NATIONAL INSTITUTE OF TECHNOLOGY
ANDHRA PRADESH

SCHEME OF INSTRUCTION AND SYLLABI

B.Tech. – BIOTECHNOLOGY

Effective from 2020-21

NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

VISION

To nurture and produce highly competent engineers, scientists and entrepreneurs committed towards catering to futuristic societal challenges through holistic education synergetic with innovations and vibrant research eco-system.

MISSION

- To implement best practices in teaching-learning methodologies for establishing dynamic knowledge-connected society.
- To create a conducive environment for carrying out research in multi-disciplinary areas and thereby nurturing novel thinking capabilities.
- To strengthen industry-institute interface to inculcate entrepreneurship abilities.
- To address all technological needs of the Nation for self-sustenance.

DEPARTMENT OF BIOTECHNOLOGY

VISION

To nurture competent biotechnologists who will disseminate their knowledge for the development of sustainable technologies with their innovative approaches.

MISSION

- Maintaining high academic standards by adopting effective pedagogy, and continuously upgrading the program curriculum to meet the current needs.
- Providing a flexible environment for faculty and students to flourish in teaching, research and entrepreneurship.
- Creating Institute-Industry interface by inculcating skills and knowledge through training programmes to address the socio-economic issues.

Department of Biotechnology:

About the Department:

The Department of Biotechnology at the National Institute of Technology Andhra Pradesh was established in the year 2015. Currently, we are offering undergraduate B. Tech, M. Tech, M.S (by Research) (Part-time) and Ph.D. (Part-time and Full time) programmes. The department is committed to impart quality education and offer excellent research environment to its ongoing programmes to motivate budding engineers, scientists and entrepreneurs to enhance their problem-solving skills for societal benefits. The department has faculty members from diverse specializations from reputed national and international institutes. Our laboratories are well equipped with modern infrastructure to meet the requirements of academic programmes. The research area of our faculty members include: Microbial Biotechnology, Bioprocess Engineering, Downstream processing, Modelling and Simulation of Bioprocesses, Prebiotics, Probiotics, Bioinformatics, Plant Biotechnology, Drug Delivery, Phytopharmacology, Environmental Biotechnology, and Nano-biotechnology. The departmental activities are supported by non-teaching staff. The aim of the department is to inculcate the knowledge of Biotechnology to the young minds who can contribute towards the development of the society.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Biotechnology
M.Tech.	Bioprocess Engineering
MS (by research)	Biotechnology
Ph.D.	Biotechnology

Note: Refer to the Rules and Regulations for B.Tech. program (weblink) given on the institute website.

B.Tech. – BIOTECHNOLOGY

Program Outcomes (POs)

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

PO1	Acquire in the depth knowledge on fundamentals of mathematics, bioscience, engineering for the conceptualization of complex biological system.
PO2	Define and analyze of complex engineering problems in biological system and provide potential solutions for solving technological problems in various domains of Biotechnology with a due consideration to the societal, public health, cultural, and environmental factors.
PO3	Design system components or processes for the development of high throughput process and products with due consideration to the public health, safety, cultural, societal, and environment factors.
PO4	Design, execute, analyze and interpret experimental data for investigating complex problems in Biotechnology and allied fields.
PO5	Create and apply modern engineering tools for the prediction and modelling of complex bioengineering activities with valid assumptions.
PO6	Identify societal, health, safety, legal and cultural issues and provide suitable solutions with logical thinking.
PO7	Understand the existing engineering solutions and their possible impact in societal and environmental contexts and able to bring sustainable development through greener way
PO8	Demonstrate adherence to accepted standards of professional bioethics, standards, and social responsibilities.
PO9	Possess self-management and team work skills towards collaborative, multidisciplinary scientific endeavours in order to achieve common goals.
PO10	Acquire communication skills relevant to professional positions and able to comprehend and prepare effective reports, design documentation, make effective presentations, and give and receive clear instructions.
PO11	Develop entrepreneurial and managerial skills for the implementation of multidisciplinary projects.
PO12	Possess the attitude necessary for life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1	Able to apply the knowledge gained during the course of the program from sciences and engineering in general and all biotechnology courses in particular to identify, formulate and solve real life problems faced in industries and/or during research work.
PSO2	Able to design, perform and analyze of experiments independently and update them with latest tools and techniques in the field of biotechnology and inter-disciplinary areas to choose research career nationally and internationally.
PSO3	Able to think and work independently and/or as a team to involve entrepreneurial activates for developing their own start-ups.

Degree Requirements for B.Tech. (Biotechnology) Programme

	Proposed Credits (New regulation)
Basic Science Core (BSC)	**19 (11.7%)**
Engineering Science Core (ESC)	**14 (8.64%)**
Humanities and Social Science Core (HSC)	**06 (3.7%)**
Program Core Courses (PCC)	**71 (43.82%)**
Departmental Elective Courses (DEC)	**15 (9.25%)**
Open Elective Courses (OPC)	**09 (5.55%)**
Program Major Project (PRC)/Skill Development (SD)/Foreign Languages	**22 (13.58%)**
EAA: Games and Sports (MSC)	**2 (1.23%)**
MOOCs (MOE)	**4 (2.46%)**
Total	**162**

Choice Based Credit System: 26.54 %
NOTE: The minimum no. of credits required to award B.Tech. degree is 162 as per the proposed curriculum.

Credit Distribution in Each Semester										
	I	II	III	IV	V	VI	VII	VIII	TOT	REQ
BSC	8	8	3	0	0	0	0	0	**19**	≥ **19**
ESC	4	10	0	0	0	0	0	0	**14**	≥ **14**
HSC	3	0	0	0	0	3	0	0	**6**	≥ **06**
PCC	0	0	17	20	16	8	10	0	**71**	≥ **62**
DEC	0	0	0	0	0	6	6	3	**15**	≥ **15**
OPC	0	0	0	0	3	3	0	3	**9**	≥ **09**
PRC/ SD	5	2	0	2	0	3	4	6	**22**	≥ **15**
EAA (MSC)	1	1	0	0	0	0	0	0	**2**	≥ **2**
MOOCS (MOE)	0	0	0	0	2	0	0	2	**4**	≥ **4**
	21	**21**	**20**	**22**	**21**	**23**	**20**	**14**	**162**	

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B.Tech. (Biotechnology) Course Structure

I – Year: I/II – Semester

PHYSICS CYCLE							
S.No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA101 /MA151	Differential and Integral Calculus / Matrices and Differential Equations	3	0	0	**03**	**BSC**
2	HS101	English for Technical Communication	2	0	2	**03**	**HSC**
3	PH101	Engineering Physics	3	0	0	**03**	**BSC**
4	EC101	Basic Electronics Engineering	2	0	0	**02**	**ESC**
5	CE102	Environmental Science and Engineering	2	0	0	**02**	**ESC**
6	CS101	Introduction to Algorithmic Thinking and Programming	3	0	0	**03**	**SD**
7	CS102	Introduction to Algorithmic Thinking and Programming Lab	0	1	2	**02**	**SD**
8	PH102	Engineering Physics Lab	0	1	2	**02**	**BSC**
9	EA101 /EA151	Physical Education/Health Education	0	0	3	**01**	**MSC**
		Total	**15**	**2**	**9**	**21**	

