BIOECONOMY AND ENTREPRENEURSHIP		Semester	V
Course Code	**BBT501**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To make the students learn the principles of Biobusiness management.
- To enable the students, understand the concepts of Bioeconomy
- To motivate the students to explore various entrepreneurial opportunities.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION

Bio-economics- Concept, Development of Economics and Bioscience (Concept of resource economics for scarcity of biological resources), Bioresource elasticity, Evolution and Development of Economics and Biology (Charles Darwin and the evolutionary paradigm). Introduction to bio-business, from the Indian context, SWOT analysis of bio- business. Ownership, Development of Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Entrepreneurship in India; Entrepreneurship, its barriers. Small scale industries: Definition; Characteristics; Need and rationale; Objectives; Scope; Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. Global bio business and industry future trends.

Module-2 (8 Hours)

BIOECONOMY:

Benefits and challenges of knowledge-based bioeconomy, sustainable food security (Europe and African Perspective), Development of resource (agricultural) efficient bioeconomy, Social and economic challenges for bioeconomy, Forestry model, Regulation of renewable resource, Investing in agriculture harvesting capacity, Economic Growth, Development, and Innovation in terms of bioeconomy, Environmental Economics and the Role of Government, Modelling and Tools Supporting the Transition to a Bioeconomy, Role of biobased Economy in sustainable development.

Module-3 (8 Hours)

BIOECONOMY RESEARCH:

Inter- and trans disciplinarity in Bioeconomy &research approaches, primary production, processing of biobased resources, Markets, Sustainability Management and Entrepreneurship in biobased products. Biobased Resources and Value Chains, Processing of Biobased Resources, Markets, Sustainability Management and Entrepreneurship opportunity in biobased product. Food Security and Healthy Nutrition in the Context of the Bioeconomy, Use of Biomass for the Production of Fuel and Chemicals, The importance of Biotechnology for the Bioeconomy.

Module-4 (8 Hours)
ENTREPRENEURSHIP OPPORTUNITY IN AGRI BIOTECHNOLOGY: Business opportunity, Essential requirement, marketing, strategies, schemes, challenges and scope-with case study on Plant cell and tissue culture technique, poly house culture. Herbal bulk drug production, Nutraceuticals, value added herbal products. Bio ethanol production using Agri waste, Algal source. Integration of system biology for agricultural applications. Biosensor development in Agri management
Module-5 (8 Hours)
ENTREPRENEURSHIP OPPORTUNITY IN INDUSTRIAL BIOTECHNOLOGY: Business opportunity, Essential requirement, marketing strategies, schemes, challenges and scope-with case study- Pollution monitoring and Bioremediation for Industrial pollutants, Pesticides, Herbicides etc. Integrated compost production- microbe enriched compost. Bio pesticide/insecticide production. Fermented products-probiotic and prebiotics. Stem cell production, stem cell bank, contract research. Production of monoclonal/polyclonal antibodies, Single cell protein and secondary metabolite production. Contact research in microbial genomics.
Course outcome (Course Skill Set) At the end of the course, the student will be able to : 1. Understand the importance of Bio-business and Entrepreneurial opportunities. 2. Know the importance of Bioeconomy and Research 3. Plan a project with a work plan, budget and schedule. 4. Exploit the opportunities under start-up schemes

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Principles of Management by P. C. Tripathi, P. N. Reddy. Tata Mc Graw Hill FifthEdition,2012.
- Entrepreneurship Development by S. S. Khanka. S. Chand &Co Publishing, 2006.
- Practical Approach to IPR by Rachana Singh Puri, IK Intl. Ltd. 2009.
- Bioethics & Biosafety by R Rallapalli & Geetha Bali. APH Publication, 2007.
- Bioethics & Biosaftey by Sateesh M K, IK Publishers, 2008.
- Management Fundamentals -Concepts, Application, Skill Development by Robers Lusier Cengage Learning, 1996.
- Intellectual Property Rights in the WTO and developing country by Watal Jayashree, Oxford University Press, 2001.

Web links and Video Lectures (e-Resources):

- https://www.futurelearn.com/subjects/science-engineering-and-maths-courses/biology-and-biotechnology
- https://www.edx.org/course/the-science-and-business-of-biotechnology
- https://www.edx.org/learn/biotechnology
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies based on research findings
- Model making and Poster presentations on specific case studies.

ENZYME TECHNOLOGY + LAB		Semester	V
Course Code	**BBT502**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	3
Examination nature (SEE)	Theory/practical		

Course objectives:

- To understand the classification, catalytic actions and diverse applications of enzymes.
- To understand the techniques and protocols related to purification, activity, immobilization and engineering of enzymes.
- To understand the kinetics of enzyme catalyzed reactions.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

MODULE-1 (8 HOURS)

ENZYMES AN OVERVIEW:

Structure and properties of enzymes, Classification and nomenclature of enzymes, Sources of enzymes, Mechanism of enzymes action (Acid base, Covalent, Metal ion catalysis, Substrate strain & entropy effects), Mechanism of action of coenzymes(NAD/NADP, FAD/FADH2, PLP, Coenzyme A, TPP, Biotin), Strategies of enzyme purification, Characterisation of enzymes,

MODULE-2 (8 HOURS)

ENZYMATIC TECHNIQUES:

Advantages of biocatalyst over chemical catalyst, isolated enzymes over whole cell system, immobilised enzymes over free enzymes. Enzyme Assay: Basic principles of enzyme assays, Standardization and optimization of enzyme assays, Measurement of enzyme activity (fixed incubation and kinetic methods). Biocatalysts from extremophiles microorganisms (extremozymes) and their applications

MODULE-3 (8 HOURS)

ENZYME IMMOBILISATION

Immobilisation of Enzymes: Enzyme immobilization techniques, Kinetics of immobilized enzymes (Effect of ionic and hydrophobic interaction on partition, Effect of diffusion on productivity), Design and configuration of immobilized enzyme reactors. Applications of immobilized enzyme technology, Economic argument for immobilization.

MODULE-4 (8 HOURS)

ENZYME ENGINEERING:

Biotransformation: Basic reaction mechanism, Biotransformation of drugs (Hydroxylation and dehydrogenation of Progesterone to therapeutically superior derivatives). Novel Enzymes: Modified enzymes (Enzyme engineering and Solvent engineering), Synzymes (Host gust complexion chemistry, Enzyme design using steroid, Semisynthetic enzymes, Abzymes, Peptide synthesis).

MODULE-5 (8 HOURS)

APPLICATIONS:

Enzymes in medicine: Diagnostic enzymes (Glucose oxidase, Lactate dehydrogenase, Aspartate transaminase, Alanine transaminase, Creatine kinase, Alkaline phosphatase, acid phosphatase etc.), Therapeutic enzymes (Acetylcholinesterase, Angiotensin converting enzyme, HMGCoA reductase, glucose-6-phosphate dehydrogenase etc.),

Replacement enzymes (Amylase, protease, lipase, cellulose etc.). Enzymes in detergents (Protease, Amylases, Lipases, Cellulases etc.), Enzymes in food and beverage industry (Starch hydrolysis, Bakery, Brewing, Dairy, Fruit and vegetables, Meat), Enzymes in leather industry (Soaking, Dehairing, Bating, Degreasing), Enzymes in textile industry (Biopolishing, Biostoning, Desizing, Bleach clean up, Bioscouring,

PRACTICAL COMPONENT OF IPCC*(May cover all / major modules)*

Sl.NO	Experiments
1	Isolation of β - amylase enzyme from sweet potato.
2	Determination of activity of α- amylase in saliva.
3	Plotting standard graph of Maltose and Plotting standard graph of BSA.
4	Isolation of papain from papaya and assay of papain using calorimetric method
5	Estimation of total protein and specific activity of α- amylase in saliva.
6	Estimation of Alkaline phosphatase using *p*-nitrophenyl phosphate (*p*NPP).
7	Estimation of protease activity using Casein as a substrate.
8	Partial purification of α- amylase using ammonium sulphate precipitation method
9	Immobilisation of β – amylase using sodium alginate
10	Determination of molecular weight of α- amylase by SDS-PAGE
11	Separation of enzymes using Thin Layer Chromatography
12	Determining catalase activity of natural samples using hydrogen peroxide

Course outcomes (Course Skill Set):

At the end of the course, the student will be able to:

1. Define enzymes and its catalytic action, mechanism & kinetics with few examples.
2. Explain the various techniques involved in the extraction and utilization of enzymes in biotransformation Elaborate about the kinetics of enzyme catalysed reactions.
3. Exploit catalytic properties of biocatalyst in bioprocess, medicine, leather processing, food processing and detergent industry.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.

- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Books

- Enzyme Technology : Pacemaker Of Biotechnology, Krishna Prasad Nooralabettu, PHI Learning, New Delhi, 2011
- Enzyme Technology by Martin Chaplin and Christopher Bucke, Cambridge University Press, 1990.
- Enzymes by Dixon and Webb, Academic Press 2nd Edition, 1964.
- Principles of Enzymology for technological Applications by Butterworth Heinemann. Oxford University Press, 1993.
- Purifying Proteins for Proteomics by Richard J Simpson, I K International, 2003.
- Fundaments of Enzymology by Prices and Stevens. Oxford Press. Third Edition, 1999.
- Enzymes in Industry: Production and Applications by W. Gerhartz. Wiley-VCH Publishers 3rd Edition, 2007.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.classcentral.com/course/swayam-enzymology-19860
- https://www.udemy.com/course/enzymology/
- https://onlinecourses.swayam2.ac.in/cec20_bt20/preview
- https://www.coursera.org/lecture/industrial-biotech/engineering-enzymes-i-directed-evolution-b8hmZ
- https://stores.biotecnika.org/products/enzymology-certification-course

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Use of hands-on model for enzyme kinetics as well as collecting and graphing their own data to find V_{max} and K_m value using MS-Excel
- Small groups of students develop their own understanding of enzyme technology concepts, explore models, and use enzyme technology theoretical knowledge to develop important skills.
- Physical models of an enzyme mechanism to understand biocatalysis.

GENOMICS, PROTEOMICS AND BIOINFORMATICS		Semester	V
Course Code	**BBT503**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	4:0:0:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To inculcate the fundamentals of Genomics, Proteomics and Bioinformatics.
- To comprehend the applications of Genomics, Proteomics and Bioinformatics in biotechnology research.
- To impart knowledge of various software tools used in Genomics, Proteomics and Bioinformatics studies.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (10 Hours)

INTRODUCTION:

Polymorphisms–Types of polymorphism, genome sequences and data base subscriptions. Early sequencing efforts. Extraction of DNA, Methods of preparing genomic DNA for sequencing, DNA sequence analysis methods-Maxam & Gilbert Method, Sanger Dideoxy method, Fluorescence method, shot-gun approach. NGS method sand their principles. Bioinformatics tools and automation in Genome Sequencing, analysis of raw genome sequence data, Transcriptome (RNA) sequencing, Exome sequencing, Genome Annotation, Using NGS to detect sequence variants, Utility of EST database in sequencing.

Module-2 (10 Hours)

GENOMICS:

General architecture of prokaryotic and eukaryotic genome. Regulation of transcription, transcription factors and the coordination of gene expression, Gene variation and Single Nucleotide Polymorphisms (SNPs), Bioinformatics in detection of Polymorphisms - dbSNP, Gene-disease association, diagnostic genes and drug targets, genotyping tools - DNA Chips. Genome projects of Model systems: Drosophila, Yeast, C. *elegans*. *E. coli.,* Arabidopsis and rice; Human genome project and the genetic map. Interference RNA, RNA silencing, SiRNA. Genetic and physical maps: Breeding requirements for mapping. Molecular markers - RFLP, RAPD, AFLP, Micro-array in functional genomics. Bioinformatics tools in microarray data analysis. Tools for comparative genomics: BLAST2, Vista, MUMmer, COG, VOG. Mummer, COG, VOG.

Module-3 (10 Hours)

PROTEOMICS:

Two-dimensional PAGE for proteome analysis, Detection of proteins on SDS gels, Protein cleavage, Edman protein microsequencing, Automation in proteomics, Protein protein interaction assays - Two-hybrid methods, TAP/ GFP tags, Phage Display, Mass-spec based analysis of protein expression. MS-MS approaches, Peptide Mass finger printing and Post Translational Modifications Interactomics, Protein Arrays and "Protein Chip" - interactions and detection techniques. Phage antibodies as tools for proteomics. Proteome-wide interaction maps, Proteomics workflows; Proteomics and the study of diseases, Applications of proteome analysis to drug development and toxicology. Organellar proteomics. Protein Engineering.

