S. Collins.

Tissue Engineering

Biomaterials: Natural and synthetic polymers.

Basic biology: Fibrous extracellular matrix of the human body and their characteristic features, Cell-Polymer interaction.

Methods to develop Scaffolds for Tissue engineering: hydrogel, porous scaffold, and Textile-based techniques used for medical application, Rapid prototyping/3D printing, Wound healing.

Organ regeneration: Cartilage, Skin, Liver, Blood Vessel, Kidney, Urinary bladder, Tendons, Ligaments, Cornea.

Text Books/References:

1. Principles of Tissue Engineering, 4th Edition, Editors: Robert Lanza, Robert Langer, Joseph Vacanti, eBook ISBN: 9780123983701, Imprint: Academic Press,
2. Tissue Engineering: Principles and Practices, 1st Edition, John P. Fisher, Antonios G. Mikos, Joseph D. Bronzino, Donald R. Peterson,CRC Press, ,ISBN 9781138077867 - CAT# K34349,
3. Biomaterials for Musculoskeletal Regeneration- Applications By Bikramjit Basu, Sourabh Ghosh, Springer, 2016, ISBN 978-981-10-3017-8.

Nano Biotechnology

Basics of Quantum Mechanics and Atomic Structure: Duality of light, de Broglie waves, electrons in potential well, structure of hydrogen atom, classic atomic bonding, LCAO theory, band theory, energy bands for metals, semi-conductors and insulators

Surface Science of Nanomaterials: crystal structure, close packed structures – FCC, HCP and BCC, surface structure for close-packed surfaces, surface reconfiguration (surface relaxation & surface reconstruction) adsorption, wetting, surface area in nanomaterials

Introduction to Nanostructures: Carbon nanotubes (CNT), fullerene ('C60'), quantum dots and semiconductor nanoparticles, metal-based nanostructures, nanowires, polymer-based nanostructures, gold nanostructures

Nanomaterial Characterization: X-ray diffraction, electron microscopy, interaction between electron beam and solids, TEM, SEM, SPM (STM & AFM), AES, XPS, SIMS

Nano biomaterials: Biomimetic nanotechnology, protein-based nanostructures, Nano motors, bacterial (E. coli) and mammalian (Myosin family), DNA nanotechnology, nanostructures in cells study, microarray platforms, Nano printing of DNA, RNA, and proteins biochips applications in nano scale detection, lab-on-a-chip devices (LOC), tissue engineering

Nanotechnology in Biomedical Application: micro- and Nano electromechanical devices in drug delivery, other applications in drug delivery, photodynamic therapy in targeted drug administration, Nano biosensors, applications of quantum dots in biotechnology, DNA based nanomaterials as biosensors

Health and Environmental Impacts of Nanotechnology: Engineered nanomaterial of relevance to human health, routes of entry into the body, toxic effects on health, plants and microbes are nanofactories

Text Books/References:

2. Fundamentals and applications of nanomaterials by Guo Z and Tan L, Artech house (2009).
3. Nanobiotechnology by Balaji S, MJP Publishers (2010).
4. Nanobiotechnology: concepts, applications and perspectives by Niemeyer CM and Mirkin CA, Wiley-VCH (2004).
5. Introduction to Nanoscience by Lindsay SM, Oxford University Press (2010).

Open Subjects[OS]

Open Subject – I

3D Printing & Design

1. 3D Printing (Additive Manufacturing)

Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes, Applications.

2. CAD for Additive Manufacturing

CAD Data formats, Data translation, Data loss, STL format.

3. Additive Manufacturing Techniques

3.1 Stereo- Lithography, LOM, FDM, SLS, SLM, Binder Jet technology.
3.2 Process, Process parameter, Process Selection for various applications.
3.3 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defence, Automotive, Construction, Food Processing, Machine Tools.

