RAMAIAH
Institute of Technology

CURRICULUM

for the Academic year 2021 – 2022

DEPARTMENT OF BIOTECHNOLOGY

VII & VIII SEMESTER B.E

RAMAIAH INSTITUTE OF TECHNOLOGY
(Autonomous Institute, Affiliated to VTU)
Bangalore – 560054.

About the Institute

Dr. M. S. Ramaiah a philanthropist, founded 'Gokula Education Foundation' in 1962 with an objective of serving the society. M S Ramaiah Institute of Technology (MSRIT) was established under the aegis of this foundation in the same year, creating a landmark in technical education in India. MSRIT offers 17 UG programs and 15 PG programs. All these programs are approved by AICTE. All eligible UG and PG programs are accredited by National Board of Accreditation (NBA). The institute is accredited with **'A^{+}' grade by NAAC in March 2021** for 5 years. University Grants Commission (UGC) & Visvesvaraya Technological University (VTU) have conferred Autonomous Status to MSRIT for both UG and PG Programs since 2007. The institute is a participant to the Technical Education Quality Improvement Program (TEQIP), an initiative of the Government of India. The institute has 380 competent faculty out of which 60% are doctorates. Some of the distinguished features of MSRIT are: State of the art laboratories, individual computing facility for all faculty members, all research departments active with sponsored funded projects and more than 300 scholars pursuing Ph.D. To promote research culture, the institute has established Centre of Excellence for Imaging Technologies, Centre for Advanced Materials Technology, Centre for Antennas and Radio Frequency systems (CARFS), Center for Cyber Physical Systems & Schneider Centre of Excellence. **M S Ramaiah Institute of Technology has obtained "Scimago Institutions Rankings" All India Rank 65 & world ranking 578 for the year 2020.**

The Entrepreneurship Development Cell (EDC) and Section 8 company "Ramaiah Evolute" have been set up on campus to incubate startups. **M S Ramaiah Institute of Technology secured All India Rank 8th for the year 2020 for Atal Ranking of Institutions on Innovation Achievements (ARIIA), by MoE, Govt. of India.** MSRIT has a strong Placement and Training department with a committed team, a good Mentoring/Proctorial system, a fully equipped Sports department, large air-conditioned library with good collection of book volumes and subscription to International and National Journals. The Digital Library subscribes to online e-journals from Elsevier Science Direct, IEEE, Taylor & Francis, Springer Link, etc. MSRIT is a member of DELNET, CMTI and VTU E-Library Consortium. MSRIT has a modern auditorium and several hi-tech conference halls with video conferencing facilities. The institute has excellent hostel facilities for boys and girls. MSRIT Alumni have distinguished themselves by occupying high positions in India and abroad and are in touch with the institute through an active Alumni Association.

As per the National Institutional Ranking Framework (NIRF), MoE, Government of India, M S Ramaiah Institute of Technology has achieved 65th rank among 1143 top Engineering institutions of India for the year 2021 and is 1st amongst the Engineering colleges affiliated to VTU, Karnataka.

About the Department

The department of Biotechnology established in 2002 offers a four year B.E. Biotechnology Program with an intake of 60 students and a two years PG Program, M.Tech in Biotechnology with an intake of 18 students. The department is a recognized Research Centre by VTU, Belgaum, offering M.Sc (Engg.) by research and PhD programs. The Department also offers a Post Graduate Diploma in Biopharmaceutical Technology under the Biotechnology Skill Enhancement Programme (BiSEP), supported by the Department of IT & BT, Government of Karnataka with a sanctioned budget of Rs. 162.5 Lakhs.

The department has 14 faculty members, of them 13 are PhD holders. The faculty members have competence in Core areas of Biotechnology viz. Food and Agricultural Biotechnology, Health and Medical Biotechnology & Environmental Biotechnology and Bioprocess Engineering. The department research is focused towards these core areas and funded by national and state funding agencies like DST, KBITS, AICTE, VGST, VTU and RGUHS.

The department faculties and students have publications in Scopus indexed peer reviewed journals of Elsevier, Taylor and Francis, Springer etc. Faculties have published book chapters and presented their research work in national and international conferences. A sizeable number of students have pursued their higher education at various premier institutes in India and abroad after having qualified GATE, GRE & TOEFL exams. The students undergo internships at various premier institutes in India and abroad. Several students receive the Indian Science Academies Summer Internship every year. The department has collaborations with some of the leading biotech industries like: Biocon, Hindustan Unilever Limited (HUL), Bristol Myers Squibb India Ltd, Novozymes South Asia Pvt Ltd, Himalaya Drug Company, Beckman Coulter, Sami Labs, Sartorius AG, Genotypic Technology, Aristogene Biosciences, GangaGen, Connexios Life Sciences, Acquity Labs & Celest Pharma.

VISION OF THE INSTITUTE

To be an Institution of International Eminence, renowned for imparting quality technical education, cutting edge research and innovation to meet global socio-economic needs.

MISSION OF THE INSTITUTE

RIT shall meet the global socio-economic needs through

1. Imparting quality technical education by nurturing a conducive learning environment through continuous improvement and customization.
2. Establishing research clusters in emerging areas in collaboration with globally reputed organizations.
3. Establishing innovative skills development, techno-entrepreneurial activities and consultancy for socio-economic needs.

QUALITY POLICY

We at Ramaiah Institute of Technology strive to deliver comprehensive, continually enhanced, global quality technical and management education through an established Quality Management System complemented by the synergistic interaction of the stakeholders concerned

DEPARTMENT VISION

To be a leading Biotechnology Engineering department that imparts quality technical education with strong research component, to develop solutions in the field of food, health and environment.

DEPARTMENT MISSION

To provide quality technical education in a conducive learning environment to produce professionals, researchers with a zeal for lifelong learning and a commitment to society.

Programme Educational Objectives (PEOs) of the program

PEO 1: To impart strong foundation in mathematics, basic and engineering sciences contributing to Biotechnology.

PEO 2: To produce graduates who can pursue higher education and research in biotechnology and allied fields.

PEO 3: To produce graduates with an ability to design, develop and implement research projects and apply to solve problems related to areas of biotechnology.

PEO 4: To provide opportunities to students to work in multidisciplinary teams with professional ethics, good communication, leadership skills and commitment to society.

Programme Outcomes (PO): As per NBA guidelines

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO)

1. To have thorough grounding in Mathematics, Chemistry and Biology.
2. To be proficient in the principles and practices of advanced biological sciences.
3. To apply engineering principles to biological systems to solve Biotechnology problems.