Module-4 (10 Hours)

DATABASES& SEQUENCE ANALYSIS:

Bioinformatics resources: NCBI, EBI, ExPASy, RCSB. Significance of databases towards informatics projects. Databases and classifications. Gen Bank, DDBJ, EMBL, PIR, Uniprot-KB, SWISS-PROT, TrEMBL. Genebank flatfile. Protein Data Bank (PDB) flat file; FASTA Format, PIR Format; Structure file formats. the Modular Nature of proteins, Optional Alignment Methods, substitution matrices, Statistical significance of Alignments, BLAST and its different types, Progressive Alignment Methods, MUSCLE, Motifs and Patterns, PROSITE, Hidden Markov Models (HMMs). Phylogenetic analysis: Alignment, Tree Building, and Tree Evaluation, Tree – Building Methods-Distance based and character-based methods, Evaluating Trees and Data- Bootstrapping (parametric and nonparametric), Phylogenetic softwares (CLUSTAL-omega, PHYLIP etc).

Module-5 (10 Hours)

INSILICO APPLICATIONS:

Detecting Functional Sites in the Prokaryotic and Eukaryotic Genomes (promoters, transcription factor binding sites, translation initiation sites), Integrated Gene Parsing, finding RNA Genes, Web based tools (GENSCAN, GRAIL, GENEFINDER). Protein Identity based on composition, Physical properties Based on sequence, secondary structure and folding classes, tertiary structure. protein fold prediction tools, Related web-based software (JPRED, NNPREDICT, SOPMA, DSSP, STRIDE). Restriction mapping, Utilities, DNA strider, MacVector and OMIGA, Web based tools (MAP, REBASE); Primer design – need for tools, Primer design programs and software (PRIME3). 3D Structure Modeling in drug discovery, molecular docking, quantitative structure activity relationship (QSAR), deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Ligand-Receptor Interactions: Docking softwares (AUTODOCK, HEX), Energy Calculations (no derivation).

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Detail the basic concepts in Genomics, Proteomics and Bioinformatics.
2. Demonstrate the applications of Genomics, Proteomics and Bioinformatics in biotechnology research.
3. Apply various software tools used in Genomics, Proteomics and Bioinformatics for specific case studies.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Genomics and Proteomics Principles, Technologies, and Applications. By Devarajan Thangadurai and Jeyabalan Sangeetha. Apple Academic Press.2021.
- Concepts and Techniques in Genomics and Proteomics, by N Saraswathy, P Ramalingam. Woodhead Publishing Series in Biomedicine, 2011.
- Introduction to Proteomics by D.C Liebler; Humana Press, 2002.
- Introduction to Genomics Arthur M Lesk, Oxford University Press, 2007
- Discovering Genomics, Proteomics & Bioinformatics,by A M Campbell & L J Heyer,Pearson Education, 2007
- Proteins and Proteomics by Richard J Simpson, IK International, 2003.
- Genomics & Proteomics by Sabesan Ane Books, 2007.
- Purifying Proteins for Proteomics by Richard J Simpson IK International, 2004.
- BIOINFORMATICS by Andreas D Baxevanis. Wiley Interscience. 2020.
- BIOINFORMATICS: by David W Mount, cold spring harbor. 8. Introduction to Bioinformatics by Arthur Lesk, III edition, Oxford Publications. 2004,
- Structural Bioinformatics by Philip E Bourne, John Wiley & Sons. 2009.
- Fundamental Concepts of Bioinformatics by D E Krane & M L Raymer, Pearson, 2002.
- Introduction to Bioinormatics by Arthur Lesk, Oxford University Press, 2014.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.coursera.org/courses?query=bioinformatics
- https://www.edx.org/learn/bioinformatics
- https://bioinfotraining.bio.cam.ac.uk/
- https://onlinecourses.nptel.ac.in/noc19_bt25/preview
- https://pll.harvard.edu/course/introduction-proteomics?delta=0
- https://www.coursera.org/courses?query=genomics
- https://www.classcentral.com/subject/genomics
- https://online.stanford.edu/programs/genetics-and-genomics-program

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning.

- NGS and Microarray data Analysis
- Proteomic data network analysis.

BIOINFORMATICS LAB		Semester	V
Course Code	**BBTL504**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	100
Examination type (SEE)	Practical		

Course objectives:
This laboratory course enables students to get practical experience in:

- To learn the usage of online resources, database sand tools related to biological data.
- To learn the underlying concepts of Bioinformatics and their diverse applications.
- To learn the utilities of various computational tools for specific biological problems.

Sl.NO	Experiments
1	Bibliographic search from PUBMED, SCIRUS, SCIENCEDIRECT and Sequence retrieval from Nucleic acid and Protein databases.
2	Similarity Sequence searches (FASTA and BLAST) – Retrieval of homologs, paralogs, orthologs, and xenologs
3	Pair wise comparison of sequences – Analysis of parameters affecting alignment using SIM and EMBOSS-Needle
4	Multiple alignments of sequences with CLUSTAL-Omega and pattern determination using PROSITE
5	Evolutionary studies / Phylogenetic analysis – construction Using DRAWTREE and DRAWGRAM
6	Identification of functional sites in Genes / Genomes using GENSCAN Webserver
7	Secondary structure prediction of proteins using SOPMA and DSSP
8	Small Molecule sketching using Marvin sketch and bond optimization in 2D & 3D format (SDF, MOL2 file formats)
9	Restriction mapping of given sequence using NEBCUTTER and Primer design Using PRIME3 for molecular biology experiment.
10	PDB structure retrieval and visualization: Analysis of homologous structures.
11	Comparative Modelling of homologous sequences and validation of modelled structures using SWISS-MODEL
Demonstration Experiments (For CIE)	
12	Docking studies – Analysis of substrate / ligand binding using ARGULAB Package Molecular
13	Dynamics Simulation of Protein dynamics using GROMACS Protein-Ligand RMSD and RMSF in MD simulation

Course outcomes (Course Skill Set):
At the end of the course the student will be able to:

1. Comprehend the underlying concepts of Bioinformatics and their requirements.
2. Detail the utilities of relevant online resources, databases and software tools for case-specific problems.
3. Apply various software tools for diverse case-studies and analyse the results for optimized solutions.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
- General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

- Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.
  The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- BIOINFORMATICS by Andreas D Baxevanis. Wiley Interscience. 2020.
- BIOINFORMATICS: by David W Mount, cold spring harbor. 8. Introduction to Bioinformatics by Arthur Lesk, III edition, Oxford Publications. 2004,
- Structural Bioinformatics by Philip E Bourne, John Wiley & Sons. 2009.
- Fundamental Concepts of Bioinformatics by D E Krane & M L Raymer, Pearson, 2002.
- Introduction to Bioinormatics by Arthur Lesk, Oxford University Press, 2014.

Web links and Video Lectures (e-Resources):

- https://www.udemy.com/course/learn-bioinformatics-in-6-days/
- https://omicstutorials.com/introduction-to-bioinformatics-sequencing-resource-video-tutorial/
- https://cshl.libguides.com/c.php?g=746451&p=5434221
- https://www.youtube.com/watch?v=OOmmXrkFFDg
- https://www.youtube.com/watch?v=arpLDElBjsM
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

FOOD PROCESSING AND NUTRACEUTICALS		Semester	V
Course Code	**BBT515A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To impart knowledge on different unit operations and its significance in food industry.
- To learn the operation and utilization of equipment involved.
- To choose suitable techniques for the food processing operation.
- To understand the basic concepts of Nutraceuticals and functional food, their chemical nature and methods of extraction.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION

Principle, objectives techniques and importance of food processing, types of foods, post-harvest changes in raw materials, food preservation techniques: drying, thermal processing, freezing, irradiation, salting, fermentation, modifies atmospheric packing, chemical preservatives, recent trends in food processing. Novel processing technologies such as high-pressure processing (HPP), pulsed electric field (PEF) and cold plasma.

Module-2 (8 Hours)

PROCESSING OF CEREALS, MILLETS, PULSES AND LEGUME

Composition, Nutritive value and Structure of cereals, millets, pulses and legume, Types of processing methods. Changes during storage.

Module-3 (8 Hours)

PROCESSING OF ANIMAL MEAT, FISH, POULTRY AND MILK

Types, Composition and nutritive value of animal meat, fish poultry and milk. Post-harvest changes. Types of processing methods. Changes during storage.

Module-4 (8 Hours)

PROCESSING OF FRUITS, VEGETABLES, NUTS AND OIL SEEDS

General composition and nutritional values. Post-harvest changes, Processing methods, Changes during the storage.

Module-5 (8 Hours)

NUTRACEUTICALS

Introduction to Nutraceuticals and functional foods; importance, history, definition, classification, list of functional foods and their benefits, Phytochemicals, zoochemicals and microbes in food, plants, animals and microbes.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. Be able to understand and identify the specific processing technologies used for the various food products derived from raw materials.
2. Understand the application of scientific principles in the processing technologies specific to the raw materials.
3. Grasp the changes in the composition of foods with respect to the type of processing technology used.
4. Students will develop a good insight in the concepts of functional foods and their nutraceutical importance.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Food Science, B Srilakshmi, New Age International Publishers, 2018.
- Foods Facts and Principles, N. Shakuntala Manay and Shdhakara Swamy, New Age International Publishers, New Delhi 2008.
- The Complete Technology Book on Meat, Poultry and Fish Processing, NIIR Project Consultancy Services, 2013
- Girdharilal, Siddappaa, G.S and Tandon, G.L.1998. Preservation of fruits & Vegetables, ICAR, New Delhi
- Handbook of Fruits and Fruit Processing, Nirmal K. Sinha, Jiwan S. Sidhu, Jozsef Barta, James S. B. Wu M. Pilar Cano, John Wiley & Sons, Ltd. 2013.
- Robinson R. K., Modern dairy Technology, 2nd Ed., Chapman and Hall, New York. 1994.
- Subbulaksmi G and Shobha A. Udipi, Food processing and preservation, New Age International, 2008.

- Bisset, Normal Grainger and Max WichH "Herbal Drugs and Phytopharmaceuticals", 2nd Edition, CRC, 2001.
- Handbook of Nutraceuticals and Functional Foods: Robert Wildman, CRC, Publications. 2006
- WEBB, PP, Dietary Supplements and Functional Foods Blackwell Publishing Ltd (United Kingdom), 2006

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc20_ag02/preview
- https://archive.nptel.ac.in/courses/126/105/126105013/
- https://archive.nptel.ac.in/courses/126/105/126105011/
- https://onlinecourses.swayam2.ac.in/ugc19_hs33/preview
- https://www.youtube.com/watch?v=QxORI49hcI4
- https://www.youtube.com/watch?v=QKlyy4s3Yoc
- https://onlinecourses.swayam2.ac.in/cec22_ag02/preview
- https://archive.nptel.ac.in/courses/110/106/110106164/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Audio and video presentations of various food processing methods
- Online tools for surprise quizzes
- Visit food processing industries

FORENSIC BIOLOGY		Semester	V
Course Code	**BBT515B**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To know about the various areas of forensic sciences.
- To understand the techniques involved in forensic analysis.
- To know about the legal issues and ethics related to forensic science.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

FORENSIC SCIENCE:

Criminalistics: Definition, Principles of the forensic science, disciplines of forensic science and their Functions. Developments in forensic science in India and abroad. Types of evidence materials in different type of crimes, source and significance of evidence material, tools and techniques in crime scene search, Identification, collection, preservation, packaging and forwarding of evidence materials. Reconstruction of scenes of crime, lifting, developing and preserving fingerprints, footprints and tyre impressions and pattern evidence, Sampling, Chain of custody. Pursuit to crime scene: Securing the scene, Documentation crime scene (including photography and sketching).