4. Materials

4.1 Polymers, Metals, Non-Metals, Ceramics
4.2 Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties.
4.3 Support Materials

5. Additive Manufacturing Equipment

5.1 Process Equipment- Design and process parameters
5.2 Governing Bonding Mechanism
5.3 Common faults and troubleshooting
5.4 Process Design

6. Post Processing: Requirement and Techniques

7. Product Quality

7.1 Inspection and testing
7.2 Defects and their causes

Text Books/References:

1. Sabrie Soloman, "3D Printing and Design", Khanna Publishing House, Delhi.
2. Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
3. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
4. CK Chua, Kah Fai Leong, "3D Printing and Rapid Prototyping- Principles and Applications", World Scientific, 2017.
5. J.D. Majumdar and I. Manna, "Laser-Assisted Fabrication of Materials", Springer Series in Material Science, 2013.
6. L. Lu, J. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Kulwer Academic Press, 2001.
7. Zhiqiang Fan and Frank Liou, "Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy", InTech, 2012.

Internet of Things

Introduction to IoT

Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.

Elements of IoT

Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces.

Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

IoT Application Development

Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.

IoT Case Studies

IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation.

Text Books/References:

1. Vijay Madisetti, Arshdeep Bahga, Ïnternet of Things, "A Hands on Approach", University Press
2. Jeeva Jose, "Internet of Things", Khanna Publishing House, New Delhi, 2018.
3. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs
4. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
5. Adrian McEwen, "Designing the Internet of Things", Wiley
6. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill
7. Cuno Pfister, "Getting Started with the Internet of Things", O Reilly Media

Image Processing

Unit I: Image Processing Foundations

Review of image processing techniques – classical filtering operations – thresholding techniques – edge detection techniques – corner and interest point detection – mathematical morphology – texture.

Unit II: Shapes and Regions

Binary shape analysis – connectedness – object labeling and counting – size filtering – distance functions – skeletons and thinning – deformable shape analysis – boundary tracking procedures – active contours – shape models and shape recognition – centroidal profiles – handling occlusion – boundary length measures – boundary descriptors – chain codes – Fourier descriptors – region descriptors – moments.

Unit III: Hough Transform

Line detection – Hough Transform (HT) for line detection – foot-of-normal method – line localization – line fitting – RANSAC for straight line detection – HT based circular object detection – accurate center location – speed problem – ellipse detection – Case study: Human Iris location – hole detection – generalized Hough Transform (GHT) – spatial matched filtering – GHT for ellipse detection – object location – GHT for feature collation.

Unit IV: 3D Vision and Motion

Methods for 3D vision – projection schemes – shape from shading – photometric stereo – shape from texture – shape from focus – active range finding – surface representations – point-based representation – volumetric representations – 3D object recognition – 3D reconstruction – introduction to motion – triangulation – bundle adjustment – translational alignment – parametric motion – spline-based motion – optical flow – layered motion.

Unit V: Applications

Application: Photo album – Face detection – Face recognition – Eigenfaces – Active appearance and 3D shape models of faces Application: Surveillance – foreground-background separation – particle filters – Chamfer matching, tracking, and occlusion – combining views from multiple cameras – human gait analysis Application: In-vehicle vision system: locating roadway – road markings – identifying road signs – locating pedestrians.

Text Books/References:

1. E. R. Davies, "Computer & Machine Vision", Fourth Edition, Academic Press, 2012.
2. R. Szeliski, "Computer Vision: Algorithms and Applications", Springer 2011.
3. Simon J. D. Prince, "Computer Vision: Models, Learning, and Inference", Cambridge University Press, 2012.
4. Mark Nixon and Alberto S. Aquado, "Feature Extraction & Image Processing for Computer Vision", Third Edition, Academic Press, 2012.
5. D. L. Baggio et al., "Mastering OpenCV with Practical Computer Vision Projects", Packt Publishing, 2012.
6. Jan Erik Solem, "Programming Computer Vision with Python: Tools and algorithms for analyzing images", O'Reilly Media, 2012.