Curriculum Course Credits Distribution
Batch 2018-2022

Category	Semester								Total
	I	II	III	IV	V	VI	VII	VIII	
Basic Sciences (BSC)	9	8	4	4					25
Engineering Sciences (ESC)	11	10							21
Humanities, Social Sciences and Management (HSMC)		2			3		3		8
Professional Courses-Core (PCC)			21	21	15	11	10		78
Professional Courses-Elective (PEC)					3	6	6		15
Other Open Elective Courses (OEC)					3	3			6
Seminar (SE), Project Work (PROJ), Internship (IN)						4	1	17	22
Total	**20**	**20**	**25**	**25**	**24**	**24**	**20**	**17**	**175**

SCHEME OF TEACHING

VII Semester						
Sl. No.	**Course Code**	**Course**	**Credits**			
			L	**T**	**P**	**Total**
1.	BT71	Bioprocess Modelling and Equipment Design	3	1	0	4
2.	BT72	Bioprocess Control and Automation	3	1	0	4
3.	BT73	Plant Design, Economics, Entrepreneurship and Management	3	0	0	3
4.	BTE74X	Professional Elective-IV	3	0	0	3
5.	BTE75X	Professional Elective-V	3	0	0	3
6.	BTL76	Bioprocess Simulation Lab	0	0	1	1
7.	BTL77	Bioprocess Control and Automation Lab	0	0	1	1
8.	BTSE	Seminar	0	0	1	1
Total			**15**	**2**	**3**	**20**

Professional Elective-IV						
1.	BTE741	Pharmaceutical Biotechnology	3	0	0	3
2.	BTE742	Drug Design and Development	3	0	0	3
3.	BTE743	Metabolic Engineering	3	0	0	3
Professional Elective-V						
1.	BTE751	Animal Biotechnology	3	0	0	3
2.	BTE752	Medical Biotechnology	3	0	0	3
3.	BTE753	Biomedical Engineering	3	0	0	3

VIII Semester						
Sl. No.	**Course Code**	**Course**	**Credits**			
			L	**T**	**P**	**Total**
1.	BTIN	Internship	0	0	3	3
2.	BTP	Project Work	0	0	14	14
Total			**0**	**0**	**17**	**17**

AICTE Activity Points to be earned by students admitted to BE program (For more details refer to Chapter 6, AICTE, Activity Point Program, Model Internship Guidelines):
Every regular student, who is admitted to the 4-year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. Students entering 4 years Degree Program through lateral entry are required to earn 75 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the student's 8th Semester grade card. The activities to earn the points can be spread over the duration of the course. However, minimum prescribed duration should be fulfilled. Activity Points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression. In case student fail to earn the prescribed activity points; eight semester Grade Card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the Eight Semester grade card.

BIOPROCESS MODELLING AND EQUIPMENT DESIGN

Course Code	**:** BT71	**Credits:** 3:1:0
Contact Hours	**:** 42L+14T	
Prerequisite(s)	**:** Heat and Mass transfer and Bioreaction Engineering	
Course Coordinator(s)	**:** Dr. Samrat K & Dr. Chandraprabha M N	

UNIT-I

Bioprocess Modelling

Definitions, Conservation Principle, Model Representation, Types of Modelling Equations, Types of Mathematical Models, Use of Simulated Process Model, Modelling and Assessment in Process Development, Process and fermentation models for development of processes for bioproducts and biopharmaceuticals, Sustainability assessment of bioprocess.

UNIT-II

Bioprocess Simulation:

Solving linear and nonlinear algebraic equations, ordinary differential equations, partial differential equations. Design and analysis of experiments, Machine learning approaches in process simulation and optimization.

UNIT-III

Introduction to Process Design:

Nature of design, design factors, degrees of freedom, design variables, optimization, nature of process equipment, general design procedure, basic considerations in design, standards, codes, and their significance, equipment classification and their selection, design pressure, design temperature, design stress, design loads, review of fabrication techniques, economics and environmental considerations in design procedure. Piping design. Materials of construction. Sketching techniques, Equipment symbols, Process Flow sheet development for production of citric acid, penicillin, monoclonal antibodies, enzymes etc. Safety considerations in design.

UNIT-IV

Design of Bioreactors and Heat Exchangers:

Bioreactors: Overview, basic design equation for bioreactors. Functional and mechanical design of bioreactors. Heat exchangers: Introduction to heat exchanger, Functional design and mechanical design of double pipe heat exchangers, Shell and tube heat exchangers, cooling coils, jacked vessels.

UNIT-V

Design of Mass transfer Equipment:

Functional and mechanical design of tray and bubble column distillation units, evaporators, absorbers, crystallizers, dryers, extraction systems.

Text Books

1. Amiya K Jana, Chemical Process Modelling and Computer Simulation, 3rd edition, Prentice Hall India, 2017.
2. Michael B. Cutlip, Mordechai Shacham. Problem Solving in Chemical and Biochemical Engineering with POLYMATH, Excel, and MATLAB, Prentice Hall, 2008.
3. S Thakore, B Bhatt. Introduction to Process Engineering and Design, 2nd edition McGraw Hill Education, 2017.

Reference Books

1. William M. (Bill) Huitt, Bioprocessing Piping and Equipment Design: A Companion Guide for the ASME BPE Standard, John Wiley & Sons, Inc., 2016.
2. Ashok Kumar Verma, Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, CRC Press, 2017.
3. Binay Kanti Dutta, Mathematical Methods in Chemical and Biological Engineering, CRC Press, 2017.
4. Simant R. Upreti, Process Modeling and Simulation for Chemical Engineers: Theory and Practice, John Wiley & Sons, Inc., 2017.
5. Coulson JM, Richardson JF, Sinnott RK and Gavin Towler (2015). Chemical Engineering Design, Vol. 6, fifth edition, Butterworth-Heinemann press.
6. Tapobrata Panda., Bioreactors: Analysis and Design, 1st Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2011.

Course outcome (COs):

On completion of this course, student will have improved ability to:

1. Develop model equations for given bioprocess systems from the problem statement (PO-1, 2, 3, 5 PSO-3)
2. Demonstrate the ability to solve bioprocess models and use of process simulation (PO- 2, 3, 5 PSO-3)
3. Understand the basic aspects of bioprocess equipment design (PO- 2, 3, 4; PSO-2, 3)
4. Design bioreactors and heat transfer equipment for bioprocess operations (PO- 2, 3, 4, 5; PSO-3)
5. Design mass transfer equipment employed in bioprocess industries (PO- 2, 3, 4, 5; PSO-3)
6. Design mass transfer equipment employed in bioprocess industries (PO- 2, 3, 4, 5; PSO-3)

BIOPROCESS CONTROL AND AUTOMATION

Course Code	**:** BT72	**Credits:**	3:1:0
Contact Hours	**:** 42+14		
Prerequisite(s)	**:** Bioreaction Engineering		
Course Coordinator(s)	**:** Mr. M Gokulakrishnan & Dr. Chandraprabha M N		

UNIT-I

Introduction: Biochemical process, Industrial control problem- example, variables of a process, control configuration types, hardware for a process control system, Process characteristics, Laplace transform, Monitoring and control of bioreactors, Biochemical Reactor Instrumentation, principles of measurement and classification of process control instruments- physical, chemical and bio-chemical parameters, Introduction to flow, pressure, temperature and level measurements, sensors for medium and gases. Online and offline measurements of cells, substrates and products.