Module-2 (8 Hours)

FORENSIC BIOLOGY AND FORENSIC MEDICINE:

Death causes manner and mode of death, Signs of death and changes after death. Somatic death, molecular death, early changes after death - Algor mortis, rigor mortis, Brief introduction to Forensic Osteology and Odontology, Forensic Botany, Entomology, Wild Life Forensics & Microbial Forensics, Forensic serology, Forensic Ballistics, Forensic Document Examination, Handwriting Characteristics, Determination of human and animal origin from bones, hair, flesh, nails, skin, teeth body tissue, fluids/ stains. Blood, semen, saliva, sweat, tear pus, vomit, etc., via relevant techniques. Forensic Characterization of Hair, Blood & Semen. Psychological Techniques in Forensic Science Principles and legal aspects of Polygraph, Narco analysis and Brain mapping including their concepts, significance, method, future perspective of the technique, limitations.

Module-3 (8 Hours)

FORENSIC DNA PROFILING:

Nature and structure of human genome and its diversity, mt-DNA, Y Chromosomes. DNA Extraction-Organic and Inorganic extraction, Comparison of Extraction methods, Commercial kits, DNA typing systems- RFLP analysis, PCR amplifications, sequence polymorphism. DNA Profiling: Introduction, History of DNA Typing, molecular biology of DNA, variations, polymorphism, Concept of sequence variation - VNTRs, STRs, Mini STRs, SNPs. Detection techniques -, Y-STR, Mitochondrial DNA. X-STR, Microbial DNA testing, Non-Human DNA testing, Plant DNA testing, Ancient DNA typing, STR kits, STR typing, RNA and its application in forensics.

Evaluation of results, New & Future technologies. DNA profiling applications in disputed paternity cases, child swapping, missing person's identity, veterinary, wild life and agriculture cases etc., legal perspectives DNA profiling in India & abroad.

Module-4 (8 Hours)

FORENSIC TOXICOLOGY:

Branches of Toxicology, Introduction & Scope, Classification of poisons, based on their origin, mode of action, chemical nature, poisons and poisoning in India, Classification of poisoning: accidental, homicidal, suicidal and miscellaneous, sign and symptoms of poisons and antidotes. Extraction of poisons from blood, urine, stomach wash and vomit, cold drink, food material, toxicological analysis of Nail, Bones and bile in decomposed materials. Brief introduction to Forensic Pharmacology, Clinical Toxicology, Entomotoxicology, Forensic Veterinary Toxicology, Environmental Forensic Toxicology. trouble shooting in toxicological analysis, disposal of analysis samples, Hair analysis: hair for forensic examination of drugs and poisons, Food poisons: symptom of food poisoning, collection and preservation of evidence material, detection and identification by colour test and instrumental techniques, Plant poison Animal Poisons. Factors affecting the intensity of poisoning. Importance of post-mortem examination in poisoning cases.

Module-5 (8 Hours)

RECENT TRENDS IN FORENSIC SCIENCE-

Environmental Forensics: Definition, Legal processes involving environmental forensic science. Geo-forensics Global Positioning System; Basic principles and applications. Biometrics in Personal Identification: Introduction, Concepts of Biometric Authentication, Role in person Identification, Techniques and Technologies (Finger Print Technology, Face Recognition, IRIS, Retina Geometry, Hand Geometry, Speaker Recognition, Signature Verification and other forensic related techniques). Bioterrorism: Definition, Concepts of Biosecurity and microbial forensics, Weapons of mass destruction (WMD), mass-casualty weapons (MCW), NBC and CBRNE, Dirty Bombs.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. At the end of the course, the student will be able to :
2. Describe the safety procedures and evidence handling at the crime scene and/or at the laboratory.
3. Distinguish between different types of physical evidence and pattern evidence based upon approaches in forensic chemistry and biology.
4. Analyse digital evidences and interpret the same via statistical means.
5. Apply basics of biology in toxicological evidences without compromising on Ethical guidelines.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- Forensic Science in India: A vision for the twenty first century Select, Nanda, B.B. and Tewari, R.K. Publisher, New Delhi, 2001.
- Forensic Science: An introduction to scientific and investigative techniques, James, S.H and Nordby, J.J., CRC Press, 2003
- Criminalistics: An Introduction to Forensic Science, R. Saferstein, Prentice Hall Inc., USA. 1976
- Encyclopedia of Forensic Sciences, J Siegel, P.J Saukko, Vol. I, II and III, Acad. Press, 2000.
- An Introduction to Forensic DNA Analysis, Rudin, Norah, CRC Levis Publishers, 2002.
- Fundamentals of Forensic Science, Houck, M.M. & Siegel, JA, Academic Press, London, 2006.
- Forensic Science in Criminal Investigation & Trials, Sharma, B.R., Universal Publishing Co., New Delhi, 2003.
- DFS Manual of Forensic Toxicology, Directorate Of Forensic Science Services, Ministry, Of Home Affairs, GOI, New Delhi,2021.
- A C Moffat Clarke's Analysis of Drugs and Poisons, (Formerly Isolation & Identification of Drugs) 3rd Ed. 2023.
- Casarett & Doll's Toxicology, The Basic Science of poisons. Curtis D. Klaassen, 2003
- Clark, E.G.C. : Isolation and identification of Drugs, VI and Vol. II, 1966, 1975-1986.
- Curry A.S, Analytical Methods in Human Toxicology, Part II, CRC Press Ohio,1986
- Curry, A.S. Poison Detection in Human Organs. 1976

Web links and Video Lectures (e-Resources):

- https://www.udemy.com/topic/digital-forensics/
  https://www.futurelearn.com/courses/collections/forensics
- https://www.coursera.org/learn/forensic-science
- https://www.classcentral.com/tag/forensic-science
- https://teachers-ab.libguides.com/c.php?g=710613&p=5063458
- https://www.coursera.org/courses?query=food%20science
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Case study based learning
- Group discussions related to investigations

MEDICINAL CHEMISTRY AND CHEMOINFORMATICS		Semester	V
Course Code	**BBT515C**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To understand the basic concepts, databases and tools of medicinal chemistry used in drug design.
- To understand the basic concepts of chemoinformatics, databases and tools used in drug design.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION:

History and development of medicinal chemistry, Physicochemical properties in relation to biological action Ionization, Solubility, Partition Coefficient, Hydrogen bonding, Protein binding, Chelation, Bioisosterism, Optical and Geometrical isomerism, Drug molecules and biological action, Drug receptor interaction including transduction mechanisms. Drug metabolism (phase I and II), Factors affecting drug metabolism including stereo chemical aspects. Principles of Drug Design: Traditional analog (QSAR)and mechanism-based approaches, Computer Aided Drug Designing (CADD) and molecular modelling

Module-2 (8 Hours)

DRUGS AND THEIR ACTION:

Development of selected drugs via medicinal chemistry routes as case studies (structure activity relationship including physicochemical properties, mode of action and uses): Cholinergics and Anticholinesterases, Adrenergic .drugs, Antispasmodic and anti-ulcer drugs, neuromuscular blocking agents, Autacoids, Antihistamines, Eicosanoids, Analgesic-antipyretics, anti-inflammatory (non-steroidal) agents. Drugs affecting uterine motility Oxytocics (including oxytocin, ergot alkaloids and prostaglandins)

Module-3 (8 Hours)

MOLECULAR RECOGNITION IN DRUG-RECEPTOR BINDING:

Molecular forces, Binding energetics, Enzyme Inhibitors, Modes of inhibition of Targets. Case studies a. Antibacterial Drugs and their resistance, Antiviral Drugs and their resistance, Anticancer Drugs and development of resistance, Neurotransmitters (adrenergic, cholinergic effects; psychopharmacology), CNS depressants (sedative/hypnotic, major/minor tranquilizers), CNS stimulants (Steroids)

Module-4 (8 Hours)

CHEMOINFORMATICS:

Introduction Chemoinformatics definition, scope of chemoinformatics, history of chemoinformatics, why to use informatics methods in chemistry, Representations of chemical compounds Introduction, Computer Representations of Chemical Structures: Graph Theoretic Representations, Linear Notations, Connection Tables, Canonical Representations of Molecular Structures. 2D structure databases, Reaction Databases, The

Representation of Patents and Patent Databases. Representations of 3D molecular structures: Experimental 3D Databases, 3D Database Searching.

Module-5 (8 Hours)

MOLECULAR DESCRIPTORS:

Introduction, Descriptors Calculated from the 2D Structure: Simple Counts, Physicochemical Properties, Molar Refractivity. Structure Searching: Substructure Searching, Screening Methods, Similarity searching, Drug and Drug Targets Drug: definition, "Drug-Likeness" and Compound Filters, rule of five. Lead Compound: definition, natural and synthetic resources of lead compounds. Drug targets: Enzymes, receptors, carrier proteins, structural proteins, nucleic acids, etc. Chemoinformatics tools for drug discovery Combinatorial Synthesis and Combinatorial Library, QSAR, 3D Pharmacophores. Screening Methods: High-throughput screening, Virtual Screening. Protein–Ligand Docking. The Prediction of ADMET Properties, Toxicity Prediction.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Apply the basic concepts of medicinal chemistry, databases and tools towards drug design.
2. Apply the basic concepts of chemoinformatics, databases and tools involved in drug design.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- Foye's Principles of Medicinal Chemistry by Lemke, Thomas L. Williams, David A., Lippincott, Williams & Wilkins 7th edition, 2012.
- Burgers Medicinal Chemistry. Drug Discovery and Development, Edited by Donald J Abraham, Volumes 1 – 8, Wiley, 2021.

- Introduction to principles of drug design by Smith and Williams, CRC Press, 2005.
- Handbook of Chemoinformatics, volume 1, by John Gastiger, Thomas Engel, WILEYVCH pub, 2003.
- An Introduction to Chemoinformatics, by Andrew R. Leach & Valerie j. Gillet, Springer, 2004
- Instant Notes in Medicinal Chemistry, by G. Patrick, BIOS Scientific pub, 2001.
- Chemoinformatics: A Textbook by Johann Gasteiger and Thomas Engel, Wiley, 2003.
- Chemoinformatics in Drug Discovery: 23 (Methods & Principles in Medicinal Chemistry) by Tudor I. Oprea, Raimund Mannhold, Hugo Kubinyi and Gerd Folkers, Wiley, 2005.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.classcentral.com/course/swayam-medicinal-chemistry-12908
- https://onlinecourses.nptel.ac.in/noc20_cy16/preview
- https://www.edx.org/course/medicinal-chemistry-the-molecular-basis-of-drug-di
- https://www.futurelearn.com/courses/discovering-science-medicinal-chemistry
- https://www.mooc-list.com/tags/medicinal-chemistry

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies based on research findings
  Poster presentations on specific case studies.

BIOPROCESS EQUIPMENTS DESIGN AND CAED		Semester	V
Course Code	**BBT515D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To learn different types of shell & tube heat exchanger, condenser, fermentor, packed column distillation
- To learn the functional design of shell & tube heat exchanger, condenser, fermentor, packed column distillation

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

PROCESS DESIGN OF DOUBLE PIPE HEAT EXCHANGER:

Introduction to heat exchanger, Functional design – Energy balance equation, log mean temperature difference (co-current, counter counter), Heat transfer coefficients (inside, outside & overall), area, length, number of hair pins, diameter of tube. Pressure drop calculations. Detailed drawing of sectional front view of Heat exchanger.

Module-2 (8 Hours)

PROCESS DESIGN OF SHELL & TUBE HEAT EXCHANGER:

Introduction to Heat Exchanger, Functional design – Energy balance equation, log mean temperature difference (co-current, counter current), Heat transfer coefficients (inside, outside & overall), area, length, number of tubes, tube sheet diameter, pitch type, diameter of tube sheet. Mechanical design – baffle, thickness of shell, thickness of tube sheet, thickness of head, pressure drop calculations – tube side and shell side. Detailed drawing of sectional front view of Heat exchanger (1-1, 1-2) with tube sheet layout.

Module-3 (8 Hours)

PROCESS DESIGN OF VERTICAL CONDENSER:

Heat balance, shell side heat transfer coefficient, tube side heat transfer coefficient, overall heat transfer coefficient for condensation (Uc), clean surface area, over all coefficient for subcooling, area for sub-cooling, total clean surface area, overall heat transfer coefficient (Ud) and pressure drop calculations. Detailed drawing of sectional front view.