4. Apply chain codes and other region descriptors.
5. Apply Hough Transform for line, circle, and ellipse detections.
6. Apply 3D vision techniques.
7. Implement motion related techniques.
8. Develop applications using computer vision techniques.

Biomaterials

Course Content: Introduction to Materials, General structure and properties. Classification of common materials and applications. Chemical Bonding, Crystalline, Amorphous. Melting, Solidification, Nucleation, Phase diagrams. Metal and alloys in Medical application: Stainless steel, cobalt based alloys, titanium based alloys (including shape memory alloys). Ceramics and glasses-bio ceramics: Type of Ceramics and their classification, Calcinations, Annealing, Sintering, Nearly inert ceramics, bio-reactive glasses and glass ceramics, Calcium phosphate ceramics. Introductions to polymers: Definition, classification, Polymerization. Rubber, plastics, fibers and resins and structure-properties relationship. Biodegradable polymers; Natural polymers, Composites, Pyrolytic carbon, Carbon nanotubes. Bulk Proper, Surface properties and modification of surface properties. Basic principles of engineering manufacturing, methods and applications of common manufacturing processes, milling, grinding, finishing, rolling, forging, Concept of biomimetic synthesis, Preparation of fiber and wire, Fabrication of Porous Materials, Direct molding Technique, Different advanced fabrication technique.

Text Books/References:

1. Biomaterials Science - An Introduction to Materials in Medicine, Buddy Ratner Allan Hoffman Frederick Schoen Jack Lemons, ISBN: 9780080470368, Academic Press, Published Date: 18th August 2004.
2. Biomaterials: An Introduction- J. Bo. Park.
3. Materials Science and Engineering- Callister.
4. Materials for Medical Engineering- Euromat 99 vol-2.

Artificial Intelligence

1. Introduction

Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search tree.

2. Search Algorithms

Random search, Search with closed and open list, Depth and Breadth first search, Heuristic search, Best first search, A* algorithm, Game Search.

3. Probabilistic Reasoning

Probability, conditional probability, Bayes Rule, Bayesian Networks- representation, construction and inference, temporal model, hidden Markov model.

4. Markov Decision process

MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.

5. Reinforcement Learning

Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning- Q learning.

Text Books/References:

1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3rd Edition, Prentice Hall
2. Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill
3. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi.
4. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, 2011
5. David Poole and Alan Mackworth, "Artificial Intelligence: Foundations for Computational Agents", Cambridge University Press 2010.

Websites:

1. https://nptel.ac.in/courses/106105077
2. https://nptel.ac.in/courses/106106126
3. https://aima.cs.berkeley.edu
4. https://ai.berkeley,edu/project_overview.html (for Practicals)

Quantum Computing

1. Introduction to Quantum Computing

- Motivation for studying Quantum Computing
- Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.)
- Origin of Quantum Computing
- Overview of major concepts in Quantum Computing
  - Qubits and multi-qubits states, Bra-ket notation. ○ Bloch Sphere representation
  - Quantum Superposition
  - Quantum Entanglement

2. Math Foundation for Quantum Computing

Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigenvalues and Eigenvectors.

3. Building Blocks for Quantum Program

- Architecture of a Quantum Computing platform
- Details of q-bit system of information representation:
  - Block Sphere
  - Multi-qubits States
  - Quantum superposition of qubits (valid and invalid superposition)
  - Quantum Entanglement
  - Useful states from quantum algorithmic perspective e.g. Bell State
  - Operation on qubits: Measuring and transforming using gates.
  - Quantum Logic gates and Circuit: Pauli, Hadamard, phase shift, controlled gates, Ising, Deutsch, swap etc.
- Programming model for a Quantum Computing
  - Program ○ Steps performed on classical computer
  - Steps performed on Quantum Computer
  - Moving data between bits and qubits

4. Quantum Algorithms

- Basic techniques exploited by quantum algorithms.
  - Amplitude amplification
  - Quantum Fourier Transform
  - Phase Kick-back
  - Quantum Phase estimation
  - Quantum Walks
- Major Algorithms
  - Shor's Algorithm ○ Grover's Algorithm ○ Deutsch's Algorithm
  - Deutsch -Jozsa Algorithm
- OSS Toolkits for implementing Quantum program
  - IBM quantum experience
  - Microsoft Q
  - Rigetti PyQuil (QPU/QVM)

Text Books/References:

1. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University Press.
2. David McMahon, "Quantum Computing Explained", Wiley.