UNIT-II

Systems and Process Dynamics: Development of mathematical model- CSTR, I order system-examples, mercury in glass thermometer, level, mixing. Linearization, I order system in series, interacting and non-interacting systems. Second order system with under damping, derivation of transfer function for various systems, dead time, response of I and II order over damped and under damped systems, to step, ramp, impulse (pulses) and sinusoidal changes. Numericals.

UNIT-III

Controllers and Final Control Elements: Controllers-discontinuous and continuous, two position control, proportional, derivative, integral control; proportional Reset (integral) (P+I); proportional +rate (derivative (P+D); proportional+reset+rate controller (PID), actuators, positioners, valve body, valve plugs, Valve characteristics, final control elements. Transfer functions for controllers and final control element, Numericals.

UNIT-IV

Transient Response of Closed Loop Systems: Block diagram reduction, block diagram & Transfer functions for servo and regulator problems. Transient response of I and II order processes for set point changes and load changes with proportional, PI, PD and PID controllers, Numericals.

UNIT-V

Stability of Closed Loop Control Systems Concepts of stability, stability criteria, Routh test for stability, Root-locus method, Bode plots and stability criteria, tuning of controllers, Numericals.

Text Books

1. Donald R. Coughanowr (2013) Process Systems Analysis and Control, McGraw-Hill, 3rd ed.,
2. Pauline MD (2013) Bioprocess engineering principles, 2nd edition, Reed Elsevier India.
3. George Stephanopoulos (2009) Chemical process control 1st ed., Prentice Hall of India.

Reference Books

1. Bailey and Ollis (2010) Biochemical engineering fundamentals. McGraw Hill (2nd Ed)
2. Shuler and Kargi (2002) Bioprocess engineering, 2nd ed., Prentice Hall.
3. Tarun K Ghosh (ed.) (1984) Biotechnology and bioprocess engineering: Proceedings, VII international biotechnology symposium. Delhi.
4. Wankat PC (2005) Rate controlled separations, 1st ed., Springer.
5. Donald P Eckman (2004) Industrial Instrumentation, 1st ed., Wiley Eastern

Course outcome (COs):

1. Determine the parameters to be measured and controlled in the bioreactor. (PO – 2,3,4,9; PSO -2)
2. Predict the response of first order, second order and first order system in series for various input changes. (PO – 1,2; PSO -1)
3. Determine and analyze the different control actions involved in the bioreactor. (PO – 2,3,4,9; PSO -3)
4. Evaluate the transient response of first and second order systems for load and set point change. (PO – 2,3; PSO -3)
5. Predict the stability of the closed loop control system. (PO – 3,4; PSO -3)

PLANT DESIGN, ECONOMICS AND ENTREPRENEURSHIP

Course Code	**:** BT73	**Credits:**	3:0:0
Contact Hours	**:** 42L		
Prerequisite(s)	**:** Nil		
Course Coordinator(s)	**:** Dr. Bhavya S G & Dr. Chandraprabha M N		

UNIT-I

Process Design Development & General Design Considerations: Process design and development, flow diagrams, marketability of the product, availability of technology, raw materials, equipment design-specification and manufacturing/procurement, human resources, land and utilities, site characteristics, waste disposal, government regulations and other legal restrictions, community factors and other factors affecting investment and production costs.. Depreciation & interest and investment cost: Time value of Money, Types of Interests, Nominal and effective interest rates, Continuous interest, annuities, Perpetuities, Depreciation, Types of depreciation, Methods for estimating depreciation. Numericals.

UNIT-II

Cost Estimation: Capital Investments: Fixed capital investments including land, building, equipment and utilities, installation costs, working capital investment. Cost indius. Manufacturing costs: Direct production costs (including raw materials, human resources, maintenance and repair, operating supplies, power and other utilities, royalties, etc.,), fixed charges, Plant Overhead cost: Administration, safety and other auxiliary services, payroll overhead, warehouse and storage facilities. Numericals.

UNIT-III

Profitability, Alternative Investments and Replacements: Profitability, basis for evaluating project profitability, Methods for profitability evaluation, Alternative investments, Replacement analysis: Replacement models, Break-Even analysis: Meaning and importance of Break-even point, Break-even chart and analysis. Numericals.

UNIT-IV

Entrepreneurship: Meaning and importance, concepts of entrepreneurship, characteristics of successful entrepreneurs, classification of entrepreneurs, myths of entrepreneurship, evolution of entrepreneurship, development of entrepreneurship, stages in entrepreneurial process, role of entrepreneurs in the economic development, entrepreneurship development in India, barriers for entrepreneurship, profiles of successful entrepreneurs. Identification of business opportunities, market, technical, financial and social feasibility studies. Preparation Report: meaning of the project,

project identification, project selection, project report, need and significance of report, formulation and guidance by Planning Commission for project Report, network analysis, errors of project report, project appraisal.

UNIT-V

Small scale Industries: Definition, characteristics, need, rationale objectives, scope for SSIs. Role of SSI in economic development, advantages of SSI, Steps to start SSI, Govt. policies and support for SSI (during 5 year plans), Impact of liberalization, globalization of SSI, Effect of WTO/GATT, IPR and small Business enterprises, supporting agencies of Govt. for SSI – nature of support, objectives, types of help, Brief definitions and description of ancillary and tiny industry. IPR and small business enterprises. Institutions supporting SSIs and SBEs – central and state level institutions Women entrepreneurs: definition, environment, challenges, for women entrepreneurs, strategies for development of women entrepreneurs self help groups, Institutions and women's organization supporting women entrepreneurs, profiles of successful women entrepreneurs.

Textbooks:

1. Peters and Timmerhaus (2003) Plant Design and Economics for Chemical Engineers, 5th edition, McGraw Hill.
2. Rudd and Watson (1987) Strategy of Process Engineering, Wiley.
3. Poornima M C (2013) Entrepreneurship Development and Small Business Enterprises", 2nd edition, Pearson education.

Reference Books:

1. Vasanth Desai (2011) Dynamics of Entrepreneurial Development & Management, 6th edition, Himalaya Publishing House.
2. Khanka SS (2004) Entrepreneurship Development, S Chand & Co.
3. Norman Scarborough, Jeffrey Cornwall (2018), Essentials of Entrepreneurship and small Business Management, 9th edition, Pearson education.