Module-4 (8 Hours)

PROCESS DESIGN OF FERMENTER:

Functional design- Based on the type of bioreactor (batch reactor MFR) and cell growth kinetics and performance equation, determine the volume of the reactor, according to H/D ratio determine height and diameter. Mechanical design- Thickness of the shell (cylindrical, spherical), thickness of top & bottom cover, flange calculations – width and thickness of gasket, number of bolts, bolts circle diameter and bolt diameter.

Module-5 (8 Hours)

PROCESS DESIGN OF PACKED DISTILLATION COLUMN:

Functional design- material balance, energy balance, height of the packed column using NTU and HTU concepts, Mass transfer coefficients, Diameter of columns, top and bottom free space. Functional design- material balance, energy balance, height of the packed column using NTU and HTU concepts, Mass transfer coefficients, Diameter of columns, top and bottom free space. Detailed drawing for the above design (showing clearly inlets, outlets liquid distributors, packing support).

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Differentiate between different types of heat exchangers
2. Know the different components of HE
3. Do detailed design and drawing of DPHE, STHE and condenser,
4. Know the function of fermenter, packed column distillation
5. Design and draw the fermenter, packed column distillation.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- Mass Transfer Operations, by Rober E Treybal, McGraw Hill, 1981.
- Process Equipment Design –Vessel Design, by Brownell & Young, John Willey, 1951.
- Chemical Engineering, by J. M. Coulson & J. F. Richardson, Vol 6, Pregman Press, 1993.
- Chemical Engineers Handbook, by R. H. Perry & D. W. Green , 7thEdn, McGraw Hill,.

• Process Heat Transfer‖ by Donald Q. Kern, McGraw Hill, 1997. • Process Design of Equipment by S.D Dawande, Vol II, Central Techno Publications, 3rd edition, 2003.
Web links and Video Lectures (e-Resources):
• https://onlinecourses.nptel.ac.in/noc21_ch18/preview • https://nptel.ac.in/courses/103107143 • https://onlinecourses.nptel.ac.in/noc22_bt19/preview • https://www.digimat.in/nptel/courses/video/103107207/L01.html
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning • AV presentation by students (on topics as per choice of the teacher) • Online tools for surprise quizzes • Collection of case studies based on research findings • Poster presentations on specific case studies.

BIOPROCESS CONTROL AND AUTOMATION+LAB		Semester	VI
Course Code	**BBT601**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	3
Examination nature (SEE)	Theory/Lab		

Course objectives:

- To understand the basics of process dynamics, principles and instrumentation.
- To study various types of input functions and its response.
- To study the different types of controllers and their design stability aspect.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

MODULE-1 (8 HOURS)

INSTRUMENTATION:

Instrumentation-principles, Introduction to flow, pressure, temperature and liquid level measurements, measurement of important physico-chemical and biochemical parameters, methods of on-line and off-line biomass estimation, flow injection analysis for measurement of substrates, products and other metabolites. Online data analysis for state and parameter estimation techniques for biochemical processes.

MODULE-2 (8 HOURS)

FIRST ORDER SYSTEMS:

Process characteristics, Laplace and inverse Laplace transforms, first order systems – examples, mercury in glass thermometer, Mixing process, liquid level system with resistance, constant output (through pump), response of first order system for Step, Impulse, Linear and Sinusoidal changes in input. Conceptual numericals**.**

MODULE-3 (8 HOURS)

SECOND ORDER SYSTEMS

Interacting and non-interacting systems and their dynamic response to step, input. Second order systems with transfer functions (spring-damper, control valve, U-tube manometer), response of second order system to step, impulse and sinusoidal input – Over damped, underdamped and critically damped condition of second order system, transportation lag.

MODULE-4 (8 HOURS)

CONTROLLERS AND FINAL CONTROL ELEMENTS

Actuators, Positioners, Valve body, Valve plugs, Characteristics of final control elements (Transfer function for control valve), controllers – two position control, proportional control, derivative control, integral control, P-I (proportional-integral) control, P-D (proportional-derivative) control, P-I-D (proportional-integral-derivative) control, Block diagram reduction techniques, servo and regulatory problems, conceptual numericals.

MODULE-5 (8 HOURS)

CONTROLLER DESIGN AND STABILITY:

Criteria for stability, Routh test; Root locus (basics), Introduction to frequency response, Qualitative discussion about Bode criteria of stability; Conceptual numerical.

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	Dynamics of First order system (mercury thermometer) for step input
2	Dynamics of First order system (mercury thermometer) for pulse input
3	Dynamics of First order system (Single tank System) for step input
4	Dynamics of First order system (Single tank System) for pulse input
5	Characteristics of Transducers (Flow)
6	Interacting System responses to step input
7	Interacting System responses to pulse input
8	Non-interacting system responses to step input
9	Non-interacting system responses to pulse input
10	Temperature controller – responses to set point / load change
11	Pressure controller – responses to set point / load change
12	Characteristics of Transducers (Pressure and Temperature)

Course outcomes (Course Skill Set):

At the end of the course, the student will be able to:

1. Understand the basics of instrumentation , classification, various input function of automatic process control system
2. Classify and characterize the transducers based on critical process parameters
3. Demonstrate the working of First order systems and controllers.
4. Calculate and Analyze the output obtained from different systems and perform theoretical validation

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous

evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.

- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Books

- Process System analysis and Control by Donald R Coughanowr, McGraw-Hill, 2013.
- Chemical Process Control by George Stephanopoulos, Prentice-Hall of India, 1982.
- Bioprocess Engineering Principles by Pauline M. Doran, Academic Press, 2011.
- Biochemical Engineering Fundamentals by Bailey and Ollis, Mcgraw Hill, 2nd Edition, 2001.
- Essentials of Process Control by Luyben and Luyben, McGraw-HillEducation, 2005

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.digimat.in/nptel/courses/video/103105064/L02.html
- https://www.youtube.com/watch?v=sp8jdeATxSo
- https://www.youtube.com/watch?v=7m0fuww_2EA
- https://microbiologynote.com/bioreactor/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Collection of case studies based on research findings
- Model making and Poster presentations on specific case studies.

BIOKINETICS		Semester	VI
Course Code	**BBT602**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	4:0:0:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To discuss the different models of chemical reactions and how various factors such as temperature affect reaction rate.
- To study the performance and distinguish between the different types of ideal and nonideal reactors.
- To determine the optimum pH, temperature and concentration of an enzyme.
- To understand the aspects of substrate affinity and enzyme inhibition.
- To describe medium requirements and medium formulation for maximizing the yields.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (10 Hours)

INTRODUCTION:

Law of mass action and rate equation, definitions and examples of elementary and non-elementary reactions, theories of reaction rate and temperature dependency, analysis of experimental reactor data - evaluation of Rate equation by integral and differential analysis for constant volume system. Conceptual numericals.

Module-2 (10 Hours)

BIOREACTORS:

Design equations for homogeneous system - batch, stirred tank and tubular flow reactor, size comparison of single reactors, combination of reactor systems - Qualitative design for parallel and series reactors. Conceptual numericals. Nonideal reactors, residence time distribution studies for pulse and step input, Exit age distribution of fluid in reactors, RTD's for CSTR and PFR, calculations of conversions for First order reactions, tanks in series models. Conceptual numericals.

Module-3 (10 Hours)

ENZYME KINETICS:

Enzymes and their Classifications Enzyme active site, Units of enzyme activity types of enzyme specificities, initial velocity studies, formation of ES complex, derivation of Michaelis-Menton equation, definition of K_m and V_{max}, Lineweaver-Burk and Eadie-Hofstee plots, Enzyme inhibition: competitive, uncompetitive and non-competitive; Regulations – allosteric and feedback regulation. Conceptual numericals.

Module-4 (10 Hours)

KINETICS OF MICROBIAL GROWTH:

Batch growth kinetics, Elemental balance of biological conversion with and without extracellular product

formation, Degree of reduction, Theoretical prediction of yield coefficients, Factors affecting microbial growth, Monod growth kinetics, Conceptual numericals. Case studies.

Module-5 (10 Hours)

MEDIA OPTIMIZATION:

Medium requirements for fermentation processes- Carbon, nitrogen, minerals, vitamins and other complex nutrients; oxygen requirements; Medium formulation for optimal growth and product formation, examples of simple and complex media; thermal death kinetics of microorganisms; Batch and continuous heat – Sterilization of Liquid media; Filter sterilization of liquid media. Case studies.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. Detail the mechanism and kinetics of chemical, enzyme and microbial reactions.
2. Identify and summarize the parameters from a range of reactions to optimize reactor design and development.
3. Demonstrate the use of various scientific parameters to improve the performance of fermentation process.
4. Formulate a suitable media for maximized microbial growth and product yields, by analysing various parameters.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.
- Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Enzyme Technology : Pacemaker Of Biotechnology, Krishna Prasad Nooralabettu, PHI Learning, New Delhi, 2011
- Chemical Reaction Engineering by Levenspiel O, John Wiley, 1999
- Bioprocess Engineering by Shuler and Kargi Prentice Hall, 2002
- Elements of Chemical Reaction Engineering by Fogler, H.S., Prentice Hall, 2008
- Biochemical Engineering Fundamentals by Bailey and Ollis, McGraw Hill, 2017
- Bioprocess Engineering by Aiba, Humprey & Millis, Academic Press. Biochemical Engineering by James Lee, Prentice-Hall. 2009
- Bioprocess Engineering Principles by Pauline M. Doran, Elsevier Science, 2013
- Principles of Biochemistry by Albert Lehninger, CBS publishers, 2017
- Enzyme Kinetics by Plowman, McGraw Hill, 1972
- Chemical Engineering Kinetics by Smith J.M., McGraw Hill. Wolf R. Vieth, 1981
- Enzyme Kinetics and Mechanism by Paul F Cook & W W Cleland, Garland Science, 2007

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=k9oLo5Io5KM
- https://archive.nptel.ac.in/courses/102/102/102102033/
- https://www.youtube.com/watch?v=NsVb7Ov5b1Q
- https://archive.nptel.ac.in/courses/103/105/103105054/
- https://www.digimat.in/nptel/courses/video/102102033/L24.html
- https://www.youtube.com/watch?v=phJaCaUWeSw

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies based on research findings
  Poster presentations on specific case studies.

BIOPHARMACEUTICALS		Semester	VI
Course Code	**BBT613A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- Learn the basics of application of biology in drug discovery, drug formulation, infrastructural requirements and safety issues in line with the FDA requirements.
- Learn to analyse the Pharmacokinetics and Pharmacodynamics parameters, toxicology and mode of action of drugs.
- Learn to apply the principles of pharmacology to conventional, Biosimilars and transplantation-based therapeutics and disorders.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION

Descriptions & Monographs; Standards & Specifications; Testing of Drugs; Various Countries Pharmacopoeias; Indian, British, U.S, European, Japanese pharmacokinetic concepts, current research trends, new advances and approved biologicals for pharmaceutical use and manufacturing principles.

Module-2 (8 Hours)

DRUG METABOLISM:

Principles of basic and clinical pharmacokinetics and pharmacodynamics, Pharmacodynamics and Pharmacokinetics, Disease target identification and selection, receptor based approaches, agonists, antagonists, enzyme inhibitors Basic concepts, ADME definitions, Need of pharmacokinetic study; Interpretations from pharmacokinetics parameters, Examples of Pharmacodynamic parameters of various drugs; Evolution of Drug Metabolism Phase I Metabolism (microsomal oxidation, hydroxylation, dealkylation) Phase II Metabolism(Drug conjugation pathway) CYP Families.

Module-3 (8 Hours)

BIOSIMILARS AND ITS SCENARIO

Approved follow-on proteins/biosimilars: Characteristic of high selling peptides and proteins, products with expired patents: Target products for FOB (Follow on biologicals)/Biosimilars development peptides; recombinant non glycosylated proteins; recombinant glycosylated proteins: Industries dealing with biogenerics and its market value; World Scenario; Indian Scenario.

Module-4 (8 Hours)

THERAPEUTICS BASED ON BIOTECHNOLOGY:

Hematopoietic growth factor and coagulation factors ,interferons and cytokines; Preparation and standardization of hormones-thyroid, insulin and growth hormones; Enzymes-Enzymatic therapy and monographs; antibiotics and their derivatives-penicillin, streptomycin, tetracycline, cephalosporins, macrolides, peptide antibiotics , vaccines BCG, DPT, Poliomyelitis, Typhus, toxoids-diphtheria and tetanus;

antitoxins diphtheria and gas gangrene, any two); others-whole human blood, dried human plasma, gamma globulins, clinical dextran and absorbable haemostats, uses, and storage.