I – Year: I/II – Semester

CHEMISTRY CYCLE							
S.No.	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	MA101 /MA151	Differential and Integral Calculus / Matrices and Differential Equations	3	0	0	**03**	**BSC**
2	ME102	Engineering Graphics with Computer Aided Drafting	0	1	2	**02**	**ESC**
3	CY101	Engineering Chemistry	3	0	0	**03**	**BSC**
4	EE101	Elements of Electrical Engineering	2	0	0	**02**	**ESC**
5	BT101	Biology for Engineers	2	0	0	**02**	**ESC**
6	ME101	Basics of Mechanical Engineering	2	0	0	**02**	**ESC**
7	CE101	Engineering Mechanics	2	0	0	**02**	**ESC**
8	ME103	Workshop Practice	0	1	2	**02**	**SD**
9	CY102	Engineering Chemistry Lab	0	1	2	**02**	**BSC**
10	EA101 /EA151	Physical Education/Health Education	0	0	3	**01**	**MSC**
		Total	**14**	**3**	**9**	**21**	

Summer Internship – I[#]

Note:

BSC: Basic Science Core

HSC: Humanities and Social Science Core

DEC: Departmental Elective Courses

Program Major Project (PRC)/Skill Development (SD)/Foreign Languages

ESC: Engineering Science Core

PCC: Program Core Courses

OPC: Open Elective Courses

EAA (MSC): Games and Sports MOOCs (MOE)

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B.Tech. (Biotechnology) Course Structure

II – Year: I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	MA201	Applied Mathematical Methods	3	0	0	**03**	**BSC**
2	BT201	Microbiology	3	0	0	**03**	**PCC**
3	BT202	Biochemistry	3	0	0	**03**	**PCC**
4	BT203	Bioprocess Calculations	3	0	0	**03**	**PCC**
5	BT204	Chemical and Biochemical Thermodynamics	3	1	0	**04**	**PCC**
6	BT205	Microbiology Lab	0	0	3	**02**	**PCC**
7	BT206	Biochemistry Lab.	0	0	3	**02**	**PCC**
		Total	**15**	**1**	**6**	**20**	

II – Year: II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT251	Computing for Biotechnology	2	1	2	**04**	**PCC**
2	BT252	Transport Phenomena in Bioprocess Systems	3	0	0	**03**	**PCC**
3	BT253	Cell Biology	3	0	0	**03**	**PCC**
4	BT254	Molecular Biology & Genetics	3	0	0	**03**	**PCC**
5	BT255	Biological Reaction Engineering	3	0	0	**03**	**PCC**
6	BT256	Transport Phenomena in Bioprocess Systems Laboratory	0	0	3	**02**	**PCC**
7	BT257	Cell and Molecular Biology Lab.	0	0	3	**02**	**PCC**
8	BT299	Mini Project – I (EPICS based)	0	0	4	**02**	**SD**
		Total	**14**	**1**	**12**	**22**	

Summer Internship – II[#]

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B.Tech. (Biotechnology) Course Structure

III – Year: I – Semester

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT301	Bioprocess Engineering	3	0	0	**03**	**PCC**
2	BT302	Immunology	3	0	0	**03**	**PCC**
3	BT303	Genetic Engineering	3	0	0	**03**	**PCC**
4	BT304	Biostatistics	3	0	0	**03**	**PCC**
5	BT305	Bioprocess Engineering Lab.	0	0	3	**02**	**PCC**
6	BT306	Genetic Engineering Lab.	0	0	3	**02**	**PCC**
7		Open Elective – 1/ Foreign language	3	0	0	**03**	**OPC/SD**
8	MBT3XX	MOOCS-1[$]	2	0	0	**02**	**MOE**
		Total	**17**	**0**	**6**	**21**	

III – Year: II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT351	Downstream Processing Technology	3	0	0	**03**	**PCC**
2	BT352	Analytical Methods in Biotechnology	3	0	0	**03**	**PCC**
3	SM355	Engineering Economics and Management	3	0	0	**03**	**HSC**
4		Department Elective –1	3	0	0	**03**	**DEC**
5		Department Elective – 2	3	0	0	**03**	**DEC**
6	BT353	Downstream Processing Technology Lab	0	0	3	**02**	**PCC**
7		Open Elective – 2/ Foreign language elective	3	0	0	**03**	**OPC/SD**
8	BT399	Mini Project - II	0	0	6	**03**	**SD**
		Total	**18**	**0**	**9**	**23**	

Summer Internship – III[#]

#: The student can do Summer Internship with duration of minimum 60 days at Institutes / Organizations / Industries and produce the certificate of completion and copy of internship report to the department.
It is optional only, Not Mandatory.

SCHEME OF INSTRUCTION

B.Tech. (Biotechnology) Course Structure

IV – Year: I – Semester

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	BT401	Bioinformatics	3	0	0	**03**	**PCC**
2	BT402	Bioprocess Modelling and simulations	3	0	0	**03**	**PCC**
3	BT403	Algal Biotechnology**	2	0	0	**02**	**PCC**
4		Department Elective –3	3	0	0	**03**	**DEC**
5		Department Elective – 4	3	0	0	**03**	**DEC**
6	BT404	Bioinformatics Lab	0	0	3	**02**	**PCC**
7	BT449	Project-Work Part - A	0	0	8	**04**	**PRC**
		Total	**14**	**0**	**11**	**20**	

**: The PCC Subject may be offered with the support of Industry.

IV – Year: II – Semester

S.No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Department Elective – 5*	3	0	0	**03**	**DEC**
2		Open Elective – 3*	3	0	0	**03**	**OPC**
3	MBT4XX	MOOCS-2[$]	2	0	0	**02**	**MOE**
4	BT499	Project-Work Part – B (with option of Industrial Training /Internship)	0	0	12	**06**	**PRC**
		Total	**8**	**0**	**12**	**14**	**8**

*If the students are in Industrial training, the electives may be conducted online.

[$]MOOCS course approved by DAC

Department Elective Courses:

Semester	Elective Number	Course Code	Course Title
6th	1	BT361	Industrial Biotechnology
6th	1	BT362	Nano Biotechnology
6th	1	BT363	Biopharmaceutical Technology
6th	2	BT371	Plant Biotechnology
6th	2	BT372	Metabolic Regulation and Engineering
6th	2	BT373	Environmental Biotechnology
7th	3	BT411	Animal Biotechnology
7th	3	BT412	Enzyme Technology
7th	3	BT413	Bioreactor design and analysis
7th	4	BT421	Bioprocess Instrumentation & Control
7th	4	BT422	Food Biotechnology
7th	4	BT423	Bioprocess Design & Economics
8th	5	BT461	Biosafety, Bioethics and IPR
8th	5	BT462	Biofuel Technology
8th	5	BT463	Drug design and development

Open Elective Courses (offered to other departments):

Semester	Elective Number	Course Code	Course Title
5th	1	BT341	Environmental Technology
6th	2	BT391	Bioenergy and Biofuels
8th	3	BT491	Ethics and IPR

Minors:

Courses for Minor in Food Science and Technology							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Offered Sem**
1	BTM251	Essentials of food technology	3	1	0	**04**	**4th**
2	BTM301	Food Processing & Preservation	3	1	0	**04**	**5th**
3	BTM351	Food Product development	3	0	0	**03**	**6th**
4	BTM352	Food Processing Lab	0	0	3	**02**	**6th**
5		Electives – I	3	0	0	**03**	**7th**
	BTM401	Food Safety Systems*					
	BTM402	Fermented foods*					
	BTM403	Advances in food engineering*					
		TOTAL	**12**	**2**	**3**	**16**	

*Course choices for Elective – I

Courses for Minor in Computational Drug Design							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Offered sem**
1	BTM252	Omics Technologies	3	1	0	**04**	**4th**
2		Electives – I	3	0	0	**03**	**5th**
	BTM302	Peptide Therapeutics#					
	BTM303	Python for Bioinformatics#					
	BTM304	Machine Learning Methods and Biological Networks#					
3	BTM353	Structural Bioinformatics	3	0	0	**03**	**6th**
4	BTM354	Principles of Bioinformatics Laboratory	0	0	3	**02**	**6th**
5	BTM404	Molecular Simulation and Drug Design	3	1	0	**04**	**7th**
		TOTAL	**12**	**2**	**3**	**16**	

#Course choices for Elective - I

Honors:

Courses for Honors							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Offered sem**
1	BTH301	Cell and Tissue Culture Technology	3	1	0	**04**	**5th**
2	BTH302	Bioreaction engineering	3	1	0	**04**	**5th**
3	BTH451	Bioreactor Design and Analysis	3	1	0	**04**	**7th**
4	BTH452	Downstream Bioprocessing	3	1	0	**04**	**7th**
5	BTH453	Molecular Genetics	3	1	0	**04**	**7th**
		TOTAL	**15**	**5**	**0**	**20**	

Note:

1. A student is permitted to register Minor or Honors only, but not both.
2. A student is permitted to register only one minor/ one Honors.
3. A student can opt courses offered or take MOOCS courses up to 6 credits for Honors degree upon approval of DAC committee.

DETAILED SYLLABUS

I Year B. Tech
(Common for All Branches)

MA101	Differential and Integral Calculus I B.Tech. I Semester - all sections	BSC	3-0-0	3 Credits

Pre-Requisites: None

Syllabus:

Differential Calculus of functions of several variable: Review of Limit, continuity (sequential verification) and differentiability, Partial differentiation; Total differentiation; Euler's theorem and generalization; Change of variables- Jacobians; Maxima and minima of functions of several variables (2 and 3 variables); Lagrange's method of multipliers. (14)

Integral Calculus: Convergence of improper integrals; Beta and Gamma integrals; Differentiation under integral sign; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals. (14)

Vector Calculus: Scalar and vector fields; vector differentiation; level surfaces; directional derivative; gradient of a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stokes' theorem; Gauss Divergence theorem. (14)

Text Reference:

1. Joel R. Hass, Maurice D. Weir, George B. Thomas, Thomas' Calculus, 12th edition, Pearson , 2010.
2. Erwin Kreyszig, *"Advanced Engineering Mathematics"*, Eighth Edition, John Wiley and Sons, 2015
3. B. S. Grewal, *"Higher Engineering Mathematics"*, Khanna Publications, 2015
4. R. K. Jain and S. R. K. Iyengar, *"Advanced Engineering Mathematics"*, Fifth Edition, Narosa Publishing House, 2016.
5. T. M. Apostol, Calculus, Volumes 1 and 2 (2nd Edition), Wiley Eastern, 1980.

MA151	Matrices and Differential Equations I B.Tech. II Semester - all sections	BSC	3-0-0	3 Credits

Pre-Requisites: Mathematics-I

Syllabus:

Matrix Theory: Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigenvalues and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices. (14)

Ordinary Differential Equations of Higher Order : Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems - forced oscillations, electric circuits, etc. (14)

Laplace Transforms: Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function; Convolution theorem, Solving certain initial value problems, Solving system of linear differential equations, Finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc. (14)

Text Reference:

1. E. Kreyszig, Advanced Engineering Mathematics, Eighth Edition, John Wiley and Sons, 2015.
2. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Fifth Edition, Narosa Publishing House, 2016.
4. G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole India, 2006.
5. T. M. Apostol, Calculus, Volume 2 (2nd Edition), Wiley Eastern, 1980.

HS101	ENGLISH FOR TECHNICAL COMMUNICATION	SD	2 – 0 – 2	3 Credits

Pre-Requisites: None

Syllabus:

Grammar Principles and Vocabulary Building: -Exposure to basics of grammar- tenses—active and passive voice- their usage-Concord -Error Detection-Idioms and Phrases-Phrasal verbs—their meanings and usage, Synonyms and antonyms

Developing paragraphs using mind mapping- Definition- structure- Types and Composition-unity of theme- coherence- organization patterns-essays and their structure-note-making

Letter Writing: Formal letters-- communicative purpose-strategy- letter format and mechanics- letters of request, complaint and invitation-writing emails

Reading Comprehension –skimming-scanning-intensive and extensive reading-reading to retrieve information ––techniques of comprehension -find clues to locate important points-answering objective type questions–inference, elimination

Delegation- steps involved in delegation-preparing delegation for a program
Preparing Questionnaire-Determine audience and content of each question-response structure-develop wording for each question-establish sequence of questions

Profiling Readers-Audience analysis- Identifying potential audience- Identifying primary, secondary, tertiary readers,and gatekeepers- Identifying the needs, values, and attitude of the readers
Resume Writing-Writing for Professional Networking-Academic writing-research proposals-Interpretation of Graphs.

Technical Report-Writing - kinds of reports-proposals, progress and final reports- their structure- features- process of writing a report-editing.

Language Laboratory
Introduction to basic phonetics: Vowels, Consonants, Diphthongs, phonetic symbols
Listening: Challenges in listening, enhancing listening skills, listening activities
Speaking:JAM using cue cards-role play-Group presentation-presentation with emphasis on body language- public speaking-extempore speech
Group discussion: Dos and don'ts, intensive practice
Mock interview:Interview etiquette, common interview questions

Text Books:

1. Emden, Joan van. *Effective Communication for Science and Technology*. Macmillan Education UK, 2001.
2. Mohan, Krishna and Meera Banerji. *Developing Communication Skills*. Macmillan India Limited, 2000.
3. Murphy, Raymond. Intermediate English Grammar. Cambridge University Press, 2014.
4. Narayanaswami, V. R. Strengthen Your Writing. Orient Longman Private Limited, 2005.
5. Soundaraj, Francis. Speaking and Writing for Effective Business Communication. Macmillan Publishers India Limited, 2007.
6. Ur, Penny. Discussions that Work. Cambridge University Press, 1981.