3. IBM Experience: https://quantumexperience,ng,bluemix.net
4. Microsoft Quantum Development Kit https://www.microsoft.com/en-us/quantum/development-kit.
5. Forest SDK PyQuil: https://pyquil.readthedocs.io/en/stable/

*****

Cyber Security

1. Cyber Security Concepts

Essential Terminologies: CIA, Risks, Breaches, Threats, Attacks, Exploits. Information Gathering (Social Engineering, Foot Printing & Scanning).
Open Source/ Free/ Trial Tools: nmap, zenmap, Port Scanners, Network scanners.

2. Cryptography and Cryptanalysis

Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security, Security Protocols: - security at the Application Layer- PGP and S/MIME, Security at the Transport Layer- SSL and TLS, Security at the Network Layer-IPSec.
Open Source/ Free/ Trial Tools: Implementation of Cryptographic techniques, OpenSSL, Hash Values Calculations MD5, SHA1, SHA256, SHA 512, Steganography (Stools).

3. Infrastructure and Network Security

Introduction to System Security, Server Security, OS Security, Physical Security, Introduction to Networks, Network packet Sniffing, Network Design Simulation. DOS/ DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Intrusion detection and Prevention Techniques, Host based Intrusion Prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation.
Open Source/ Free/ Trial Tools: DOS Attacks, DDOS attacks, Wireshark, Cain & abel, iptables/ Windows Firewall, snort, suricata, fail2ban.

4. Cyber Security Vulnerabilities & Safe Guards

Internet Security, Cloud Computing & Security, Social Network sites security, Cyber Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband communications, Poor Cyber

Security Awareness. Cyber Security Safeguards- Overview, Access control, IT Audit, Authentication. Open Web Application Security Project (OWASP), Web Site Audit and Vulnerabilities assessment.
Open Source/ Free/ Trial Tools: WinAudit, Zap proxy (OWASP), burp suite, DVWA kit.

5. Malware

Explanation of Malware, Types of Malware: Virus, Worms, Trojans, Rootkits, Robots, Adware's, Spywares, Ransom wares, Zombies etc., OS Hardening (Process Management, Memory Management, Task Management, Windows Registry/ services another configuration), Malware Analysis.
Open Source/ Free/ Trial Tools: Antivirus Protection, Anti Spywares, System tuning tools, Anti Phishing.

6. Security in Evolving Technology

Biometrics, Mobile Computing and Hardening on android and ios, IOT Security, Web server configuration and Security. Introduction, Basic security for HTTP Applications and Services, Basic Security for Web Services like SOAP, REST etc., Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges.

Open Source/ Free/ Trial Tools: adb for android, xcode for ios, Implementation of REST/ SOAP web services and Security implementations.

7. Cyber Laws and Forensics

Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013. Introduction to Cyber Forensics, Need of Cyber Forensics, Cyber Evidence, Documentation and Management of Crime Sense, Image Capturing and its importance, Partial Volume Image Web Attack Investigations, Denial of Service Investigations, Internet Crime Investigations, Internet Forensics, Steps for Investigating Internet Crime, Email Crime Investigations.

Open Source/ Free/ Trial Tools: Case Studies related to Cyber Law, Common Forensic Tools like dd, md5sum, sha1sum, Ram dump analysis, USB device.

Text Books/References:

William Stallings, "Cryptography and Network Security", Pearson Education/PHI, 2006.