Module-5 (8 Hours)

TRANSPLANTATION THERAPY:

Laws of transplantation, host vs. Graft and graft vs. Host reactions; HLA, classification immunosuppressants, drugs for immune suppressive therapy: corticosteroids, anti-metabolites and calcineurin inhibitors, Clinical aspects of antiallergic, immunosuppressive, immune stimulating and substitutive therapy.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. Apply the basics of biology in drug discovery, drug formulation, the infrastructural requirements and safety issues in line with the FDA requirements.
2. Analyse the Pharmacokinetics and Pharmacodynamics parameters, toxicology and mode of action of drugs.
3. Apply the principles of pharmacology to conventional, Biosimilars and transplantation-based therapeutics and disorders.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- Biopharmaceuticals, Biochemistry and Biotechnology by Gary Walsh, Wiley Pub. 1998.
- Principles of Medicinal Chemistry by Foye Lippincott Williams & Wilkins Publishers Sixth Edition, 2008.
- Industrial Pharmaceutical Biotechnology by Heinrich Klefenz Wiley-VC Hedition, 2002

Web links and Video Lectures (e-Resources):
• https://ocr.od.nih.gov/courses/ippcr.html • https://www.udemy.com/topic/clinical-research/ • VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning • Group Discussion of Case studies • Model Making and poster presentations

BIOMEDICAL IMAGING AND HEALTH INFORMATICS		Semester	VI
Course Code	**BBT613B**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To provide basic skills and knowledge in health informatics.
- To introduce problems, challenges and research practices that health informatics addresses.
- To learn ethical and diversity issues in health informatics.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

BIOMEDICAL IMAGING:

Introduction to Biomedical Imaging, its history and development, Imaging with ionizing radiation: Physics of x-ray imaging, X-ray generators and detectors. Dual-energy x-ray absorptiometry (DEXA),Computed Tomography: Principles of image formation and reconstruction techniques, Computed Tomography: Instrumentation and Data analysis

Module-2 (8 Hours)

NUCLEAR IMAGING MODALITIES:

Scintigraphy, positron emission tomography (PET) & single-photon emission computed tomography (SPECT), Magnetic Resonance Imaging: Physical foundations of Magnetic Resonance Imaging: Image formation. Ultrasound Imaging, spectral imaging, and medical image processing labs. Outlook and trends in biomedical imaging

Module-3 (8 Hours)

HEALTH INFORMATICS:

Aim and scope, historical perspectives, concepts, definitions and activities in Health informatics, introduction to the application of information technology to integrated hospital information systems and patient-specific information; nursing, radiology, pathology, and pharmacy services, Future trends, research in health informatics, training and career opportunities.

Module-4 (8 Hours)

HOSPITAL MANAGEMENT AND INFORMATION SYSTEMS:

Hospital Management and Information Systems (HMIS), its need, benefits, capabilities, development, functional areas. Modules forming HMIS, HMIS and Internet, Pre-requisites for HMIS, why HMIS fails, health information system, disaster management plans, advantages of HMIS. Health Level 7 (HL7). Study of picture archival & communication systems (PACS), PACS Administrator, PACS Technology overview, PACS Administration: The Business Perspective.

Module-5 (8 Hours)
ELECTRONIC HEALTH RECORDS: Pathology Laboratory Module, Blood Bank Module, Operation Theatre Module, Medical Stores Module, Pharmacy Module, Inventory Module, Radiology Module, Medical Records Index Module, Administration Module, Personal Registration Module, Employee Information Module, Financial modules, Health & Family Welfare, Medical Research, Communication, General Information.
Course outcome (Course Skill Set) At the end of the course, the student will be able to : 1. Demonstrate basic skills and knowledge in health informatics for application in future health-related careers. 2. Gain knowledge about problems, challenges and research practices that health informatics addresses. 3. Demonstrate ability to identify genomic variants associated with a disease phenotype and Perform visualization and simple analysis for disease prognosis. 4. Analyze ethical and diversity issues in health informatics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Radiological Imaging, The Theory of Image Formation, Detection, and Processing byHarrison Barrett and William Swindell, Academic Press,1996.
- Introduction to Biomedical Imaging by Andrew G. Webb, Wiley, 2017.
- Medical Imaging Systems by A. Macovski by R. Bracewell, Springer ebook, 2018.
- Medical imaging signals and systems by Jerry L Prince and Jonathan M Links, Prentice-Hall. 2005.
- Principles of magnetic resonance imaging byZhi-Pei Liang, Paul C. Lauterber, IEEE, 2000.
- NMR Imaging in Biomedicine by P. Mansfield and P. Morris, Elsevier, 1982.
- Digital Image Processing by K. Castleman, Pearson, 2011.
- Medical Imaging Technology by Mark A. Haidekker, Springer, 2013.
- Biomedical Informatics: Computer Applications in Health Care and Biomedicine by Edward H. Shortliffe, James J. Cimino, Michael F. Chiang, Springer, 2021.
- Consumer Health Informatics: Enabling Digital Health for Everyone by Catherine Arnott Smith, Alla Keselman, CRC Press, 2020.
- Health Informatics: Integrating Healthcare and Information Technology byLeonidas Waugh, Foster Academics, 2020.
- An Introduction to Healthcare Informatics, Building Data-Driven Tools by Peter Mccaffrey, Academic Press, 2020.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.medvarsity.com/courses/clinical-imaging/
- https://www.edx.org/learn/biomedical-imaging
- https://www.coursera.org/courses?query=radiology
- https://www.udemy.com/topic/medical-imaging/
- https://www.coursera.org/browse/health/health-informatics

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered
- Discussion on recent advancements and case studies

SYNTHETIC BIOLOGY AND TISSUE ENGINEERING		Semester	VI
Course Code	**BBT613C**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

- To understand the fundamental principles of tissue engineering and synthetic biology.
- To apply the principles and processes for development of engineered biomaterials.
- To pick up related computational skills, software and tools for designing specific applications.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION TO SYNTHETIC BIOLOGY:

History, current, and future. Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells as Therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number viability, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties.

Module-2 (8 Hours)

APPLICATIONS OF SYNTHETIC BIOLOGY:

Applications of synthetic biology. Synthetic and Biological Substitutes, Cell Therapy and Tissue engineering. Tissue Organization and Tissue Dynamics, The cell component in tissue engineering, Cell types and their origin, Compartment models for cell differentiation (tutorial), Cell nutrition, Diffusion, Chemotaxis.

Module-3 (8 Hours)

APPLICATIONS OF GENETIC CIRCUITS:

Biological background of gene regulation. Experimental foundation for gene circuit construction. Mathematical modelling and simulation. Engineered functional circuits: from modules and systems. Bacterial circuits: Feedback, feedforward, signal propagators, and band filter. Bacterial communication circuits: Population control and patterning systems. Bacterial communication circuits: Synchronized oscillators. Functional synthetic systems: From modules to systems. Gene circuit design and engineering: Biobricks/BioFAB and designing softwares. Synthetic circuits beyond bacteria: Phage, virus, and eukaryotic. In vitro/cell-free systems. Applications: Biomedicine and Biomaterials, Biofuels and Bioremediation.

Module-4 (8 Hours)

TISSUE ENGINEERING:

Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology number viability, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties.

Module-5 (8 Hours)

TISSUE ARCHITECTURE AND BIOMATERIALS:

Tissue types and Tissue components, Tissue repair, Engineering wound healing and sequence of events. Basic wound healing Applications of growth factors: VEGF/angiogenesis, Basic properties, Cell-Matrix& Cell-Cell Interactions, telomeres and Self-renewal, Control of cell migration in tissue engineering. Biomaterials: Properties of biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials, Role of Nanotechnology.

Course outcome (Course Skill Set)

1. To demonstrate the fundamental principles of tissue engineering and synthetic biology.
2. To apply the principles and processes for development of engineered biomaterials.
3. To list related computational tools for designing specific utilities.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Synthetic Biology: Tools and Applications by H. Zhao, Academic Press, 2013.
- Tissue Engineering by Clemens Van Bliterswijk, Academic Press; 2nd edition,2014.
- Tissue Engineering by Bernhard Palsson and Sangeeta Bhatia, Pearson, 2003.
- Tissue Engineering by Palsson, Hubbell, Plonsey and Bronzino, CRC Press, 2003.
- Tissue Engineering by Bernhard O.Palsson, Sangeeta N.Bhatia, Pearson Publishers 2009.
- Fundamentals of Tissue Engineering and Regenerative Medicine by Meyer, U, Meyer, Th. Handschel, J. Wiesmann, H.P. 2009.
- Stem cell transplantation, tissue engineering, and cancer applications by Bernard N. Kennedy

(editor). Nova Science Publishers, 2008.
- Stem cell-based tissue repair by Raphael Gorodetsky, Richard Schäfer. RSC Publishing, 2011.
- Handbook of Stem Cells, R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, Two- Volume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells, Academic Press, 2004.
- Essential of Stem Cell Biology, R. Lanza, J. Gearhart etal (Eds), Elsevier Academic press,2006.
- Translational Approaches In Tissue Engineering & Regenrative Medicine by J. J. Mao, G. Vunjak-Novakovic et al (Eds), Artech House, INC Publications, 2008.
- Stem Cell Repair and Regeneration by Naggy N. Habib, M.Y. Levicar, , L. G. Jiao,.and N. Fisk,volume-2, Imperial College Press,2007.

Web links and Video Lectures (e-Resources):

- https://www.edx.org/course/principles-of-synthetic-biology
- https://www.coursera.org/lecture/genes/synthetic-biology-8CrH2
- https://www.mooc-list.com/tags/synthetic-biology
- https://www.ibiology.org/playlists/synthetic-biology/
- https://www.classcentral.com/course/swayam-plant-physiology-and-plant-tissue-culture-14238
- https://www.classcentral.com/course/swayam-tissue-engineering-14337
- https://www.classcentral.com/course/tissue101-494
- https://onlinecourses.nptel.ac.in/noc21_bt33/preview
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Jingge Ma, Chengtie Wu, Bioactive inorganic particles-based biomaterials for skin tissue engineering, Exploration, Wiley Online Library10.1002/EXP.20210083, (2022).
- Journal of Tissue Engineering
- Synthetic Biology - in Bioengineering and Biotechnology
- Synthetic biology meets tissue engineering - PMC - NCBI
- Front. Bioeng. Biotechnol., 11 September 2020 | https://doi.org/10.3389/fbioe.2020.01009
- Online tools for surprise quizzes
- Collection of case studies via Newspapers/Journal articles, on topics covered
- Group discussions on recent advancements and case studies.

SYSTEMS BIOLOGY & RATIONAL DRUG DESIGN		Semester	VI
Course Code	**BBT613D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To understand the basic concepts of biological networks, their models, tools and statistical measures to characterize their properties.
- To learn the basic concepts, principles and methods of metabolic engineering networks and flux balance analysis.
- To understand the process of drug development, from target identification to final drug registration via computational tools.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION:

Introduction and basic concepts in biological systems. Genotype-phenotype mapping - Concepts of genotypes and phenotypes, genotype networks and fitness landscapes. Gene regulation networks - Negative and positive regulation in transcription networks. Feed-forward loops - Oscillatory circuits. Optimality and robustness - Robustness in biological systems. Principles of optimality. Stochasticity in biological processes.

Module-2 (8 Hours)

NETWORK BIOLOGY:

Introduction to Static Networks, Network Biology and Applications, Reconstruction of Biological Networks, Dynamic Modelling of Biological Systems: Introduction, Solving ODEs & Parameter Estimation, Constraint-based approaches to Modelling Metabolic Networks, Perturbations to Metabolic Networks, Elementary Modes, Applications of Constraint based Modelling, Metabolic Flux balance Analysis, Modelling Regulation, Host-pathogen interactions, Robustness of Biological Systems.