Reference:

1. Aarts, Bas. *Oxford Modern English Grammar*. Oxford University Press, 2011.
2. Anderson, Marilyn, Pramod K. Nayar, and Madhucchanda Sen. *Critical Thinking, Academic Writing and Presentation Skills*. Pearson Education, 2008.
3. Blake,Gary.*The Elements of Technical Writing*. Pearson,2000
4. Brown, Carla L. *Essential Delegation Skills*. Routledge, 2017.
5. Busan, Tony. *Mind Map Mastery*. Walkins, 2018.
6. Carlisle, Joanne and Melinda S. Rice. *Improving Reading Comprehension Research-based Principles and Practices*. York Press, 2002.
7. Carter, Ronald and Michael McCarthy. *Cambridge Grammar of English: A Comprehensive Guide*. Cambridge University Press, 2006.
8. Carter, Ronald, Rebecca Hughes, and Michael McCarthy. *Exploring Grammar in Context: Upper-intermediate and Advanced.* Cambridge University Press, 2000.
9. Eastwood, John. *Oxford Guide to English Grammar*. Oxford University Press, 1994.
10. Harris, David.F. *Complete Guide to Writing Questionnaires.* I& M Press, 2014.
11. Hering, Lutz and Heike Hering. *How to Write Technical Reports: Understandable Structure, Good Design, Convincing Presentation*. Springer; 2010.
12. HuckinN.Thomas and Leslie A.Olsen*Technical Writing and Professional Communication for Non-native Speakers*. McGraw-Hill Education,1991.
13. Laplante, Phillip A*. Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals.* CRC Press, 2018.
14. McQuail, Dennis. *Audience Analysis*. Sage, 1997
15. Ogden, Richard. *Introduction to English Phonetics*. Edinburgh University Press, 2017.
16. Parker, Glenn M. *Team Players and Teamwork: New Strategies for Developing Successful Collaboration*. Wiley, 2011.
17. Seely, John. *Oxford Guide to Effective Writing and Speaking: How to Communicate Clearly*. Oxford University Press: 2013.

PH101	Engineering Physics	BSC	3-0-0	3 Credits

Syllabus:

Waves and Optics

Interference: Superposition principle, coherence of light, methods to produce coherent light: division of amplitude and wave front division, Young's double slit experiment: concept, working principle, and applications, Newton's ring: concept, working principle, and applications

Diffraction: Fraunhofer's single-slit diffraction, diffraction grating, and resolving power of a grating.

Polarization: Types of optical polarization, various methods to produce polarized light, working and applications of retarder plates, and half-shade polarimeter: construction and working principle.

Lasers and Optical Communication

LASER: Basic theory of LASER, Einstein's coefficients and their relations, concept of population inversion, components of lasers, modes of laser beam, construction and working principle of various types of lasers: Ruby, Helium-Neon, and semiconductor diode lasers.

Optical Fibre: Optical fibre and its working principle, total internal reflection, numerical aperture, modes of propagation, and classification of optical fibres.

Quantum Physics

Origin of quantum theory and related experiments: Black-Body radiation, photo-electric effect, and Compton effect. Heisenberg's uncertainty principle, de- Broglie's wave concept, phase and group velocities, wave function, and its properties, operators, Schrödinger's time-dependent and time-independent equations, particle in one-dimensional, infinite potential and finite potential wells, and quantum tunneling phenomena and their applications in alpha decay, and scanning tunneling microscopy (STM).

Magnetic, Superconducting and Dielectric Materials

Magnetic Materials: Introduction to Weiss theory of ferromagnetism, concepts of magnetic domains, Curie transition, hard and soft magnetic materials and their applications, magneto-resistance, GMR, and TMR.

Superconducting Materials: Introduction to superconductivity, Meissner effect, Type-I and Type-II superconductors and their applications.

Dielectric Materials: Introduction to dielectrics, dielectric constant, polarizability, frequency and temperature dependent polarization mechanism in dielectrics, dielectric loss, and applications.

Advanced Functional Materials & NDT

Smart Materials: Biomaterials, high-temperature materials and smart materials, applications of functional materials.

Nanomaterials: Introduction, classification, and properties of nanomaterials, various methods of synthesizing nanomaterials: top-down (ball milling) and bottom-up (sol-gel) approaches.

Photovoltaic Materials: Solar spectrum, photovoltaic effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, and applications.

NDT: Methods of non-destructive testing

References:

1. A Textbook of Engineering Physics, M. N. Avadhanulu, P. G. Kshirsagar, S. Chand and Company (2015).
2. Concepts of Modern Physics, Beiser A., Mc. Graw Hill Publishers (2003).
3. Optics, Ajoy Ghatak, Tata Mc Graw Hill (2012).
4. Materials Science and Engineering: An Introduction (Tenth edition), William D. Callister, John Wiley & Sons (2018).
5. Introduction to Solid State Physics, Charles Kittel, Wiley Publishers (2011).

EC101	Basic Electronics Engineering	ESC	2–0–0	2 Credits

Syllabus:

Introduction to electronics systems, diode circuit models and applications, Zener diode as regulator, photodiode.

Transistor and applications: Introduction to transistors, BJT Characteristics, biasing and applications. FET and MOSFET characteristics and applications.

Feedback in Electronic Systems: open loop and closed loop systems, Negative and positive Feedback, Principles of LC and RC oscillators.

Integrated Circuits: Operational amplifiers Characteristics and applications, linear operations using Op-amps.

Digital Circuits: Number systems and logic gates, Combinational Logic circuits, Sequential Circuits, Analog to Digital and Digital to Analog converters (ADC/DAC).

Laboratory measuring instruments: principles of digital multi-meters, Cathode ray oscilloscopes (CRO).

Reading:

1. Bhargava N. N., D C Kulshreshtha and S C Gupta, Basic Electronics & Linear Circuits, 2nd Edition, Tata McGraw Hill, 2013.
2. S. Sedra and K. C. Smith, Microelectronic Circuits, Oxford University Press , 6th Edition
3. Leach , Malvino, Saha, Digital Principles and Applications, McGraw Hill Education , 8th Edition
4. Boylestad, Robert L., Louis Nashelsky, Electronic Devices and Circuit, Pearson , 11th Edition
5. Helfrick and Cooper, — Modern Electronic Instrumentation and Measurement Techniques‖ PHI, 2011
6. Neil Storey, Electronics A Systems Approach, 4th Edition, Pearson Education Publishing Company Pvt Ltd.

CE102	ENVIRONMENTAL SCIENCE AND ENGINEERING	ESC	2-0-0	2 Credits

Syllabus:

Introduction to Environmental Science: Environment and Societal Problems, Major - Environmental Issues, Global Climate Change Agreements, Montreal, Kyoto Protocol & Paris Agreement, Basics of Environmental Impact Assessment, Principles of Sustainability, and related indices, Population Dynamics, Urbanization. Identification and Evaluation of Emerging Environmental Issues with Air, Water, Wastewater and Solid Wastes, Introduction to Environmental Forensics.

Water & Wastewater Treatment: Water Sources, constituents, potable water quality requirements (IS 10500), overview of water treatment, sources and types of pollutants, their effects, self-purification capacity of water bodies, principles of wastewater treatment, 5R Concept.

Air & Noise Pollution: Sources, classification and their effects, national ambient air quality standards (NAAQS), air quality index, dispersion of pollutants, control of air pollution, understanding and improving indoor air quality, sources of noise pollution, effects, quantification of noise pollution.