1. V.K. Jain, "Cryptography and Network Security", Khanna Publishing House.
2. Gupta Sarika, "Information and Cyber Security", Khanna Publishing House, Delhi.
3. Atul Kahate, "Cryptography and Network Security", McGraw Hill.
4. V.K. Pachghare, "Cryptography and Information Security", PHI Learning
5. Nina Godbole, "Information System Security", Wiley
6. Bothra Harsh, "Hacking", Khanna Publishing House, Delhi.

Design Thinking

Unit I - Introduction to Design thinking

1. Importance of design thinking in daily life;
2. Types of innovation in design
3. Skills required for designing products for end users;
4. Need for design thinking in entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India);
5. Copyright possibilities for design.
6. Various practical applications of design thinking in industry verticals – product, process, research, finance, HR, marketing, operations, etc.

Unit II – Design thinking process

1. Scoping – list the requirements for the end users.
2. Identifying insights – spot user pain points in application situations.
3. Establish design criteria – various qualitative and quantitative parameters.
4. Concept development – to meet end user requirements.

Unit III - Design Strategy

1. Principles to design and build a prototype – use of computer aided tools for visual depiction.
2. Validation of assumptions & prototypes under simulated user conditions.
3. Re-design and customization to suit requirements.
4. Field survey of the design.

5. Costing & suitability to production requirements – availability of components, sourcing, quality, final build.

Unit IV - Marketing & promoting the design

1. Identification of customer segments for the designed products & processes.
2. Pitching methods to communicate the design elements.
3. Developing distribution channels – franchising to promote design;
4. Policies, promotion, advertising;
5. Branding and market linkages for "virtual startup company".

Unit V – Knowledge Centers

1. Introduction to TED, Stanford India Bio design.
2. Various Indian and global institutions for design thinking support.
3. Tinkering labs in India – fix Atal Tinkering Lab, India STEM foundation.
4. Certifications in designs.

Text Books/References:

1. Jeanne Liedtka and Tim Ogilvie Designing for Growth: A Design Thinking Tool Kit for Managers (Columbia University Press, 2011).
2. Jeanne Liedtka, Tim Ogilvie, and Rachel Brozenske, The Designing for Growth Field Book: A Step-by-Step Project Guide (Columbia University Press, 2014).
3. Human-Centered Design Toolkit (IDEO); https://www.ideo.com/post/design-kit
4. Design Thinking BootCamp Bootleg (Stanford D-School); https://dschool.stanford.edu/resources/the-bootcamp-bootleg
5. Collective Action Toolkit (frogdesign): https://www.frogdesign.com/wpcontent/uploads/2016/03/CAT_2.0_English.pd f
6. Design Thinking for Educators (IDEO):https://designthinkingforeducators.com/
7. Brown, Tim, and Barry Kātz. Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation. New York: Harper Business, 2009.
8. Cross, Nigel. Design Thinking: Understanding How Designers Think and Work. Oxford: Berg, 2011.
9. Bennett, Kevin. "Design Thinking: Creating a Better Understanding of Today to Get to a Better Tomorrow." Forbes (2013): n. pag. Web. 6 Apr. 2014. http://www.forbes.com/sites/ darden/2013/08/29/design-thinkingcreating-a-better-understanding-of-today-to-get-to-a-better-tomorrow/
10. Martin, Roger L. "The innovation catalysts." Harvard Business Review 89(6) (2011): 82-87.
11. "David Kelley: Human-centered design | Talk Video | TED." TED: Ideas worth spreading. N.p., n.d. Web. 4 Mar. 2014. https://www.ted.com/talks/david_kelley_on_human_centered_design?language =en

Open Subject – III

Robotics

Introduction to Robotics

- Types and components of a robot, Classification of robots, closed-loop and open loop control systems.
- Kinematics systems; Definition of mechanisms and manipulators, Social issues and safety.