Course Outcomes (COs):

On completion of this course student will have improved ability to:

1. Acquire knowledge in the design of a chemical plant. (PO–1, 2, 3; PSO-1)
2. Conduct preliminary feasibility study of the plant design assigned. (PO–2, 3, 4; PSO-2)
3. Estimate the cost analysis involved in the design of a chemical plant. (PO–4, 5; PSO-2)
4. Analyze the project profitability and alternative investments for the selection of good investment projects (PO–4, 5; PSO-2)
5. Develop entrepreneurs with substantial knowledge in engineering concepts. (PO–6, 11; PSO-3)

PHARMACEUTICAL BIOTECHNOLOGY

Course Code	**:** BTE741	**Credits:**	3:0:0
Contact Hours	**:** 42L		
Prerequisite(s)	**:** Nil		
Course Coordinator(s)	**:** Dr. Lokesh K N and Dr. P Dhamodhar		

UNIT-I

Introduction to Pharmaceutical Biotechnology: scope, Development of drugs and pharmaceutical industry-organic therapeutic agent's uses and economics, regulatory bodies, introduction to drugs and cosmetics act, overview and important schedule C and C1, schedule M, Schedule Y.

UNIT-II

Pharmacokinetics and Pharmacodynamics: Introduction to pharmacokinetics and pharmacodynamics, Drug metabolism- half-life of drugs, physico chemical principles, Biotransformation/pharmacokinetic studies, elimination and distribution of protein therapeutics, pharmacodynamics principles.

UNIT-III

Recent Advances in Pharmaceutical Biotechnology: Introduction to nutraceuticals, edible vaccines, Introduction to Health Bioinformatics, pharmacogenomics. Commercially available important diagnostic kits, diagnostic kits for detection of blood sugar, HIV, Malaria etc, recent advances in diagnostic kits.

UNIT-IV

Manufacturing Principles: Manufacturing facilities, Clean room concept introduction to recombinant DNA technology and production of important therapeutic biopharmaceutical like haemopoietic growth factors (interleukins, erythropoietin's), therapeutic hormones (insulin, human growth factor) and blood products.

UNIT-V

Formulations of Biopharmaceutical, Analysis and Control: Manufacturing facilities, excipients used in parental formulations, shelf life of protein based pharmaceuticals, delivery of protein (rate controlled, target specific, site specific, soluble carrier system etc) Analytical methods for the tests for various drugs and pharmaceuticals, different packaging techniques, quality control.

Textbooks:

1. Heinrich Klefenz (1995) Industrial Pharmaceutical Biotechnology, Wiley-VCH.
2. Gary Walsh (2013) Biopharmaceuticals: Biochemistry and Biotechnology, 2nd Edition, John Wiley & Sons, Inc.

Reference Books:

1. Gregory Bock, Dalia Cohen, Jamie Goode, Novartis and J. Craig Venter (2001) From Genome to Therapy: Integrating New Technologies with Drug Development, John Wiley & Sons, Inc.
2. Susanna Wu-Pong, Yongyut Rojanasakul, and Joseph Robinson (2006) Biopharmaceutical Drug Design and Development, Humana Press.
3. Herbert A Kirst, Wu-Kuang Yeh, Milton J (2001) Enzyme technologies for pharmaceutical and biotechnological applications, Marcel Dekker, Inc.

Course Outcomes (COs):

On completion of this course student will have improved ability to: -

1. Correlate the importance of Pharmacy with other basic science for development of novel therapeutics and diagnostics. (PO-2, 5, 12; PSO-1,3).
2. Assess pharmacokinetic and Pharmacodynamic profile of new drug candidates. (PO-, 2, 3, 5; PSO-3).
3. Comprehend the principles of immunodiagnostics or other molecular biological tools for disease management. (PO-2, 3, 5; PSO-2).
4. Apply GMP / GLP guidelines in development or processing of Biopharmaceuticals. (PO-2, 3, 4; PSO-2).
5. Competent to serve in Pharmaceutical Industry/clinical research organization (CRO). (PO-4, 5, 7, 9, 10, 11; PSO-1, 3).

DRUG DESIGN AND DEVELOPMENT

Course Code	**:** BTE742	**Credits:**	3:0:0
Contact Hours	**:** 42L		
Prerequisite(s)	**:** Genomics, Proteomics & Bioinformatics		
Course Coordinator(s)	**:** Dr. Krishna Murthy T P & Dr. K N Lokesh		

UNIT-I

Drug discovery: Introduction to Drug design and development pathway. Pharmacokinetics: Drug absorption, Drug distribution, Drug metabolism, Drug excretion, Drug administration, Drug dosing, Formulation-Drug delivery, Pharmacodynamics, Classification of drugs, Drug nomenclature. Types of Drug targets, Miscellaneous drug targets: Lipids, carbohydrates, biosynthetic building blocks.

UNIT-II

Enzymes as drug targets- Enzyme kinetics, Inhibitors acting at the active site of an enzyme-Inhibitors acting at allosteric binding sites, Uncompetitive and non-competitive inhibitors- Transition-state analogues, Suicide substrates, Medicinal uses of enzyme inhibitors

Receptors as drug targets: Role of the receptor, Neurotransmitters and hormones, Receptor types and subtypes, Receptor activation. Receptors and signal transduction, Design of agonists and antagonists, Partial agonists, Inverse agonists, Desensitization and sensitization, Tolerance and dependence, Affinity, efficacy, potency.

UNIT-III

Nucleic acids as drug targets: Intercalating drugs acting on DNA, Topoisomerase poisons: non-intercalating, Alkylating and metallating agents, Chain cutters. Chain terminators, Control of gene transcription, Agents that act on RNA, Agents those bind to ribosomes. Antisense therapy.

Target identification: Choosing a disease, Choosing a drug target, Target specificity and selectivity, Multi-target drugs, Identifying a bioassay, Finding a lead compound, Properties of lead compounds, Isolation and purification, Structure determination, Herbal medicine.

UNIT-IV

Drug Design: Structure activity relationships, Identification of a pharmacophore, Drug optimization, Optimizing access to the target: Optimizing hydrophilic/hydrophobic properties-Making drugs more resistant to chemical and enzymatic degradation,

Making drugs less resistant to drug metabolism, Prodrugs, Drug alliances, Endogenous compounds as drugs, Peptides and peptidomimetics in drug design

Drug Development: Preclinical and clinical trials: Toxicity testing, Drug metabolism studies, Pharmacology, formulation, and stability tests, Clinical trials, Patenting and regulatory affairs: Patents, Regulatory affairs, Chemical and process development.