Solid Waste Management: Sources and characteristics of solid waste, effects, 3R concept, sustainable practices in waste management, CPHEEO guidelines for solid waste management, transition to zero waste lifestyle.

Reading:

1. G.B. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2013.
2. Gerard Kiely, Environmental Engineering, McGraw Hill Education Pvt Ltd, Special Indian Edition, 2007.
3. Benny Joseph, Environmental Science and Engineering, Tata McGraw-Hill, New Delhi, 2006.

References:

1. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous (1985), Environmental Engineering, McGraw Hill Inc., New York
2. W P Cunningham, M A Cunningham, Principles of Environmental Science, Inquiry and Applications, Tata McGraw Hill, Eighth Edition, 2016.

CS101	Introduction to Algorithmic Thinking and Programming	SD	3–0–0	3 Credits

Pre-requisites: None

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

CO1	Construct algorithms for solving problems that requires solutions involving searching, sorting, selection and / or a numerical method as a sub-routine.
CO2	Analyze the suitability of different algorithmic design paradigms for solving problems with an understanding of the time and space complexities incurred.
CO3	Construct algorithms for solving problems with an understanding of the internals of a computing system and its components like processor, memory and I/O sub-systems.
CO4	Construct efficient modular programs for implementing algorithms by leveraging suitable control structures.
CO5	Construct efficient programs by selecting and using suitable in-built Data Structures and programming language features available.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L											
CO2	S	M	L											
CO3	S	M	L		L									
CO4	S	M	L		S									
CO5	S	M	L		S									

S: Strong correlation, M: Medium correlation, L: Low correlation

Syllabus:

Fundamentals of Computers, Historical perspective, Early computers, Modern Computers, Hardware Components of a Computer, Data Representation in Computers, Introduction to Operating Systems, Software and Firmware, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

Problem solving techniques – Algorithmic approach, characteristics of algorithms, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms, Algorithm Analysis.

Basic Syntax in Python, Data Types, Variables, Assignments, immutable variables, Types of Operators, Expressions, Comments, Boolean Logic, Logical Operators in Python.

Conditional statements - If-else, Loops - while, for, Lazy Evaluation

Inbuilt Data Structures and their operations in Python: List, Tuples and Dictionaries.

Fundamental Algorithms: Swapping variables, Problems involving summation of a series, Sine function computation, Base Conversion, generation of sequences like Fibonacci, Reversing the digits of an integer, Character to number conversion.

Factoring Methods: Finding the square root, Finding the smallest divisor of an integer, finding the greatest common divisor using Euclid's algorithm, Computing the prime factors of an integer, generating prime numbers, Raising a number to a large power, Computation of the nth Fibonacci number.

Functions – Modular programming and benefits, user defined functions, library functions, parameter passing, Formal and Actual arguments, named arguments return values, Recursion.

Sorting algorithms: Bubble, Selection and Insertion sorts, Search algorithms: Linear and binary search

String processing: Algorithms for implementing String functions like Strlen, Strcpy, StrRev, Strcmp, Searching for a keyword or pattern in a text.

File and Directory Handling: Reading and Writing to/from a file, Formatted File creation and operations.

Simple 2D Graphics, drawing 2D objects using Turtle Graphics.

Reading List:

1. Kenneth Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2019
2. R.G. Dromey, how to solve it by Computer, Pearson, 2008.

CS102	Introduction to Algorithmic Thinking and Programming Lab	SD	0–1–2	2 Credits

Pre-requisites: None

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

CO1	Construct, debug, test and run efficient programs by leveraging suitable flow of control constructs and syntactic units of the programming language.
CO2	Construct efficient programs by constructing and translating algorithms for solving problems using sorting, searching, selection and / or arithmetic computations.
CO3	Implement, refactor, test and debug functional programs in a shell-based run time environment.
CO4	Construct efficient programs by demonstrating problem-solving skills and out-of-the-box algorithmic thinking.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	S	M	L		S				M			L	S	M
CO2	S	M	L		S				M			L	S	M
CO3	S	M	L		S				M			L	S	M
CO4	S	M	L		S				M			L	S	M
CO5	S	M	L		S				M			L	S	M

S: Strong correlation, M: Medium correlation, L: Low correlation

Syllabus:

List of Experiments:

1. Familiarization with Python installation, basic syntax and running scripts in the shell.
2. Programs on conditional control constructs.
3. Programs on iterative constructs. (While, do-while, for).
4. Programs using user defined functions and in-built function calls.
5. Programs related to Recursion.
6. Programs involving in-built data structures like List, Tuples and Dictionaries.
7. Programs related to String processing.
8. Programs related to Files and I/O.
9. Implementation of Factoring methods.
10. Programs that require sorting, searching and selection as sub-routines.
11. Problems involving simple 2D graphics.
12. Implementation of a capstone application to unify the concepts learnt in the course.

Reading List:

1. Kenneth Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2019.
2. R.G. Dromey, how to solve it by Computer, Pearson, 2008.
3. The Python Tutorial, Available at: https://docs.python.org/3/tutorial/.

PH102	Engineering Physics Lab	BSC	0-0-2	2 Credits

List of experiments (any eight of the following):

S. No	Name of the experiment
1	Determination of Planck's constant using light emitting diode.
2	Determination of wavelength of monochromatic light in Newton's ring experiment.
3	Determination of the width of narrow slit by diffraction method.
4	Determination of wavelength of He-Ne laser using diffraction by a metal scale.
5	Determination of capacitance and time constant of a capacitor using R-C circuit.
6	Determination of wavelength of mercury spectrum by normal incidence method (diffraction grating).
7	Determination of specific rotation of an optically active material-using Laurent's half-shade polarimeter.
8	Determination of resonating frequency and bandwidth of an LCR circuit.
9	Determination of dielectric constant of various dielectric materials.
10	Studying B-H curve loop and permeability of magnetic materials.
11	Measuring spatial distribution of magnetic field between a pair of identical coils using Helmholtz coils.
12	Studying current-voltage characteristics of a photovoltaic material using solar cell.
13	Determination of numerical aperture of an optical fibre.
14	Determination of resistivities of various materials using four-probe method.

Exposure to virtual lab (any three of the following):

1. LCR – Series/Parallel

2. B-H Loop tracer

3. Planck's Constant

4. Numerical aperture of Optical Fiber

5. Newton's rings

Micro project:

This can be implemented in the subsequent semesters based on the facilities available. In the case of implementation, three or four experiments from the above listed eight experiments will be replaced with the project (~40 % of the experiments will be relaxed).

References:

1. *Physics Laboratory Manual*, School of Sciences (Physics), National Institute of Technology Andhra Pradesh (2020).

2. *Practical Physics (Electricity, Magnetism, and Electronics),* R. K. Shukla, A Srivastava, New age international publishers (2011).

3. *B.Sc. Practical Physics*, C. L. Arora, S. Chand & Co. Ltd. (2012).