Robot Kinematics and Dynamics

- Kinematic Modelling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics
- Dynamic Modelling: Equations of motion: Euler-Lagrange formulation

Sensors and Vision System

- Sensor: Contact and Proximity, Position, Velocity, Force, Tactile etc.
- Introduction to Cameras, Camera calibration, Geometry of Image formation, Euclidean/Similarity/Affine/Projective transformations
- Vision applications in robotics.

Robot Control

- Basics of control: Transfer functions, Control laws: P, PD, PID.
- Non-linear and advanced controls.

Robot Actuation Systems

Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators.

Control Hardware and Interfacing

Embedded systems: Architecture and integration with sensors, actuators, components, Programming for Robot Applications.

Text Books/References:

1. Saha, S.K., "Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.
2. Ghosal, A., "Robotics", Oxford, New Delhi, 2006.
3. Niku Saeed B., "Introduction to Robotics: Analysis, Systems, Applications", PHI, New Delhi.
4. Mittal R.K. and Nagrath I.J., "Robotics and Control", Tata McGraw Hill.
5. Mukherjee S., "Robotics Process Automation", Khanna Publishing House, Delhi.
6. Craig, J.J., "Introduction to Robotics: Mechanics and Control", Pearson, New Delhi, 2009
7. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modelling and Control", John Wiley and Sons Inc, 2005
8. Steve Heath, "Embedded System Design", 2nd Edition, Newnes, Burlington, 2003
9. Merzouki R., Samantaray A.K., Pathak P.M. and Bouamama B. Ould, "Intelligent Mechatronic System: Modeling, Control and Diagnosis", Springer.

Virtual Reality

1. Introduction to Virtual Reality

Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark.

3D Computer Graphics: Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, 3D clipping, Colour theory, Simple 3D modelling, Illumination models, Reflection models, Shading algorithms, Radiosity, Hidden Surface Removal, Realism-Stereographic image.

2. Geometric Modelling

Geometric Modelling: Introduction, From 2D to 3D, 3D space curves, 3D boundary representation.

Geometrical Transformations: Introduction, Frames of reference, Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection.

Generic VR system: Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems.

3. Virtual Environment

Animating the Virtual Environment: Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object inbetweening, free from deformation, particle system.

Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.

4. VR Hardware and Software

Human factors: Introduction, the eye, the ear, the somatic senses.

VR Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems.

VR Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML.

5. VR Applications

Introduction, Engineering, Entertainment, Science, Training.

The Future: Virtual environment, modes of interaction.

Text Books/References:

1. John Vince, “Virtual Reality Systems “, Pearson Education Asia, 2007.
2. Adams, “Visualizations of Virtual Reality”, Tata McGraw Hill, 2000.
3. Grigore C. Burdea, Philippe Coiffet , “Virtual Reality Technology”, Wiley Inter Science, 2 nd Edition, 2006.
4. William R. Sherman, Alan B. Craig, “Understanding Virtual Reality: Interface, Application and Design”, Morgan Kaufmann, 2008.
5. www.vresources.org
6. www.vrac.iastate.edu
7. www.w3.org/MarkUp/VRM

Data Sciences:

1. **Introduction to Data Science:** Concept of Data Science, Traits of Big data, Web Scraping, Analysis vs Reporting.

2. **Introduction to Programming Tools for Data Science:**
   2.1 Toolkits using Python: Matplotlib, NumPy, Scikit-learn, NLTK
   2.2 Visualizing Data: Bar Charts, Line Charts, Scatterplots
   2.3 Working with data: Reading Files, Scraping the Web, Using APIs (Example: Using the Twitter APIs), Cleaning and Munging, Manipulating Data, Rescaling, Dimensionality Reduction

3. **Mathematical Foundations**
   3.1 Linear Algebra: Vectors, Matrices.
   3.2 Statistics: Describing a Single Set of Data, Correlation, Simpson's Paradox, Correlation and Causation.
   3.3 Probability: Dependence and Independence, Conditional Probability, Bayes's Theorem, Random Variables, Continuous Distributions, The Normal Distribution, The Central Limit Theorem.
   3.4 Hypothesis and Inference: Statistical Hypothesis Testing, Confidence Intervals, P Hacking, Bayesian Inference.