UNIT-V

***In silico* Drug Design** Computer aided lead design-Determining Target Structure: Literature, Experimental methods, Protein structure Prediction methods, Molecular Modelling- Complementarity between a Target and Drug: Intermolecular Forces, molecular shape, drug pharmacophore, Ligand Based drug design, Structure Based drug design, Fragment Based Drug Design, Computer aided drug design, Molecular Docking procedures: software for molecular docking**,** steps in molecular docking. Quantitative structure–activity relationship (QSAR).

Text Books:

1. Erland Stevens. Medicinal Chemistry: The Modern Drug Discovery Process. Prentice Hall; 2nd edition, 2012.
2. Graham L. Patrick. An Introduction to Medicinal Chemistry, 5th Edition, Oxford University Press, USA. 2013.

Reference Books:

1. Gareth Thomas. Medicinal Chemistry: An Introduction, Wiley-Blackwell, 2nd Edition, 2007.
2. Rick Ng, Drugs: From Discovery to Approval, Wiley-Blackwell; 3rd Edition, 2015.

Course Outcomes (COs):

On completion of this course student will have improved ability to:-

1. Correlate the relationship between various steps of Drug design & development process. (PO-2, 3; PSO2)
2. Classify and compare various molecular drug targets. (PO-2, 3, 4; PSO2)
3. Identify the target and develop lead molecules. (PO-2, 4, 6; PSO-3)
4. Optimization of lead and development of drug candidate. (PO-2, 3, 5; PSO-3)
5. Evaluate the role of Bioinformatics in *in-silico* drug design. (PO-2, 4, 5, 6; PSO-3)

METABOLIC ENGINEERING

Course Code	**:** BTE743	**Credits:**	3:0:0
Contact Hours	**:** 42L		
Prerequisite(s)	**:** Genomics, Proteomics & Bioinformatics		
Course Coordinator(s)	**:** Dr. Krishna Murthy T P and Dr. M N Chandraprabha		

UNIT-I

Cellular Metabolism: Solute transport processes in the cell- transporter classification system- catabolism and metabolic fuelling: thermodynamics of fuelling processes, products of fuelling processes, redox potentials and mobile electron carriers-biosynthesis of cellular building blocks-polymerization of building blocks to macromolecules-rare metabolic conversions-transcriptional regulation of metabolism.

UNIT-II

Balances and Reaction Models: Growth nutrients and diversity- rates and mass balances-biomass specific conversion rates-mathematical models for the batch experiment from mass balances and q-based kinetics-data reconciliation and error detection peter-black box models for growth and product formation-metabolic models for growth and product formation-thermodynamic description of microbial growth and product formation.

UNIT-III

Modelling in Metabolic Engineering: Metabolic flux analysis-metabolic flux quantification methods-metabolic control analysis: definitions and structure of metabolic reaction networks, mathematical models of metabolic-structure and flux analysis of metabolic networks-constraint based genome-scale models of cellular metabolism-multiscale modelling of metabolic regulation-validation of metabolic models.

UNIT-IV

Tools in Metabolic Engineering: Improving Protein Functions by Directed Evolution-Engineering DNA and RNA Regulatory Regions through Random Mutagenesis and Screening-Evolving Pathways and Genomes for the Production of Natural and Novel Compounds-Models Predicting Optimized Strategies for Protein Evolution-Application of Emerging Technologies to Metabolic Engineering: Genome-Wide Technologies: DNA Microarrays, Phenotypic Microarrays, and Proteomics, Monitoring and Measuring the Metabolome- In Silico Models for Metabolic Systems Engineering

UNIT-V

Developing Appropriate Hosts for Metabolic Engineering: Escherichia coli, Yeast, Bacillus subtilis, Streptomyces, Mammalian Cells.

Future Applications of Metabolic Engineering: Energy and cofactor issues in fermentation and oxyfunctionalization- microbial biosynthesis of fine chemicals applications of metabolic engineering for natural drug discovery-metabolic engineering for alternative fuels.

Textbooks:

1. George Stephanopoulos Aristos Aristidou, Jens Nielsen (1998). Metabolic Engineering: Principles and Methodologies, 1st edition, Academic Press.
2. Christina D. Smolke (2009), The Metabolic Pathway Engineering Handbook: Fundamentals, 1st edition, CRC Press.
3. Christina D. Smolke (2009), The Metabolic Pathway Engineering Handbook: Tools and Applications, 1st edition, CRC Press.

References:

1. S Y Lee and E T Papoutsakis (1999). Metabolic Engineering, Marcel Dekker, NewYork, 1999.
2. Néstor V Torres, Eberhard O. Voit (2002). Pathway Analysis and Optimization in Metabolic Engineering, 1st Edition, Cambridge University Press.
3. Stephen Van Dien (2016) Metabolic Engineering for Bioprocess Commercialization, Springer International.

Course Outcomes COs):

1. Understand the central metabolic reactions and regulations in cellular metabolism. (PO-2, 3; PSO-2)
2. Describe the various models for regulation of metabolic pathways at different levels. (PO-2, 3, 4; PSO-2)
3. Analyze the metabolic flux for real time industrial applications. (PO-2, 4, 6; PSO3)
4. Utilize various scientific tools for engineering microbial pathway. (PO-2, 4, 6; PSO-3)
5. Development of effective solutions for various industrial and environmental problems using metabolic engineering. (PO-2, 4, 6; PSO-3)

ANIMAL BIOTECHNOLOGY

Course Code	**:** BTE751	**Credits:**	3:0:0
Contact Hours	**:** 42L		
Prerequisite(s)	**:** Nil		
Course Coordinator(s)	**:** Dr. Abhijith S R & Dr. Prabha M		

UNIT-I

Introduction to animal biotechnology: Introduction, History and Scope; Cell culture Laboratory design & Equipments: Layout; Maintenance of sterility; CO2 incubator; Inverted stage microscope. Cell culture vessels; Cryopreservation; Media and reagents, CO2 and bicarbonates buffering, Different Types culture Media-Natural and Artificial Media. Principles of animal cell and tissue culture.

UNIT-II

Animal cell culture: Initiation of Cell culture-Preparation and Sterilization of substrate, Primary animal cell culture: Isolation of Explants, Disaggregation of explants, contamination. Monolayer culture. Secondary culture; Trypsinization; Passage or subcultivation. Different tissue culture techniques; Continuous cell lines; Suspension culture; Organ culture etc.; Behavior of cells in culture conditions: Morphology, division, growth pattern; Development of cell lines Characterization and maintenance of cell lines.