EA101	Physical Education	MSC	0-0-3	1 Credit

Syllabus:

I. Introduction to Physical Education & EAA = Sports and Games

Meaning & Definition of Physical Education, Aims & Objectives of Physical Education, Importance of Physical Education

II. Physical Fitness & Wellness Lifestyle

Meaning & Importance of Physical Fitness, Components of Physical Fitness (Cardiovascular Endurance, Strength Endurance Muscular Endurance, Flexibility, Body Composition), Components of Motor Fitness (Agility, Balance, Power, Speed, Coordination), Development of Fitness Components

III. Training Methods in Physical Education

Circuit Training (Circuit Training), Continues Training (Endurance), Interval Training (Speed & Endurance), Fartlek Training (Speed Endurance), Weight Training (Maximum Strength), Plyometric Training (Power), Flexibility Training

IV. Test & Measurements

Measurements: Height, Weight, Age, Calculation of BMI, Motor Fitness and Physical Fitness Tests (Pre - Test & Post-Test), Cardiovascular Endurance - 9/12 Minute Run or Walk, Muscular Endurance – Sit Ups for abdominal strength, Strength Endurance – Flexed arm hang for girls / Pull ups for boys, (Speed – 50m Dash or 30mts Fly Start, Strength – Broad Jump, Vertical Jump for Lower Body, Medicine Ball Put for Shoulder Strength, Endurance - 800mts, Flexibility - Bend and Reach, Agility (Coordination)) – Shuttle Run and Box Run

V. Formal Activities

Calisthenics (free hand exercises), Dumbbells, Woops, Wands, Laziums (Rhythmic activities), Aerobic Dance and Marching

VI. Sports / Games

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc., Teaching & Coaching of the Game/Sport, Latest General Rules of the Game/Sport.

Specifications of Play Grounds and Related Sports Equipment

EA151	Health Education	MSC	0-0-3	1 Credit

Syllabus:

Health Education & Personal Hygiene
Introduction & Meaning of Health Education, Definition of Health Education, Principles of Health Education, Importance of Health Education, Meaning of Personal Hygiene, Importance of Personal Hygiene, Personal cleanliness (teeth, ears, eyes, nose & throat, nails & fingers, skin, cloths, and hair).

Nutrition
Introduction of Nutrition, Balanced Diet, Daily Energy Requirements, Nutrient Balance, Nutritional Intake, Eating and Competition, Ideal Weight

First Aid & Injury Management
Introduction, Types and Principles of First Aid, Functions of First Aider, Reasons for Sports Injuries,The First Aid and Emergency Treatment in Various cases (drowning, dislocation & fractures, burns, electric shock, animal bite, snake bite, poison, etc.

Human Posture
Introduction, Meaning of Posture, types of Good Posture, causes of Poor Posture, preventive and Remedial Poor Posture, common Postural Deformities, Body Types, Advantages of Good Posture

Yoga
Introduction, Meaning & Importance of Yoga, Elements of Yoga, Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas, Yoga for concentration & related Asanas (standing asanas, sitting asanas, supine and prone postures.), Relaxation Techniques for improving concentration – Yoga – nidra, Pranayama

Sports / Games

Following sub topics related to any one Game/Sport of choice of student out of: Athletics, Badminton, ball badminton, Kabaddi, Kho-Kho, Table Tennis, Yoga etc.,Teaching & Coaching of the Game/Sport., Latest General Rules of the Game/Sport, Specifications of Play Grounds and Related Sports Equipment.

ME102	Engineering Graphics with Computer Aided Drafting	ESC	2-0-0	2 Credits

Syllabus:

Introduction: Overview of the course, Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Construction of Polygons, Scales. Introduction to Computer Aided Drafting (CAD), DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES, etc.

Orthographic Projection: Principles, of Orthographic projection, Four Systems of Orthographic Projections.

Projection of Points: Projections of points when they are situated in different quadrants.

Projections of Lines: Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces.

Projections of Planes: Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes.

Projections of Solids: Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes.

Sections of Solids: Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.

Isometric Views: Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views - simple objects.

Note: 50% of the Practice through manual drawing and 50% of the Practice through a Computer Aided Drafting Package.

Reading:

1. N.D. Bhatt and V.M. Panchal, Engineering Graphics, Charotar Publishers, 2013.

2. Sham Tickoo, AutoCAD 2017 for Engineers & Designers, Dreamtech Press, 23rd Edition, 2016.

CY101	Engineering Chemistry	BSC	3-0-0	3 Credits

Syllabus:

Basic Organic Chemistry

Reaction intermediates: carbocations, carbanions, free radicals and carbenes. Classification of organic reactions, examples and their mechanisms: substitution, addition, elimination and rearrangement reactions. Reimer–Tiemann reaction, Kolbe-Schmidt reaction, Cannizzaro reaction. Pinacol-Pinacolone, Hofmann and Beckmann rearrangements. Diels-Alder reaction.

Spectroscopic Techniques for Chemical Analysis

Introduction of spectroscopy, Quantum aspects of electronic, vibrational and nuclear energy levels. UV-Visible spectroscopy: Principle, Instrumentation, Beer-Lambert's law, Effect of conjugation, Woodward-Fieser empirical rules for acyclic/cyclic dienes. IR spectroscopy: Principle, Factors that affect vibrational frequencies and functional group detection. Proton NMR spectroscopy: Principle, Instrumentation, Chemical equivalency, Chemical shift and spin-spin splitting. Applications of UV-Vis, IR and proton-NMR spectroscopy in determining the structure of small organic molecules.

Coordination Chemistry

Introduction of coordination chemistry, Valence bond (VB) theory and shapes of Inorganic Compounds, Spectrochemical series, Crystal Field theory (CFT): octahedral and tetrahedral complexes, Crystal field splitting energy (CFSE); Molecular Orbital (MO) Theory: Molecular orbital diagrams for octahedral complexes (strong and weak ligand fields).

Electrochemistry

Electrodes, Electrochemical Cells, Electrochemical series and Nernst equation; Conductometry and Potentiometry; Batteries: Types of batteries, Ni-Cd and Lithium (Li)-ion batteries; Fuel Cells: Hydrogen-Oxygen, Methanol-Oxygen fuel cells; Corrosion - Theories of corrosion, Wet corrosion, Types of wet corrosion, Factors affecting the rate of corrosion, Corrosion control methods: Sacrificial anode method and Impressed current method.

Engineering Materials and Applications

Polymers: Introduction, Types of polymerization, Functionality in polymers, Number and Weight average molecular weight, Polydispersity index, Biodegradable polymers; Conductive polymers: classification, examples and applications; Organic light emitting diode (OLED): structure, principle and applications; Optical fibres: principle and Applications.

Reference books:

1. Organic Chemistry, Clayden, Greaves, Warren and Wothers, Oxford University Press, 2014.
2. Organic Spectroscopy, William Kemp, 2nd edition, Macmillan publishers, 2019.
3. Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo and Manfred Bochmann, 6th Edition, 1988.
4. Physical Chemistry, P. Atkins and Julio de Paula, 8th Edition, Freeman & Co. 2017.
5. A Textbook of Engineering Chemistry, Shashi Chawla, 2017.
6. Polymer Science and Technology, Premamoy Ghosh, 3rd edition, McGraw-Hill, 2010.