4. **Machine Learning**

Overview of Machine learning concepts – Over fitting and train/test splits, Types of Machine learning – Supervised, Unsupervised, Reinforced learning, Introduction to Bayes Theorem, Linear Regression- model assumptions, regularization (lasso, ridge, elastic net), Classification and Regression algorithms- Naïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees, and random forest, Classification Errors, Analysis of Time Series- Linear Systems Analysis, Nonlinear Dynamics, Rule Induction, Neural Networks Learning And Generalization, Overview of Deep Learning.

5. Case Studies of Data Science Application

Weather forecasting, Stock market prediction, Object recognition, Real Time Sentiment Analysis.

Text Books/References:

1. Joel Grus, "Data Science from Scratch: First Principles with Python", O'Reilly Media
2. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", 1st Edition, O'Reilly Media
3. Jain V.K., "Data Science & Analytics: Using Python, R and SPSS Programming", Khanna Publishing House, Delhi.
4. Jain V.K., "Big Data and Hadoop", Khanna Publishing House, Delhi.
5. Jeeva Jose, "Introduction to Machine Learning using Python", Khanna Publishing House, Delhi.
6. Chopra Rajiv, "Machine Learning", Khanna Publishing House, Delhi.
7. Ian Goodfellow, Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press http://www.deeplearningbook.org
8. Jiawei Han and Jian Pei, "Data Mining Concepts and Techniques", Third Edition, Morgan Kaufmann Publishers.

Food and Nutrition Technology

Module 1: Introduction to food biotechnology:

Introduction, History and scope of food Biotechnology, development and prospects of biotechnology in animal products, ancient and traditional food processing techniques; Biochemical and metabolic pathways of biological systems used in food production.

Module 2: Methods in food biotechnology:

Role of biotechnology in productivity of livestock, Modern biotechnological methods and processes in animal product development, chemical and physical factors required for growing microbial cultures in nutritive substrate; Meat species identification, Quality control, Screening products for contaminants.

Module 3: Biotechnology methods in food processing:

Use of biotechnology in the production of food additives, use of biotechnological tools for the processing and preservation and foods of animal origin, use of biotechnology improved enzymes in food processing industry, Basic principles of the industrial use of bio-reactions for production of biomass-upstream and downstream processing application of microorganisms as starter cultures in meat industry, microbial production of food ingredients; Biosensors and novel tools and their application in food science.

Module 4: Food safety & security:

Consumer concerns about risks and values, biotechnology & food safety, Ethical issues concerning GM foods; testing for GMOs; current guidelines for the production, release and movement of GMOs; Future and applications of food biotechnology in India.

Text Books/References:

1. Potter, Norman. M. Food Science, 5th Ed. Springer US
2. Manay, S.; Shadakshara Swamy, M., (2004). Foods: Facts and Principles, 4 th Ed. New Age Publishers.
3. B. Srilakshmi., (2002) Food Science, New Age Publishers.
4. Meyer, (2004). Food Chemistry. New Age
5. Deman JM. (1990) Principles of Food Chemistry. 2 nd Ed. Van Nostrand Reinhold, NY
6. Ramaswamy H and Marcott M. Food Processing Principles and Applications. CRC Press

*****

Open Subject – IV

Block Chain

Introduction

Introduction: Overview of Block chain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Permissioned Model of Block chain, Overview of Security aspects of BlockChain.

Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency.

Understanding Block chain with Crypto currency

Bitcoin and Block chain: Creation of coins, Payments and double spending, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay.

Working with Consensus in Bitcoin: Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW,

Bitcoin PoW, Attacks on PoW and the monopoly problem, Proof of Stake, Proof of Burn and Proof of Elapsed Time, The life of a Bitcoin Miner, Mining Difficulty, Mining Pool.