UNIT-III

Animal cell culture applications: Cell cloning and selection; Commercial scale production of animal cells, stem cells and their application; Application of animal cell culture for in vitro testing of drugs, Application of cell culture technology in production of human and animal viral vaccines, Hybridoma Culture- monoclonal antibody Production and its applications. Cell culture products- interferons, hybrid antibodies

UNIT-IV

Development and use of transgenic animals: Transfection and its methods and applications. Transgenic animals; Transgenic-mice methodology: Mammalian virus vector- Retroviral vector method, SV40 vector DNA microinjection method, Engineered-embryonic stem cell method, Transgenic animals produced- Mice, Rabbits, Goat, Sheep and fish. Transgene integration. Targeted gene transfer- Gene disruption and Gene replacement. Knocking in and knocking out of genes; Applications: transgenic animals as bioreactors for production of proteins of pharmaceutical value.

UNIT-V

Biotechnology for animal improvement: Conventional methods of animal improvement: cross breeding, artificial insemination, in vitro fertilization, embryo transfer technology; Ethical issues related to IVF. Cryopreservation- procedure and applications. Gene mapping, marker assisted selection and genetic improvement of desired characters of domestic animals. Detection of Transgene and transgene function. Rapid diagnosis of diseases in live-stock via: RIA, ELISA and PCR.

Textbooks:

1. Freshney RI (2016) Culture of Animal Cells, 7th Edition, Wiley-Blackwell Publisher.
2. Spier RE and Griffiths JB (2012) Animal Cell Biotechnology, Academic Press.
3. Gorakh Mal, Manishi Mukesh, Sanjeev K. Gautam, Birbal Singh (2019) Advances in Animal Biotechnology, Springer Publications.

Reference Books:

1. B. Singh (2013) Text book of Animal biotechnology. Published by TERI press.
2. Anchal Singh, Ashish S. Verma Anchal Singh, Ashish S. Verma (2013) Animal Biotechnology: Models in Discovery and Translation, Second Edition, Academic press in imprint of Elsevier.
3. Channarayappa (2006) Molecular Biotechnology: Principles and Practices. University Press (India) Pvt. Ltd., Worldwide CRC Press.
4. Channarayappa (2010) Cell Biology: Universities Press (India) Pvt Ltd.
5. John RW, Masters, (2000) Animal Cell Culture: Practical Approach, 3rdEdn, Oxford.

Course Outcomes (COs):

on completion of this course students will be able to

1. Apply the basics and principles of animal biotechnology. (PO – 2,3,4,5; PSO - 1)
2. Theoretical Knowledge of basics animal cell culture techniques (PO – 3; PSO - 2)
3. Application of stem cells, cloning, large animal models for disease and development of therapies and treatments. (PO – 2,3,5, 9, 10; PSO - 2,3)
4. Apply the gene transfer techniques for the development of transgenic animal production (PO – 2,5,10; PSO – 3)
5. Apply the basic Knowledge of Breeding Technology, diagnosis techniques using ELISA, PCR and RIA. (PO – 2,5,9,10; PSO – 3)

MEDICAL BIOTECHNOLOGY

Course Code	**:** BTE752	**Credits:**	3:0:0
Contact Hours	**:** 42L		
Prerequisite(s)	**:** Biochemistry		
Course Coordinator(s)	**:** Dr. Abhijith S.R & Dr. Lokesh K N		

UNIT-I

Infectious diseases & Vaccine Technology: Introduction to Medial Biotechnology, scope and applications. Microbial Diseases of Humans: Viruses (AIDS, Hepatitis, Rabies, COVID-19) Bacteria (Typhoid, STD, TB, Plague), Fungal and parasitic diseases. History and classification of vaccines, strategies for vaccine development, principles of vaccine preparation and standardization, cancer vaccine, AIDS vaccine development, MMR vaccine, Hepatitis vaccine, polio vaccine, COVID-19 vaccine, Future development and scope of vaccines.

UNIT-II

Stem cells & Differentiation: Definition and history, Properties of stem cells, embryonic and adult stem cells, isolation and culturing of embryonic stem cells and their properties, formation of differentiated cells from embryonic stem cells and their properties. Tissue stem cells and their identification, Hematopoietic and mesenchymal stem cells, stem cells of the epidermis, differentiating epidermal cells, models for epidermal stem cells differentiation, Neural stem cells.

UNIT-III

Stem Cell Disorders & Cell therapy: Classification and manifestations of hematopoietic stem cell disorders (Inherited and acquired), concepts of cancer stem cells. Clinical applications of hematopoietic stem cells: bone marrow stem cell transplantation, complications and benefits, stem cell replacement therapy in diseases, immunological principles, Induced pluripotent stem cells and their application in clinics. Preservation and clinical use of blood and blood components.

UNIT-IV

Molecular Diagnostics: PCR based diagnosis, Southern blot-based diagnosis, DNA sequencing of representative clones to detect mutation(s), PCR-SSCP to detect SNPs, DNA fingerprinting. Protein based diagnostics: protein biomarkers, principles of Western blotting, immunohistochemistry, ELISA and applications. Chromosomal based diagnostics: FISH, karyotyping for chromosomal abnormalities, prenatal diagnosis. Next generation sequencing and its application in clinical practice.

UNIT-V

Gene Therapy: General introduction, strategies and approaches, gene transfer methods and their applications, mechnanisms of retro and adeno virus mediated gene transfer, ex vivo and in vivo gene therapy. Clinical studies, overview of inherited and acquired diseases for gene therapy; germline gene therapy- advantages and complications. Cancer gene therapy

Text Books

1. Glick, B. R., Patten, C. L., & Delovitch, T. L. (Eds.). (2020). Medical biotechnology. John Wiley & Sons.
2. Pratibha Nallari and V. V. Rao (2010) Medical Biotechnology. First edition, Oxford University Press.
3. Judit Pongracz, Mary Keen (2009) Medical Biotechnology, A Churchill Livingstone publication.

Reference Books

1. Ben Hu, Hua Guo et al., (2021) Characteristics of SARS-CoV-2 and COVID-19, Nature Reviews Microbiology, 19, 141-154
2. Mary Clarke, Jonathan Frampton (2020) Stem cells-Biology and application, 1st edition, Taylor and Francis Publisher
3. Albert Sasson, (2006) Medical Biotechnology, Brookings Institution Press.
4. Keith Wilson & John Walker, (2000) Practical Biochemistry- 5th Edition, Cambridge University Press, UK.
5. Judit Pongracz, Mary Keen (2009) Medical Biotechnology 1st Edition, Churchill Livingstone Publications.
6. Daan Crommelin, Robert D Sindelar (2013) Pharmaceutical Biotechnology an Introduction for pharmacists and pharmaceutical scientists, Springer Publisher.