EE101	Elements of Electrical Engineering	ESC	2-0-0	2 Credits

Syllabus:

Basic Concepts

Electric Charge, Current and Electromotive force, Potential and Potential Difference; Electrical Power and Energy; Ohm's Law, Resistance, Capacitance and Inductance, Series and Parallel Connection of Resistances and Capacitances, Kirchoff's Laws and Their Applications

AC Fundamentals:

Concept of Alternating Voltage and Current, RMS and Average Values, Single Phase and Three Phase Supply; 3-ph Star-Delta connections, Alternating Voltage applied to Pure Resistance, Inductance, Capacitance and their combinations, Concept of Power and Power Factor in AC Circuit.

Measuring Instruments:

Principle and Construction of Instruments used for Measuring Current, Voltage, Power and Energy, Methods and precautions in use of these.

Electromagnetic Induction:

Concept of Magnetic Field, Magnetic Flux, Reluctance, Magneto Motive Force (MMF), Permeability; Self and Mutual Induction, Basic Electromagnetic laws, various losses in magnetic circuits;

Electrical Machines:

Elementary concepts of an electrical machine, Basic principle of a motor and a generator, Classification of Electrical machines; Principles, Construction and Working of a machine; Starters: Need, Construction and Operation; Transformer: Classification, Principles, Construction and Working of a Transformer, Applications of Transformers;

Utilization of Electricity:

Utilization concepts of Electricity for electrolysis process, Electrochemical Cells & Batteries; Application of Electricity, Energy Conversation and Efficiency

Basic Troubleshooting:

Basic Testing and faults diagnosis in electrical systems, various tools and their applications, replacement of different passive components.

Electrical Safety:

Electrical Shock and Precautions against it, Treatment of Electric Shock; Concept of Fuses and Their Classification, Selection and Application; Concept of Earthing.

Reading:

1. Edward Hughes, Electrical & Electronic Technology, Pearson, 12 th Edition, 2016.
2. Vincent Del Toro, Electrical Engineering Fundamentals, Pearson, 2 nd Edition, 2015.
3. V N Mittle and Arvind Mittal, Basic Electrical Engineering, Tata McGraw Hill, 2nd Edition, 2005.
4. E. Openshaw Taylor, Utilization of Electrical Energy, Orient Longman, 2010.

5. B.L.Theraja , Fundamentals of Electrical Engineering and Electronics volume -I, S Chand & Company 2005.
6. Ashfaq Husain, Fundamentals of Electrical Engineering, Dhanpat Rai & Sons 4 th edition, 2010.
7. H.Partab: Art & Science of Utilization of Electric Energy, Dhanpat Rai & Sons, 1998.
8. Fundamentals of Electrical Circuits by Charles k.Alexander, Mattew N.O.Saidiku, Tata McGraw Hill company.

BT101	BIOLOGY FOR ENGINEERS	ESC	2-0-0	2 Credits

Pre-requisites: None

Course Outcomes:

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

CO1	Realize the significance of biomolecules for sustaining life
CO2	Identify the difference between unicellular to multi-cellular organisms
CO3	Understand the central dogma of life and gene regulation
CO4	Analyze and understand the concepts of biology for engineering the cell

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
CO2	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
CO3	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-
CO4	2	3	3	1	-	-	-	-	-	-	-	-	-	2	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Importance of biology to engineers, Molecules of life: Water and Carbon, Evolution and origin of life, Darwins theory, Diversity of life, Chemical basis of life, Nucleic acids, Amino acids and Proteins, Carbohydrates, Lipids and Membranes.

Cell structure and function: Prokaryotic, Eukaryotic cell and Virus, Sub cellular organelles and their functions, Regulation of cellular metabolism: Cellular respiration and Fermentation, Photosynthesis, Cell division (differences between mitosis and meiosis), Mendel's Law and Patterns of inheritance.

Gene structure and expression: Difference between prokaryotic and eukaryotic gene structure, DNA replication, Transcription, RNA processing and Translation, Control of gene expression (lac operon).

Applications of Biology in Engineering: Genetic engineering (microbe, plant and animal cells for improvement), Industrial Biotechnology (Primary and Secondary metabolites), Environmental engineering, Biopharmaceuticals, Tissue engineering, Biomaterials, Stem cell engineering, Biosensors, Bioinformatics.

Text Books:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.
2. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017.

ME101	Basics of Mechanical Engineering	ESC	2-0-0	2 Credits

Syllabus:

Evolution of Mechanical Engineering: Introduction, Definition and scope of Mechanical Engineering, relation of Mechanical Engineering with other Engineering Disciplines, Revolutionary Inventions in wheels, tools, windmills, steam engine, CNC machines, Rapid Prototyping, Air-conditioning and Refrigeration, History of Mechanics, Thermodynamics and Heat Transfer, Production and Industrial Engineering, Mechatronics.

Engineering Materials: Introduction to Engineering Materials, Classification and Properties, Alloys. Composites, Micro and Nano Materials.

Manufacturing Processes: Castings - Patterns & Moulding, Metal forming, Hot Working and Cold Working Extrusion, Drawing, Rolling, Forging. Welding - Arc Welding & Gas Welding, Soldering, Brazing. Introduction to Machining processes – Lathe, Milling, Shaping, Drilling, Grinding, Introduction to NC/CNC Machines, 3D Printing.

Power Transmission: Transmission of Power, Belt Drives, Gears and Gear Trains -Simple Problems, **Fasteners and Bearings:** Fasteners - Types and Applications, Bearings - Types and Selection,

Thermodynamics: Introduction to Energy Sources - Thermodynamics - System, State, Properties, Thermodynamic Equilibrium, Process & Cycle, Zeroth law of Thermodynamics, Work & Heat, First law - Cyclic process, Change of State, Cp, Cv, Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/COP, Second law, PMM2, Carnot Cycle, Entropy - T-S and P-V diagrams.

Introduction to Steam Turbines and I.C. Engines: I.C. Engines: 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences.

Introduction to Heat Transfer and Refrigeration: Vapor Compression Refrigeration Cycle - Refrigerants, Desirable Properties of Refrigerants. Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls & Cylinders, and Overall Heat Transfer Coefficient – problems.

Reading:

1. Dixit, U.S., Hazarika, M. and Davim, J.P, A Brief History of Mechanical Engineering, Springer, 2017.
2. M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, Elements of Mechanical Engineering, Jain Brothers, New Delhi, 2008.
3. Praveen Kumar, Basic Mechanical Engineering, Pearson Education, India, 2013.
4. P.N. Gupta, M.P. Poonia, Elements of Mechanical Engineering, Standard Publishers, 2004.
5. C.P. Gupta, Rajendra Prakash, Engineering Heat Transfer, NemChand Brothers, New Delhi, 1994.
6. B.S. Raghuvanshi, Workshop Technology, Vol. 1&2, Dhanpath Rai & Sons, New Delhi, 1989.

CE101	Engineering Mechanics	ESC	2-0-0	2 Credits

Prerequisites: None

Syllabus:

Introduction - Specification of force vector, Formation of Force Vectors, Moment of Force – Cross product – Problems, Resultant of a general force system in space,

Equillibrium of force system- Degrees of freedom - Equilibrium Equations, Degree of Constraints – Free body diagrams.

Coplanar Force Systems - Introduction – Equilibrium equations – All systems, Problems

Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system – Point of action, Method of joints, Method of sections, Method of members.