Understanding Block chain for Enterprises

Permissioned Block chain: Permissioned model and use cases, Design issues for Permissioned block chains, Execute contracts, State machine replication, Overview of Consensus models for permissioned block chain- Distributed consensus in closed environment, Paxos, RAFT Consensus, Byzantine general problem, Byzantine fault tolerant system, Lamport-Shostak-Pease BFT Algorithm, BFT over Asynchronous systems.

Enterprise application of Block chain: Cross border payments, Know Your Customer (KYC), Food Security, Mortgage over Block chain, Block chain enabled Trade, We Trade – Trade Finance Network, Supply Chain Financing, Identity on Block chain.

Block chain application development

Hyperledger Fabric- Architecture, Identities and Policies, Membership and Access Control, Channels, Transaction Validation, Writing smart contract using Hyperledger Fabric, Writing smart contract using Ethereum, Overview of Ripple and Corda.

Text Books/References:

1. Melanie Swan, "Block Chain: Blueprint for a New Economy", O'Reilly, 2015
2. Josh Thompsons, "Block Chain: The BlockChain for Beginners- Guide to Block Chain Technology and Leveraging BlockChain Programming"
3. Daniel Drescher, "BlockChain Basics", Apress; 1stedition, 2017
4. Anshul Kaushik, "BlockChain and Crypto Currencies", Khanna Publishing House, Delhi.
5. Imran Bashir, "Mastering BlockChain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained", Packt Publishing
6. Ritesh Modi, "Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Block Chain", Packt Publishing
7. Salman Baset, Luc Desrosiers, Nitin Gaur, Petr Novotny, Anthony O'Dowd, Venkatraman Ramakrishna, "Hands-On Block Chain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer", Import, 2018.

*****

Bioterrorism and National Security

Terrorism and Bioterrorism

Definition-Traditional Terrorists-New Terrorists-Nuclear, chemical, and radiological weapons-The psychology of Bioterrorism-Historical perspective.

Microbes and Immune System

Primary classes of Microbes-bacteria, virus, and other Agents-Immune system-Interaction between microbes and the immune system.

Bioterrorism Weapons and Techniques

Characteristics of microbes and the reasons for their Use-Symptoms-Pathogenicity-Epidemiology-natural and targeted release-The biological, techniques of dispersal, and case studies of Anthrax, Plague-Botulism, Smallpox, and Tularemia and VHF.

Prevention and Control of Bioterrorism

Surveillance and detection- Detection equipment and sensors –Diagnosis-Treatment-Vaccinations-Supplies- Effectiveness-Liability-Public Resistance-Response-First Responders-Infectious Control-Hospital-Prevention- Protection-Decontamination-Notification-Role of Law Enforcement-Economic impact.

Bioterrorism Management

Ethical issues: personal, national, the need to inform the public without creating fear, cost-benefit Rations-Information Management-Government control and industry Support-Microbial forensics.

Text Books:

1. Bioterrorism: Guidelines for Medical and Public Health Management, Henderson, Donald, American Medical Association, 1st Edition, 2002.
2. Biological Weapons: Limiting the Threat (BCSIA Studies in International Security), Lederberg, Joshua (Editor), MIT Press ,1999.
3. Bioterrorism and Infectious Agents: A New Dilemma for the 21st Century (Emerging Infectious Diseases of the 21st Century), I.W. Fong and Kenneth Alibek, Springer, 2005.

Reference Books:

1. The Demon in the Freezer: A True Story, Preston, Richard, Fawcett Books, 2003.
2. The Anthrax Letters: A Medical Detective Story, Cole, Leonard A., Joseph Henry Press, 2003.
3. Biotechnology research in an age of terrorism: confronting the dual use dilemma, National Academies of Science, 2003.
4. http://www.centerforhealthsecurity.org/our-work/pubs_archive/pubs-pdfs/2012/sloan_book/Preparing%20for%20Bioterrorism_Gigi%20Kwik%20Gronvall_December%202012.pdf

*****