Module-3 (8 Hours)

MICROARRAYS AND GENE EXPRESSION:

Microarrays (gene expression arrays/CGH arrays). Metabolic networks and flux analysis. Metabolic engineering. DNA Microarrays, Gene Expression Data Analysis, Metabolic Pathways, Gene Regulation, Cellular Signalling, Protein-Protein Interactions, Topology of Molecular Networks. Computational Analysis of Molecular Networks, Dynamics of Molecular Networks, Dynamics of Molecular Networks, Molecular Networks, Phenotype, & Disease, Proteomics and Systems Biology. Tools for systems biology: Pathway Mapping through KEGG, Cytoscape, Virtual Cell.

Module-4 (8 Hours)

DRUG DESIGN AND DEVELOPMENT:

Rational Approaches to Drug Design and Development, Drug targets, Lead Identification and Modification, Computer-Aided Drug Design, Drug Delivery, Pre-clinical and Clinical Testing. Steps in Computational drug

design: Molecular Modelling, Importance of the Bioactive Conformation, Molecular Mimicry, Structural Similarities and Superimposition Techniques, Three – Dimensional Description of Binding Site Environment and Energy Calculation, Automatic Docking Methods, Database Search Approaches, Structure Construction Methods with known and unknown 3D Structures of the Receptor, Web based programs available for molecular modelling, molecular docking, energy minimization techniques, ADME studies and validations.

Module-5 (8 Hours)

PROTEOMICS AND SYSTEMS BIOLOGY:

Application in Drug Discovery and Development, Systems Biology Approaches and Tools for Analysis of Interactomes and Multi-target Drugs, Translational Bioinformatics and Systems Biology Approaches for Personalized Medicine, Systems Biology Methods for Disease Treatment and Translational Medicine: Systems Biology and Inflammation, Systems Biology of Cardiovascular Drugs, Cancer Systems Biology, Systemic Lupus Erythematosus: From Genes to Organ Damage, Systems Biology of Influenza, Methods in Systems Biology of Experimental Methamphetamine Drug Abuse, Systems Biology and Theranostic Approach to Drug Discovery and Development to Treat Traumatic Brain Injury.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Present the basic concepts of biological networks, their models, tools and statistical parameters.
2. Explain the basic concepts, principles and methods of metabolic engineering networks and flux balance analysis.
3. Apply the tools and techniques used in the process of drug development, from target identification to final drug registration.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- A First Course in Systems Biology by Voit E ,Garland Science, 2012
- Systems biology byKlipp E, Wiley-VCH, 2009.
- Networks: an introduction. By Newman, Oxford Univ. Press. MEJ, 2011.
- An Introduction to Systems Biology: Design Principles of Biological Circuits. By Alon, Uri. Chapman& Hall /CRC, 2006.
- Systems Biology: Properties of Reconstructed Networks byPalsson, Bernhard O. New York, Cambridge University Press, 2006.
- Optimization Methods in Metabolic Networks. Costas D. Maranas and Ali R. Zomorrodi. John Wiley & Sons, 2016.
- Systems Biology by Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald,Wiley-Blackwell, 2016.
- Systems Biology in Drug Discovery and Development: Methods and Protocols by Qing Yan, Humana Press,2010.
- An Introduction to Systems Biology: Design Principles of Biological Circuits by Alon, U. ,1st ed. CRC Press. Chapman and Hall/CRC. 2006.
- Big Mechanisms in Systems Biology. Big Data Mining, Network Modeling, and Genome-Wide Data Identification by Bor-Sen Chen, Cheng-Wei Li, Academic Press,2016.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.coursera.org/courses?query=system%20biology
- https://onlinecourses.nptel.ac.in/noc20_bt08/preview
- https://ocw.mit.edu/courses/8-591j-systems-biology-fall-2014/
- https://www.mooc-list.com/tags/systems-biology
- https://ep.jhu.edu/courses/605755-systems-biology/
- https://www.ebi.ac.uk/training/search-results?query=systemsbiology&domain=ebiweb_training&page=1&facets=Systems Biology, IIT Madras Dr. M. Vijayalakshmi
- https://ocw.mit.edu/courses/8-591j-systems-biology-fall-2014/
- https://www.coursera.org/learn/systems-biology
- https://nptel.ac.in/courses/102106035
- https://onlinecourses.nptel.ac.in/noc20_bt08
- Gunnar's Crash Course in Systems Biology. Online-lectures
- Computational systems biology in drug discovery and development: methods and applications:
- https://www.sciencedirect.com/science/article/abs/pii/S1359644607000943
- Advanced Systems Biology Methods in Drug Discovery and Translational Biomedicine - BioMed Research International

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered
- Discussion on recent advancements and case studies

ROBOTICS IN HEALTHCARE AND AGRITECH		Semester	VI
Course Code	**BBT654A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To provide knowledge on the applications of robotics in the field of health care and agriculture.
- To learn about the sensor requirements for localization and tracking in medicine and agriculture.
- To understand the design aspects of medical and agri-based robots.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION:

Need, technology, volume image data file, human resources, interface and applications. Virtual environment (VE), technology, applications of VE, advantages of simulators and after effects of VE participation. Millirobotics for remote surgery, Telesurgery, and endoscopy. Types of medical robots - Navigation - Motion Replication - Imaging - Rehabilitation and Prosthetics - State of art of robotics in the field of healthcare.

Module-2 (8 Hours)

LOCALIZATION AND TRACKING:

Position sensors requirements, Tracking - Mechanical linkages, Optical Sound-based, Electromagnetic Impedance based, In-bore MRI tracking, Video matching, Fiber optic tracking systems, Hybrid systems. Control modes, Radiosurgery, Orthopaedic Surgery, Urologic Surgery and Robotic Imaging, Cardiac Surgery, Neurosurgery, case studies.

Module-3 (8 Hours)

REHABILITATION AND ROBOTS IN MEDICAL CARE:

Rehabilitation for Limbs, Brain Machine Interfaces, Steerable Needles, case studies. Assistive robots, types of assistive robots, case studies. Design of Medical Robots. Characterization of gestures to the design of robots, Design methodologies, Technological choices – Security.

Module-4 (8 Hours)

ROBOTS IN AGRI TECH:

Developments in harvesting, crop sorting, disease detection and monitoring equipment for the agricultural industry. Solutions for planting, pruning, thinning, weeding, yield estimate, harvesting or processing. Applications of Robots in agriculture: weed control, cloud seeding, planting seeds, harvesting, environmental monitoring and soil analysis. Examples: Green seeker sensor, Robot drone tractors, Flying Robots To Spread Fertilizer, Fruit Picking and sorting Robots.

Module-5 (8 Hours)

TECHNICAL CONSIDERATIONS:

Locomotion: Legged Mobile Robots, Wheeled Mobile Robots, Complex Wheels, Tracked Vehicles, Aquatic Vehicles, Flying Vehicles, Space Robots, Case studies. Robot Kinematics: Coordinate frames, rotations, homogeneous coordinates, link coordinates, the direct kinematics problem, the inverse kinematics solution, Case studies. Mobile Robot Kinematics: Kinematic Models and Constraints, Mobile Robot Manoeuvrability, Mobile Robot Workspace, Case studies.

Actuating: DC Motors, Gearing and Efficiency, RC Servo Motors, Stepping motors, Motor Control, Case studies. Sensing I: Non-visual Sensors and Algorithms, Contact Sensors, Bumpers, Internal Sensors, Infrared Sensors, Sonar, Radar, Laser Range Finder, Lidar, Case studies.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Describe the types of medical and agri-based robots and the concepts of navigation and motion replication.
2. Discuss about the sensors used for localization and tracking for agri and healthcare applications.
3. Analyze the design characteristics, methodology and technological choices for medical and agri-based robots.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- Introduction to Robotics: Analysis, Control and Applications. By Saeed B. Niku, Wiley India, 2011.
- Robotics: Fundamental Concepts and Analysis, by Ashitava Ghosal, Oxford University Press, 2006.
- Robotic Technology and Flexible Automation by S. R. Deb & Sankha Deb, Tata Mc Hill, 2010.
- Robot Modeling and Control by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Wiley Publishers, 2006.
- Medical Robotics by Achim Schweikard, Floris Ernst, Springer, 2015.
- Medical Robots by Daniel Faust, Rosen Publishers, 2016.
- Agricultural Robots: Mechanisms and Practice by Naoshi Kondo, Kyoto University Press and Trans Pacific Press; Har/Cdr edition, 2011.
- Agricultural Robots - Fundamentals and Applications by Jun Zhou and Baohua Zhang, Intech open access, 2019.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.udemy.com/topic/robotics/
- https://www.coursera.org/courses?query=robotics
- https://www.edx.org/learn/robotics
- https://www.udemy.com/topic/robotics/
- https://www.futurelearn.com/subjects/it-and-computer-science-courses/ai-and-robotics

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered
- Discussion on recent advancements and case studies

FOOD, NUTRITION AND HEALTH		Semester	VI
Course Code	**BBT654B**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To acquaint students with fundamentals of food, nutrients and their relationship to health.
- To create awareness with respect to deriving maximum benefit from available food resources.
- To make students apply the information on nutrition and health for developing health consciousness.
- To develop the understanding about aspects related to food processing and product development.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

FOOD, NUTRITION AND HEALTH:

Introduction: Broad meaning of food, nutrition and health, Relationship between foods, nutrition and health. Functions of food- Physiological, psychological and social. Basics of major and minor nutrients: Functions, dietary sources and deficiency aspects- Carbohydrates and dietary fibre, lipids and proteins. Vitamins- Fat soluble (Vitamin A, D, E and K) and water soluble (Vitamin B: thiamine, riboflavin, niacin, pyridoxine, folate, Vitamin B12 and Vitamin C), Minerals (Ca, Fe, I, Zn etc.). Groups of foods. Anti-nutritional factors in foods

Module-2 (8 Hours)

BALANCED DIET AND NUTRITION:

Recommended Dietary Allowances for Indians, Food pyramid, factors affecting the planning of diets, Dietary Pattern, Physiological considerations and nutritional requirements (meal planning) for the following life stages: paediatrics, adolescence, adults (men and women) (sedentary, moderately and hardworking categories), pregnant and lactating women, geriatrics. Nutrition for physical fitness and sports, Techniques of measuring body composition, height and weight relationships: BMI, BMR, work capacity, physical fitness. Meaning of malnutrition (including overweight and obesity). Dieting and faulty food habits, associated challenges and disorders (like anorexia nervosa).

Module-3 (8 Hours)

NUTRITIONAL DEFICIENCIES AND DISEASES:

Meaning, Types and measurement. Protein Energy Malnutrition, Biological Value (BV) of protein, Protein Efficiency ratio, Vitamin A and D Deficiencies, Iron Deficiency (anaemia), Iodine Deficiency Disorders, Zinc Deficiency, Fluorosis. Obesity-etiology, treatment, consequences of obesity and its prevention. Diabetes mellitus: types, dietary treatment for Type I and II diabetics, complications of diabetes. Diseases of the heart and blood vessels-etiology, symptoms and diagnosis; atherosclerosis, lipids and other dietary factors

responsible for coronary heart diseases (CHD). Dietary habits during CHD, hypertension, and hyperlipidaemia. Fatty liver conditions

Module-4 (8 Hours)

FOOD PROCESSING AND PRESERVATION OF NUTRIENTS:

Means of nutritional losses during cooking/processing. Preventive measures. Selection, nutritional contribution and changes during cooking of the following food groups: Cereals, Pulses, Fruits and vegetables, Milk & milk products, Eggs, Meat, poultry and fish, Fats and Oils, Sugars. Major methods of food processing: Thermal (Blanching, steaming, baking, roasting, frying, drying), low temp (chilling, freezing) and microwave cooking; Advantages, disadvantages, methods to minimize nutrient losses. Role of packaging and storage in preserving nutrients. Nutritional labelling.

Module-5 (8 Hours)

FOOD PRODUCT DEVELOPMENT:

Innovation and food product development- Factors to consider (external and internal); Case studies indicating market concerns, consumer demands, societal changes, technological development, regulations. Repositioned, reformulated, new forms, new size and new packaging for product development. Post pandemic market scenario in novel food product development. FSSAI, HACCP - standards and guidelines. Health consciousness consumers, Nutritionists and Dieticians: differences, roles and professions.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Describe the basics of food and nutrients and their relationship with health.
2. Develop balanced diet for various age groups.
3. Correlate causes and prevention for nutritional diseases.
4. Demonstrate the techniques of food processing, preservation and novel food product development.
5. Detail the needs of nutrition as a career option.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a

maximum of 3 sub-questions), **should have a mix of topics** under that module.