Course Outcomes (COs):

On completion of this course student will have improved ability:-

1. To detect the disease-causing microbes for diagnosis, production of vaccines in prevention and treatment of diseases. (PO–2,5, 11; PSO-1,2)
2. To understand the basic biology of stem cells and their properties (PO–2, 5, 6; PSO-2)
3. To understand the benefits and scope of Embryonic stem cells and adult stem cells for therapeutics and transplantation. (PO–2, 3, 5, 12; PSO-2,3)
4. To apply the molecular and advanced techniques for analysis and diagnosis. (PO–3, 5, 6; PSO-1,3)
5. To analyze the gene transfer methods for application of gene therapy in treatment. (PO–4, 5,12; PSO-1,2)

BIOMEDICAL ENGINEERING

Course Code	**:** BTE753	**Credits:**	3:0:0
Contact Hours	**:** 42L		
Prerequisite(s)	**:** Biochemistry		
Course Coordinator(s)	**:** Dr. Prabha M & Dr. Lokesh K N		

UNIT I

Fundamentals of Biomedical Engineering: Fundamental technologies of biomedical engineering, Biomechanical Modeling; Biomechanical Testing Techniques; Fundamental of Bio Molecular Engineering: molecular cloning, genomic libraries, PCR, DNA sequencing, genomics etc., Fundamental concepts of immunology of biomedical relevance, Introduction to Automated Biotechnology: new work planners, expert systems, data-handling software and automation hardware (e.g., robots).

UNIT-II

Polymeric composites of Biomedical Applications: Fundamental approach on polymer and polymeric composites of Biomedical applications, Synthesis of biobased polymer composites, Biomedical applications of electrospun polymer composites, Biomedical application of hydroxyapatite nanocomposites, Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver, Bioreactors for Tissue Engineering.

UNIT-III

Biomedical Instrumentation and System Measurements: Analytical & Diagnostic Equipment, Therapeutic equipment, Sphygmomanometer, automation of chemical tests. Cardiovascular System Measurements: Electrocardiograph, ECG machines, vector cardiography (VCG), Respiratory System Measurements: Measurement of gas volume, respiratory transducers, Measurement of Electrical Activity in Neuromuscular System and Brain: Neuron potential, muscle potential

UNIT-IV

Biological sensors & Medical Imaging:

Sensors / receptors in the human body, basic organization of nervous system-neural mechanism, Chemoreceptor: hot and cold receptors, barro receptors, sensors for smell, sound, vision, Ion exchange membrane electrodes, enzyme electrode, glucose sensors, immunosensors, Basic principles of MOSFET biosensors & BIOMEMS, basic idea about Smart sensors. Computer assisted medical imaging- nuclear medicine, Image analysis tools, Identifying Medical Diagnoses and treatable diseases by image based

deep learning. Ultrasound imaging ultrasonography-computed X-ray tomography, Radiation therapy.

UNIT-V

Recent Advances and Applications in Biomedical Engineering: Quantum dots Treatment, Nanochip for HIV detection (targeting Cd4)., **Liposomal mediated drug delivery,** Nanotechnology based chemotherapy Nanorobotics, Cancer (pebble brain cancer) Nanoparticles A platforms for cancer therapy, **Tissue culture 3D printing**, Textiles and wound care products, Active implantable devices and bionics, Dendrimer, Artificial tissue engineering implementation and applications.

Text books

1. Mark Saltzman (May 21, 2015) Fundamental Biomedical Technologies Cambridge University Press; 2nd edition
2. Joseph D. Bronzino, Donald R. Peterson. (February 26, 2018) Biomedical Engineering Fundamentals (The Biomedical Engineering Handbook, Fourth Edition) 2nd Edition CRC Press; 2nd edition
3. Furukawa (2014) Biological Imaging and Sensing, Springer-Verlag Berlin Heidelberg.

References:

1. Professor Mark Walters (25 February 2015) Biomedical Engineering Applications, Clanrye International; Illustrated edition
2. Pfeiffer Erich A. (2014) Biomedical Instrumentation and Measurements Prentice-Hall of India Pvt.Ltd Second Edition
3. Sadasivuni, K.K., Ponnamma, D., Rajan, M., Ahmed, B., Al-Maadeed, M.A.S.A. (Eds.) (2019) Polymer Nanocomposites in Biomedical Engineering 1st Edition
4. Pascal Verdonck (2008) Advances in Biomedical Engineering Elsevier Science, 1st Edition

Course Outcomes (COs):

1. Apply the core concepts of Biomedical Engineering, its underlying Fundamentals of Bimolecular Engineering and Automated Biotechnology. (PO-1,2,3,6 &11, PSO-1)
2. Utilize the fundamental approach on polymer and polymeric composites of Biomedical applications for Engineering tissues for replacing bone, skin and other organs. (PO-1,2,3,6 & 11, PSO-3)
3. Analyse and measure the Analytical & Diagnostic Equipment and Therapeutic Equipment's to understand the various organs functions of the human. (PO-1, 2, 3, 6, 11 & 12, PSO- 2)
4. Demonstrate the biomolecules and sensory cell function with Biological sensors, Advanced imaging instruments and Computer assisted medical imaging. (PO-1, 2, 3, 5, 6, 11, & 2, PSO-3)
5. Apply Recent Advances and Applications in Biomedical Engineering to produce solutions for diagnosis and treatment of human diseases. (PO-1,2,3,5,6,11 &12, PSO-3)

BIOPROCESS SIMULATION LAB

Course Code	**:** BTL76	**Credits:**	0:0:1:0
Contact Hours	**:** 14P		
Prerequisite(s)	**:** Biokinetics & Bioreaction Engineering		
Course Coordinator(s)	**:** Dr. Krishna Murthy T P and Dr. Samrat K		

LIST OF EXPERIMENTS

1. Introduction to MATLAB/SCILAB software and its basic commands
2. Solving algebraic and differential equations using MATLAB/SCILAB
3. Management and analysis of bioprocess data using Microsoft Excel/Origin Pro
4. Design and analysis of experiments: Screening of process parameters using Microsoft Excel/Design Expert
5. Design and analysis of experiments: Optimization of process parameters using Microsoft Excel/ Design Expert
6. Development of P&ID and process flowsheet for bioprocess facility using AutoCAD and SuperPro Designer
7. Modelling and simulation of batch bioprocess using SuperPro Designer/ DWSIM/ ASPEN ONE
8. Modelling and simulation of continuous bioprocess SuperPro Designer/DWSIM/ASPEN ONE
9. 2D and 3D drafting of Bioreactor using AutoCAD
10. 2D and 3D drafting of Heat Exchanger using AutoCAD
11. Molecular dynamics simulation of biomolecules using GROMACS/Desmond
12. Modelling biological systems using VCell and Cell Designer
13. Modeling of fluid flow and mass transfer in bioreactor using COMSOL Multiphysics (Demo)
14. Machine Learning and Artificial Intelligence tools in Bioprocess Development (Demo)

Reference Books:

1. Michael B. Cutlip, Mordechai Shacham. Problem Solving in Chemical and Biochemical Engineering with POLYMATH, Excel, and MATLAB, Prentice Hall, 2008.
2. Ashok Kumar Verma, Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering, CRC Press, 2017.
3. Binay Kanti Dutta, Mathematical Methods in Chemical and Biological Engineering, CRC Press, 2017.

Course Outcomes (COs):

On completion of this course student will have improved ability to:-

1. Understand the fundamentals and to solve linear and nonlinear equations using MATLAB and Microsoft Excel®. (PO-2, 3, 4, 5; PSO-2,3)
2. Draft the drawings of bioprocessing equipment using CAD software. (PO-3, 4, 5; PSO-3)
3. Develop fermentation and process model for production of industrial products. (PO-2, 3, 4, 5; PSO-2, 3)
4. Able to simulate and analyse the results obtained from process (PO-4, 5; PSO-3)
5. Utilize wide range of software dedicated to bioprocessing development and optimization. (PO-4, 5; PSO-3)

BIOPROCESS CONTROL & AUTOMATION LAB

Course Code	**:** BTL77	**Credits:**	0:0:1
Contact Hours	**:** 14P		
Prerequisite(s)	**:** NIL		
Course Coordinator(s)	**:** Mr. Gokulakrishnan M & Dr. Chandraprabha MN		

LIST OF EXPERIMENTS

1. Dynamics of First order –Thermometer- system for step input
2. Dynamics of First order -Liquid level system - for step input
3. Dynamics of first order systems -Liquid level- for impulse input
4. Dynamics of first order systems-thermometer- for impulse input
5. Non-interacting systems
6. Interacting systems
7. Control of temperature in a bioprocess.
8. Control of pH in a bioprocess.
9. Control of Pressure in a bioprocess.
10. Control of Flow rates in a bioprocess.
11. Control of level
12. Study of Valve characteristics
13. Dynamics of second order system (Manometer)
14. Characteristics of Transducers (Temperature, Pressure, Flow)

Note: Any 12 experiments must be performed

Reference Books

1. Bailey and Ollis (2010) Biochemical engineering fundamentals. McGraw Hill (2nd Ed)
2. George Stephanopoulos (2009) Chemical process control 1st ed., Prentice Hall of India.

Course outcomes (COs):

1. Determine the control parameters of control system. (PO – 1, 2, 3, 4, 9; PSO – 3)
2. Predict the response of first order systems. (PO – 2, 3, 4; PSO – 1)
3. Predict the response of first order system in series. (PO – 2, 4; PSO – 1)
5. Analyze various control systems. (PO – 2, 3, 4, 9; PSO – 3)
6. Predict the response of the second order system. (PO – 2, 3, 4; PSO – 1)

SEMINAR			
Course Code	**:** BTSE	**Credits:**	0:0:1
Contact Hours	**:** 14 P		
Prerequisite(s)	**:** Nil		
Course Coordinator(s)	**:** Biotechnology faculty		

Course content

Through the seminar, students are expected to deepen their knowledge in their fields of specialization through reading of necessary literature, which includes technical papers in the relevant field. Students are able to deepen their knowledge by making presentations on the literature they read and holding questions and answering sessions. As a part of this exercise, the students are required to select a topic related to the program specialization and gather information from reference books, review/research article/s from indexed journal, read the same and assimilate the information presented in the article. Then students must present a 30-minute seminar, followed by a 15- 20-minute question period. A committee of two faculty members will evaluate the seminar.

Course Outcomes (COs):

On completion of this course student will have improved ability to:

1. Awareness about the scientific/technical resources and exposure to broad range of current topics in Biotechnology. (PO- 2, 5, 9, 10, 12; PSO- 2 & 3)
2. Improved ability to survey and comprehend scientific literature. (PO- 2, 5, 9, 10, 12; PSO- 2 & 3)
3. Enhance presentation skills and report writing skills. (PO- 2, 5, 9, 10, 12; PSO- 2 & 3)
4. Be able to communicate biotechnological knowledge in writing and oral with scientific illustrations. (PO- 2, 5, 9, 10, 12; PSO- 2 & 3)
5. To be able to interpret and discuss scientific data. (PO- 2, 5, 9, 10, 12; PSO- 2 & 3)

INTERNSHIP

Course Code	**:** BTIN	**Credits:**	0:0:3
Contact Hours	**:** 42 P		
Prerequisite(s)	**:** Nil		
Course Coordinator(s)	**:** Biotechnology faculty		

Course content

Internships are educational and career development opportunities that provide practical experience in a field of discipline. Internships help students to be exposed to an industrial or research environment that cannot be simulated in the classroom. Possibly it provides an opportunity to learn and understand real-time technical and managerial skills. Students are also benefited from current technological developments relevant to their field of specialization. Internships also expose students to future employers. A 4–6-week internship at industry/research organizations after the third year of the programme is a compulsory course requirement.

Course Outcomes (COs):

On completion of this course student will have improved ability to:

1. Acquire knowledge, critical thinking skills and experience in advanced techniques in Biotechnology. (PO- 2, 3,4,5; PSO- 2 & 3)
2. Learn and acquire skill sets like time-bound work habits, ethics, safety measures and team work. (PO- 6,8,9; PSO- 2 &3)
3. Communicate and present the acquired knowledge in a style consistent with scientific standards. (PO- 10 & 11; PSO- 2 & 3)
4. Appreciate the interdisciplinary nature of contemporary biotechnology research. (PO- 7 & 12; PSO 2 & 3)
5. Integrate theory and practice to explore job opportunities in the field of biotechnology and allied fields (PO- 7 & 12; PSO- 2 & 3)

PROJECT WORK

Course Code	**:** BTP	**Credits:**	0:0:14
Contact Hours	**:** 224 P		
Prerequisite(s)	**:** Nil		
Course Coordinator(s)	**:** Biotechnology faculty		

Course content

As a part of the project work students are expected to work in groups of three to four. They have to identify a research problem in consultation with their project guide. Two reviews will be conducted by the department to monitor the progress of the project work. Project presentation & submission of report is integral to the project reviews. The performance of each student will be evaluated by the project coordination committee. The project reviews & the guide's evaluation contributes to the CIE component. The final project presentation & report contribute to the SEE component.

Course Outcome (COs):

On completion of this course student will have improved ability to: -

1. Demonstrate a sound technical knowledge of their selected project topic. (PO-1,5; PSO-1)
2. Analyze complex data and draw scientific inferences or conclusion. (PO-1,2, 3, 4, 5; PSO-2, 3)
3. Apply research methodology for strategic formulation of research design. (PO-2, 3, 4, 5; PSO-3)
4. Apply ethical, biosafety or socio-environmental concepts in their research work and at professional career. (PO-6, 7, 8; PSO-3)
5. Develop managerial and teamwork/independent work skills, which can pave way for entrepreneurship. (PO-10, 11, 12; PSO-3)