3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Food Science by Potter, Norman. M. and Hotchkiss, Jospeh. N. 5th e book edition, CBS Publishers, 2021.
- Foods: Facts and Principles by Manay, S and Shadakshara Swamy M. 4th Ed. New Age Publishers. 2004.
- Food Science by B. Srilakshmi, New Age Publishers, 2002.
- Food Processing Principles and Applications by Ramaswamy H and Marcott M. CRC Press. 2006.
- Food Chemistry by Meyer. New Age Publishers, 2004.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource OLRs:

- https://www.mhbacademy.com/
- https://www.udemy.com/topic/nutrition/
- https://www.coursera.org/browse/health/nutrition
- https://www.edx.org/learn/nutrition
- https://www.oxfordhomestudy.com/courses/nutrition-certificate-programs-online/free-online-nutrition-courses
- https://onlinecourses.swayam2.ac.in/cec19_ag02/preview
- https://teachers-ab.libguides.com/c.php?g=710613&p=5063458
- https://www.coursera.org/courses?query=food%20science

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Demos on type of diets and food packaging in classes (by groups of students)
- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered with ill effects of dieting, food

NANOBIOTECHNOLOGY		Semester	VI
Course Code	**BBT654C**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To understand the principles and applications of nano-biotechnology.
- To learn the synthesis and characterization techniques in nanobiotechnology.
- To comprehend the current applications of nanobiotechnology in diagnostics and therapeutics, knowing the safety issues

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION:

A Brief History, Definition of nanotechnology, Nanobiotechnology v/s Bionanotechnology, Bottom-Up versus Top-Down approaches; Methods of synthesis of nanoparticles – Physical (bead mill, laser ablation) chemical (sol-gel, precipitation, chemical reduction) and biological (use of microbes, enzymes, plant materials), parameters affecting nanoparticle growth, shape, size and structure. Structure-property relationships in materials, Nanolithography-UV and electron beam. Fabrication in Soft Materials: Hydrogels/PDMS/other polymers for biological applications

Module-2 (8 Hours)

NANOMATERIALS AND THEIR CHARACTERIZATION :

Fullerenes - Buckyballs, carbon nanotubes, Carriers, Dendrimers, Nanoparticles, Nanocomposites, Nanoshells, Quantum Dot, Principle, Instrumentation and applications of UV, FTIR, Raman shift, Surface Plasmon resonance (SPR), SEM, TEM, Atomic force microscopy Dynamic light scattering (DLS), XRD.

Module-3 (8 Hours)

NANOMOLECULAR DIAGNOSTICS:

Rationale of Nanotechnology for molecular diagnostics, Bio-functionalization methods, Nanoparticles like Gold, Quantum Dots, and Magnetic Nanoparticles in diagnostics, Bio-nanohybrids-with relevant applications. Nanopore technology, Nano arrays. Nanobiosensors: cantilever, carbon nanotube, nanowires. Pathogen detection by magnetic nanoparticle-based techniques. Miniaturized devices in nanobiotechnology - types and applications, lab on a chip concept.

Module-4 (8 Hours)

BIOMEDICAL AND LIFE SCIENCES APPLICATIONS:

Introduction to nanomedicine, nanocapsules, nanorobots, nanopharmacology. Use of micro needles and nanoparticles for local highly controlled drug delivery. Nanotechnology products and applications in ocular, oncology, neurology and cardiology. Functions and applications of DNA based nanostructures, Biomimetic fabrication of DNA based metallic nanowires and networks, Biomolecular nanomotors (ATP synthase

complex and flagella).

Module-5 (8 Hours)

ETHICS, SAFETY AND REGULATORY ASPECTS :

Introduction, ethical, legal and social implications of Nano medicine, and nano-bio-products, Safety concerns- Health Risks, and Challenges. Assessment of the toxic effects of nanoparticles based on in-vitro & In-Vivo experiments. Case studies. Environmental effects, public perceptions, Guidelines and regulatory aspects and evaluation of Nanopharmaceuticals in India, Europe and USA, challenges and risks associated with Markets for Nano medicine. Trends in Research and education.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Elaborate the principles and applications of nano-biotechnology.
2. Apply the synthesis and characterization techniques in nanobiotechnology.
3. Demonstrate the current applications of nanobiotechnology in diagnostics and therapeutics, knowing the safety issues

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- Nanoparticle technology handbook by Masuo Hosokawa, Elsvier, 2012.
- Nanotechnology in biology and medicine by Tuvan ho Dhin, CRC press, 2006.
- The handbook of nanomedicine by Kewal K. Jain, Humana press, 2008.
- Essential of nanotechnology by Jereme Ramsden, Ventus publishing, 2006.
- Nano Biotechnology Protocols by Sandra J. Rosenthal and David W. Wright, Humana press, 2005.

- Nano biotechnology Human Health and the Environment, by Alok Dhawan, Sanjay Singh, Ashutosh Kumar Rishi Shanker, CRC Oress, 2018.
- The nanobiotechnology handbook by Yubing Xie, CRC press, 2013.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.udemy.com/course/nanotechnology
- https://www.coursera.org/courses?query=nanotechnology
- https://stores.biotecnika.org/products/nanobiotechnology-certification-course
- https://www.edx.org/learn/nanotechnology
- https://www.classcentral.com/subject/nanotechnology
- https://www.youtube.com/watch?v=ebO38bbq0_4
- https://www.coursera.org/lecture/nanotechnology/welcome-to-the-course-apP2j
- https://www.digimat.in/nptel/courses/video/102107058/L03.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Online tools for surprise quizzes
- Collection of case studies via Newspapers/Journal articles, on topics covered
- Group discussions on recent advancements
- Class Presentations and discussions of research articles from publications

ECOLOGY AND ECOSYSTEM		Semester	VI
Course Code	**BBT654D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To distinguish among allied scientific disciplines (environmental science, conservation biology, restoration ecology, and environmental engineering) and compare their purposes with that of ecology.
- To describe the ecosystem services important to human ecology.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION:

Concept of ecology and ecosystem, Structure and function of ecosystem; Basic concept of population and community ecology; ecological succession. Characteristic features of the following: a) Forest ecosystem b) Grassland ecosystem c) Desert ecosystem d) Aquatic ecosystems (ponds, streams, lakes, wetlands, rivers, oceans, estuaries), Case studies.

Module-2 (8 Hours)

ECOLOGY:

Basic concepts, scope, multidisciplinary nature and relevance; Ecosystem concept, organization and significance; Biosphere concept, organization and significance; Cybernetic nature of ecosystems. Factors affecting ecosystem: Major environmental factors (biotic and abiotic) influencing organisms in various ecosystems; Concept of limiting factors; Liebig's law of the minimum; Shelford law of tolerance. Case studies.

Module-3 (8 Hours)

ENERGY FLOW AND TROPHIC DYNAMICS:

Energy flow in ecosystems; Concept of trophic dynamics and trophic cascade; Food chains, food webs and trophic levels; Ecological pyramids; Energy transfer; Ecological efficiencies; Biogeochemical cycles (water, oxygen, carbon, nitrogen, phosphorus and sulphur). Case studies.

Module-4 (8 Hours)

POLLUTION AND ITS EFFECTS ON ECOLOGY:

Air pollution from primary and secondary pollutants; Ozone chemistry and ozone layer depletion; Acid rain and its impact on ecosystems; Water pollution: Types, sources and effects of water pollution, concept of DO, BOD and COD; Eutrophication, oil pollution and thermal pollution; Land and soil pollution: Coal mine and it's environmental impact and restoration; Salt affected soils and their management; Acid soil and its management; Fertilizers and soil pollution; Pesticide pollution of soil; Pesticides, environment and human health. Case studies.

Module-5 (8 Hours)

PRODUCTIVITY:

Primary productivity; concept, methods of estimation, world patterns of primary productivity and Man's exploitation of primary productivity; Secondary productivity; concept, methods of estimation, world patterns of secondary productivity, and man's exploitation of secondary productivity. Evolutionary Ecology: Natural Selection and its ecological significance, modern concept of species, adaptation; Significance of mutation, isolating mechanism and ecological role and other evolutionary processes in ecology. Case studies.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. Understand the importance of the ecosystem, different types and their impact on the environment.
2. Correlate the energy flow in ecosystems to maintain ecological balance.
3. Analyse the impact of Pollution on the Ecosystem.
4. Appreciate the ethical context of environmental issues and the links between human and natural systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- The Science of Ecology by R Brewer; Saunders College Pub., 1994.
- Environmental Science (9th edn.) by Dash, M.C.and Dash, S.P. Jones and Barlett Learning. 2009.
- Fundamentals of Ecology (3rd edn.) byKormondy, E. J., Tata McGraw-Hill Publishing Co., New Delhi.1996.
- Concepts of Ecology (4th edn.) by Krebs, C. J., Prentice-Hall of India Pvt. Ltd. 1985.
- Ecology: The Experimental Analysis of Distribution and Abundance by Charles J. Krebs, Pearson Publications, 2014.
- Introduction to Environmental Health by Bridgman, H., Springer Publishing Co. Ltd. New York. 1990.
- Global Air Pollution by Bhattacharjee, K., Mazumder. M.R. and Gupta-Bhattacharjee S. John Wiley and Sons. 2006.
- A Text Book of Palynology (Basic & Applied) by Chitkara, M.G. New Central Book Agency (P) Ltd. Kolkata. 1998.
- Encyclopedia of Ecology, Environment and Pollution by M G Chitkara. APH Publishing Corporation. 1998.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.edx.org/learn/ecosystems
- https://www.coursera.org/courses?query=ecology
- https://www.futurelearn.com/subjects/nature-and-environment-courses/ecology
- https://www.classcentral.com/subject/ecology
- https://www.open.edu/openlearn/nature-environment/the-environment/environmental-studies/introducing-theenvironment-ecology-and-ecosystems/content-section
- https://teachers-ab.libguides.com/c.php?g=710613&p=5063458
- https://www.coursera.org/courses?query=food%20science

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered
- Discussion on recent advancements and case studies

BIOKINETICS LAB		Semester	VI
Course Code	**BBTL606**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Total hours	100	Total marks	100
Credits	01	Exam Hours	3
Examination type (SEE)	Practical		

Course objectives:

- Describe the fundamental concepts of kinetics of reaction and the Enzyme kinetics.
- Understand the rate of reaction for different reactors, ethical responsibilities that come with conducting experiments and communicating data.
- Apply the design equations for predicting the reactor performance.
- Generate the RTD data to identify non idealitites in different reactor configuration

Sl.NO	Experiments
1	Determination of V_{max} & K_m of human salivary α- amylase
2	Time course of salivary α- amylase activity
3	Effect of pH on human salivary α- amylase activity
4	Effect of temperature on human salivary α- amylase activity
5	Effect of organic solvents on salivary α- amylase activity
6	Effect of Inhibitor on human salivary α- amylase activity
7	Effect of pH on free and immobilised α- amylase activity
8	Effect of starch concentration on free and immobilised α- amylase activity
	Demonstration Experiments
9	Mixed Flow Reactor
10	Plug Flow Reactor
11	Isothermal Batch Reactor
12	RTD in Mixed Flow Reactor and Plug Flow Reactor

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Understand the basics of instrumentation, classification, various input function of automatic process control system
2. Classify and characterize the transducers based on critical process parameters
3. Demonstrate the working of First order systems and controllers.
4. Calculate and Analyze the output obtained from different systems and perform theoretical validation

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be

decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- Enzyme Technology : Pacemaker Of Biotechnology, Krishna Prasad Nooralabettu, PHI Learning, New Delhi, 2011
- Biochemical Engineering Fundamentals by Bailey and Ollis, Mcgraw Hill.
- Bioprocess Engineering by Shule and Kargi Prentice Hall.
- Wolf R. Vieth, Bioprocess Engineering – Kinetics, Mass Transport, Reactors and Gene Expression. A Wiley – Interscience Publication.
- Smith J.M. Chemical Engineering Kinetics, McGraw Hill.
- Carbery J A. Chemical and Catalytic Reactor Engineering, McGraw Hill.
- Enzymes in Industry: Production and Applications: W. Gerhartz, VCH Publishers, New York.
- Enzyme Technology by M.F. Chaplin and C. Bucke, Cambridge University Press, Cambridge.
- Enzymes: Dixon and Webb. IRL Press.
- Principles of Enzymology for Technological Applications by B Heinemann Ltd, Oxford Press

BIO-INNOVATION AND START-UPS		Semester	VI
Course Code	**BBT657A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	1:0:0:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	1
Examination type (SEE)	Theory		

Course objectives:

- To understand the fundamentals of bioinnovation and entrepreneurship.
- To learn about the start-up schemes and project management.
- To learn about innovative programmes of Indian Government.
- To understand the aspects related to bioethics, biosafety and IPR

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (3 Hours)

BIO-INNOVATION AND REGULATORY AFFAIRS:

Definition and importance of bio-innovation; Concept of Entrepreneur and Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs as innovators in economic development- Case studies; Bio-innovation to bio-business case studies from Indian context; Indian Company act for Bio business; Regulatory affairs and Regulatory bodies (FDA, DSIR, AYUSH, FSSAI)

Module-2(3 Hours)

IPR AND BIO-INNOVATION:

Significance and types of IPR in bio-innovation; Significance of patent; Patent expiry; Public education in biotechnology for informed decision-making; Ethical concerns of biotechnology research and innovation; Biosafety management; Cartagena protocol on biosafety; Biosafety concerns at the level of individuals, institutions, society, region, country and the world; Technology management- principles of technology leasing, licensing and transfer.

Module-3(3 Hours)

MAKE-IN-INDIA AND DIGITAL INDIA:

Economic and Social Significance of Make-in-India and Digital India programmes; Various focus Sectors of Make-inIndia programme; Atmanirbhar Bharat Abhiyaan- significance, five pillars and stimulus packages towards economic growth.

Module-4(3 Hours)

START-UP SCHEMES AND FUNDING AGENCIES:

Start-up schemes in Indian government; Business incubation support schemes; Successful start-ups - case study from India and Karnataka; Biotech partners-BiSEP, BIRAC, DBT, Incubation centres; Operational biotech parks in India; Role and importance of funding agencies

Module-5(3 Hours)

PROJECT MANAGEMENT AND BUSINESS PLAN:

Project and project management; Steps of project-Project Identification; Project Selection; Project Formulation and Project Appraisal; Project Report- Need and significance; contents; Errors of project report; Writing effective business plan; Feasibility study- Market, Social, Financial and Technical.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

1. Apply the principles of bio-innovation, bioethics, biosafety and IPR in the entrepreneurial journey.
2. Utilize the knowledge of start-up schemes and innovative government programmes to draft project proposal to funding agencies.
3. Assess a project activity with a work plan, budget and schedule, along with its feasibility.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

OR

MCQ (Multiple Choice Questions) are preferred for 01 credit courses, however, if course content demands the general question paper pattern that followed for 03 credit course, then

1. The question paper will have ten questions. Each question is set for 10 marks.
2. There will be 2 questions from each module. Each of the two questions under a module may or may not have the sub-questions (with maximum sub-questions of 02, with marks distributions 5+5, 4+6, 3+7).
3. The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

- Entrepreneurship Development by S.S. Khanka S. Chand &Co, 2006.
- Practical Approach to IPR by Rachana Singh Puri, IK Intl. Ltd. 2009.
- Bioethics & Biosafety by R Rallapalli & Geetha Bali, APH Publication, 2007.
- Bioethics & Biosaftey by Sateesh M K, IK Publishers, 2008.
- Intellectual Property Rights in the WTO and developing country, by Watal Jayashree, Oxford University Press 2001.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.coursera.org/courses?query=regulatory%20affairs
- https://www.ilearngira.com/courses/free-regulatory-affairs-e-learning/
- https://www.coursera.org/courses?query=startup
- https://www.digitalindia.gov.in/
- https://www.makeinindia.com/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Group discussions, debates and seminars on case studies.
- AV presentation by students (on topics as per choice of the teacher).
- Online tools for surprise quizzes.
- Collection of case studies based on research findings.
- Poster presentations on specific case studies.

BIOINSTRUMENTATION AND SERVICING LAB		Semester	VI
Course Code	**BBTL657B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Total hours	15	Total marks	100
Credits	01	Exam Hours	2
Examination type (SEE)	Practical		

Course objectives:

- Calibrate regular laboratory instruments using standard and an SOP
- Use a regular laboratory instrument to correctly determine the parameters of an unknown solution

Sl.NO	Experiments
1	Calibration and maintenance a pH meter
2	Calibration and maintenance an Electronic Balance
3	Calibration and maintenance of micropipettes
4	Calibration and maintenance of spectrophotometer
5	Servicing of simple and compound microscope
6	Validation and maintenance of autoclave
7	Validation and maintenance of hot air oven.
8	Validation and maintenance of incubator.
	Demonstration Experiments
9	DIY experiment: on servicing of lab instruments and reactors (To be designed and executed by students themselves)
10	DIY experiment: on preventive maintenance of lab instruments and reactors (To be designed and executed by students themselves)
11	DIY experiment: on calibration of lab instruments and reactors (To be designed and executed by students themselves)
12	DIY experiment: on volumetric calibration of glasswares (To be designed and executed by students themselves)

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Develop a strategy to maintain regular laboratory instruments using standard and an SOP
2. Find solutions to service laboratory instruments to correctly determine the parameters.

E-resources:

- https://www.youtube.com/watch?v=qbKnW42ZM5c
- https://www.youtube.com/watch?v=DAwXk77DXUM
- https://www.digimat.in/nptel/courses/video/108108099/L11.html

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- Laboratory Instrumentation and Techniques, Mathew Olaniyan, Create Space Independent Publishing Platform 2017
- How to Use the Microscope: Being Practical Hints on the Selection and Use of That Instrument; Intended for Beginners (Classic Reprint), FB&C Limited, 2015.
- Textbook of Quality Assurance, By Akansha Shakya, BFC Publications, 2022.
- Calibration Handbook of Measuring Instruments, By Alessandro Brunelli, ISA, 2017
- Textbook of Diagnostic Microbiology, Saunders 1995

MODELLING AND SIMULATION IN BIOLOGY LAB		Semester	VI
Course Code	**BBTL657C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Total hours	15	Total marks	100
Credits	01	Exam Hours	2
Examination type (SEE)	Practical		

Course objectives:

- develop logical understanding of the subject.
- create the ability to model, solve and interpret Molecular Modelling, Drug Design, Chemo-informatics, Bio-Programming and Research Methodology,
- Use functions of complex variable which helps in solving many biological problems

Sl.NO	Experiments
1	Small Molecule sketching using Marvin sketch and bond optimization in 2D & 3D format (SDF, MOL2 file formats).
2	Chemical structure representation, Smiles, Chemical Structure similarity, Generation of 3D structures from 2D representations,3D structure similarity.
3	Exploration of Chemo-informatics Software- AMBER, ArgusLab 3.0, BABEL, Chemos, VEGA.
4	Advanced Visualization Software and 3D representations with VMD and Rasmol (Coordinate generations and inter-conversions, Secondary Structure Prediction , Fold Recognition, ab initio method (Rosetta Server).
5	Homology based comparative protein modelling and Energy minimizations, Validation of models.
6	Molecular Dynamics Simulation- Protein dynamics using Gromacs (Protein-ligand complex MD simulation)
7	Protein-peptide docking and Molecular dynamic simulations of a peptide
8	Identifying Differentially Expressed Genes from RNA-Seq Data MATLAB & Simulink.
	Demonstration Experiments
9	Visualize NGS Data Using Genomics Viewer App
10	Gene Expression Profile Analysis, Network Analysis and Visualization
11	PK/PD Modeling and Simulation to Guide Dosing Strategy for Antibiotics
12	Simulate the Glucose-Insulin Response glucose-insulin system in normal and diabetic humans. (SimBiology model) and Estimation of the Bioavailability of a Drug

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

1. Use Cheminformatics approaches, Molecular modelling and Molecular Dynamics Simulation, and Docking for research and industrial purpose.
2. Analyse different aspects of drug discovery process of academic research and industrial interest.

E-resources:

- https://www.youtube.com/watch?v=dchHehGDfkc
- https://www.meche.engineering.cmu.edu/faculty/zhang-computational-bio-modeling-lab.html

- https://www.youtube.com/watch?v=FLM1xPOiaSs
- https://www.mathworks.com/videos/modeling-biology-with-simbiology-an-introduction-for-igem-teams-81817.html

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks

and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- BIOLOGICAL MODELING AND SIMULATION: A Survey of Practical Models, Algorithms, and Numerical Methods, Russell Schwartz, The MIT Press, Cambridge, Massachusetts, London, England, 2008.
- Dynamic Systems Biology Modeling and Simulation, Joseph DiStefano, Academic Press, 2013

GOOD MANUFACTURING AND LABORATORY PRACTICES		Semester	VI
Course Code	**BBT657D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	1:0:0:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	1
Examination type (SEE)	Theory		

Course objectives:

- To Understand the basics of GMP and GLP
- To deduce the importance of regulatory compliance in BT related industries
- To Understand the validation of processes and products in BT industries (via case studies)

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (3 Hours)

INTRODUCTION:

Meaning, History of GMP and GLP. Scope of coverage of GMP and GLP. Key areas: GMP- for production and process focus, GLPs- for research and study focus. WHO guidelines.

Module-2 (3 Hours)

GOOD MANUFACTURING PRACTICE:

Compliance, cGMP (current GMP), its role for under manufacturing (conditions of lighting, hygiene, storage, equipment maintenance, and separation of substances to avoid contamination). Application of GMP for production and, ethical dimension in manufacturing and control.

Module-3 (3 Hours)

GOOD LABORATORY PRACTICES:

Compliance. Purpose for safeguarding the data integrity. Key areas: monitoring (conditions, processes, documentation) and archiving of studies performed in labs. Regulation for researching or marketing drugs for humans and animals, human cells/tissues, food color additives, perfumes, medical devices, biologics, and pesticides.

Module-4 (3 Hours)

INTERNATIONAL COUNCIL ON HARMONISATION GUIDELINES (ICH):

Introduction, usage, National and international regulatory authorities and their function, Regulation of Clinical and Preclinical Studies, Formulation Production Management.

Module-5 (3 Hours)

VALIDATION:

Need, scope, importance, limitations, types of validation (in Pharma and food industry), Validation of analytical procedures, Cleaning and disinfection.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

1. Apply principles of biology & basic management to comprehend the aspects of GLP, GMP & GCP
2. Identify situations wherein deviations in regulatory compliance have occurred on the basis of case examples/studies

3. Correlate & distinguish between the compliance requirements in the context of GLP, GMP & GCP.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

OR

MCQ (Multiple Choice Questions) are preferred for 01 credit courses, however, if course content demands the general question paper pattern that followed for 03 credit course, then

1. The question paper will have ten questions. Each question is set for 10 marks.
2. There will be 2 questions from each module. Each of the two questions under a module may or may not have the sub-questions (with maximum sub-questions of 02, with marks distributions 5+5, 4+6, 3+7).
3. The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

- cGMP starter guide: Principles in Good Manufacturing Practices for Beginners, Emmet P. Tobin, CreateSpace Independent Publishing Platform, April 2016.
- Good Manufacturing Practices for Pharmaceuticals: GMP in Practice, B Cooper, Createspace Independent Publishing Platform, July 2017
- Drug regulatory affairs, CBS publication, Gajendra Singh, Gaurav Agarwal and Vipul Gupta, 2005.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource Features of Risk

- https://www.pharmalessons.com/free-courses/gmptraining/
- https://www.onlinegmptraining.com/
- https://www.udemy.com/course/basic-good-manufacturing-practices-gmp/
- http://82.118.225.37/~borislav/crotraining/free-training/free-good-manufacturing-practices-gmp-training/
- ICH guidelines available in the official website "https://www.ich.org".
- ICH guidelines available in the official website "https://www.ich.org".
- Design of experiments (DoE) in pharmaceutical development, N Politis S, Colombo P, Colombo G, M Rekkas D., Drug Dev Ind Pharm. 2017 Jun;43(6):889-901

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Group Discussion of Case studies
- Model Making and poster presentations