Friction in rigid bodies- Friction – Coulombs laws of dry friction – Limiting friction, Problems on Wedge friction, Belt Friction-problems.

Centroid & Moment of Inertia - Centroid and M.I – Arial – Radius of Gyration, Parallel axis– Perpendicular axis theorem – Simple Problems.

Dynamics of Particles – Introduction to kinematics- Equations of rectilinear motion, D'Alembert's principle -Simple problems- Introduction to kinetics- Work and Energy.

Reading:

1. J.L.Meriam, L.G. Kraige, Engineering Mechanics, Statics, John Wiley &Sons,7th Edition, 2012.
2. A.K. Tayal, Engineering Mechanics, Umesh Publications, 14th Edition, 2010.
3. S S Bhavikatti and K G Rajashekarappa, Engineering Mechanics, New Age International Publication, 4th Edition.

Reference:

1. Dietmar Gross, Werner Hauger, Jorg Schroder, Wolfgang A. Wall, Nimal Rajapakse, Engineering Mechanics 1, Statics, Springer, 2nd Edition, 2013.
2. S. Timoshenko, D.H. Young, Pati Sukumar, J V Rao, Engineering Mechanics, Mc-Graw Hill, 5th Edition.

ME103	Workshop Practice	SD	0-1-2	2 Credits

Syllabus:

Fitting Shop: Preparation of T-Shape Work piece as per the given specifications, Preparation of U-Shape Work piece which contains: Filing, Sawing, Drilling, Grinding, and Practice marking operations.

Machine shop: Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools), Demonstration of different operations on Lathe machine, Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting and Study of Quick return mechanism of Shaping operation. Demonstration of the working of CNC and 3D Printing Machines.

Power Tools: Study of different hand operated power tools, uses and their demonstration and Practice of Power tools.

Carpentry: Study of Carpentry Tools, Equipment and different joints, Practice of Cross Half lap joint, half lap Dovetail joint and Mortise Tenon Joint.

Welding: Study of welding tools and welding equipment, Arc Welding Practice (Lap and Butt joint).

CY102	Engineering Chemistry Lab	BSC	0-0-2	2 Credits

List of experiments (any eight of the following):

Exp. No	Name of the experiment
1	Standardization of $KMnO_4$ solution
2	Determination of Iron in Haematite
3	Determination of Hardness of Water
4	Determination of available chlorine in bleaching powder and of iodine in Iodized salt
5	pH-metric titration of an acid vs a base
6	Conductometric titration of an acid vs a base
7	Potentiometric titration of Fe^{2+} against $K_2Cr_2O_7$
8	Colorimetric determination of Potassium Permanganate
9	Determination of rate of Corrosion of mild steel in acidic environment in the absence of presence of an inhibitor
10	Determination of Chlorophyll in Olive oil by using UV and Fluorescence spectroscopic techniques
11	Functional group analysis of organic compounds by using IR spectroscopic technique
12	Organic solvent evaporation by using rotary-evaporation technique

Virtual labs

1. Determination of unknown concentration of analyte by using the Beer-Lambert's law.
2. Identification of unknown components using spectroscopic techniques.
3. Nuclear magnetic resonance spectroscopy and evolution of simple ^1H NMR spectra of organic compounds
4. Study of kinetics of a reaction by using spectrophotometric methods.

Reference books:

1. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 1st Edition, 2006.

MA201	Applied Mathematical Methods	BSC	3-0-0	3 Credits

Pre-Requisites:

i. MA101 Differential & Integral Calculus
ii. MA151 Matrices & Differential Equations

Course Outcomes:

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

CO1	Understand and use of complex variables and evaluation of real integrals
CO2	Determine Fourier series of a given function.
CO3	Find the solution of a PDE by variable separable method
CO4	Use numerical methods to solve equations and integrals

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1														
CO2														
CO3														
CO4														
CO5														

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Complex Variables: Analytic function - Cauchy Riemann equations - Harmonic functions -Conjugate functions - complex integration - line integrals in complex plane - Cauchy's theorem (simple proof only), Cauchy's integral formula - Taylor's and Laurent's series expansions -zeros and singularities - Residues - residue theorem, use of residue theorem to evaluate the real integrals without poles on the x-axis, Conformal mapping.

Unit II

Fourier Series: Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions.

Unit III

Partial Differential Equations: Method of separation of variables - Solution of one dimensional wave equation, one dimensional heat conduction equation and two dimensional steady state heat conduction equation with illustrations.

Unit IV

Numerical Methods: Numerical solution of algebraic and transcendental equations by Regula-Falsi method and Newton-Raphson's method - Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule - Taylor series method, Euler's method, modified Euler's method, Runge-Kutta method of 2^{nd} & 4^{th} orders for solving first order ordinary differential equations.

Text Books:

1. Jain, R. K. & Iyengar, S. R. K. (2016). *Advanced engineering mathematics* (5th ed.). Narosa Publishing House.
2. Kreyszig, E. (2008). *Advanced engineering mathematics* (8th ed.). John Wiley and Sons.
3. Grewal, B. S. (2017). *Higher engineering mathematics* (44th ed.). Khanna Publications.

Reference Books:

1. Spiegel, M., Lipschutz, S., Schiller, J., & Spellman, D. (2017). *Complex variable - Schaum's outlines* (2nd ed.). McGraw Hill Education.
2. Sastry, S. S. (2012). *Introductory methods of numerical analysis* (5th ed.). Prentice Hall.

BT201	MICROBIOLOGY	PCC	3-0-0	3 Credits

Prerequisites:

i. BT101 Biology for Engineers**.**

Course Outcomes:

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

CO1	Understand the diversity of microorganisms
CO2	Understand the interaction of microorganisms with their environment
CO3	Apply appropriate methods for the control of microbial growth
CO4	Understand the principles of bacterial genetics and their mechanism
CO5	Understand the role of microorganisms in environmental remediation

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	2	2	2	-	-	-	-	1	2	3	2	2
CO2	3	2	2	2	1	2	-	-	-	-	1	2	3	2	3
CO3	-	1	1	2	3	2	2	-	-	-	1	2	3	2	2
CO4	3	3	3	2	2	2	-	1	1	-	2	3	3	2	3
CO5	3	2	2	2	2	2	2	-	-	-	1	3	3	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

History and importance of microbiology: spontaneous generation versus Biogenesis of microorganism, germ theory of disease –Koch's Postulates, Taxonomic classification of microorganisms and microbial relevance. Characteristics of microorganisms: morphological, chemical, cultural, metabolic, antigenic, genetic, pathogenicity, ecological and molecular characteristics.

Unit II

Bacterial cell structure and function: internal and external structure, spores and cysts. Cultivation of Bacteria: Nutritional requirements, physical conditions requirement, choice of media, conditions of incubation, reproduction and growth, quantitative measurement of growth. Maintenance and preservation of cultures.

Unit III

Characteristic features of fungi (yeasts and molds), algae and protozoa: morphology, reproduction, physiology economic importance. Viruses: morphology and structure, classification and nomenclature. Bacteriophage: general characteristics, discovery and significance. Animals and plants viruses

Unit IV

Control of microorganisms: fundamentals of control, physical agents, chemical agents, antibiotics. Microbial genetics: inheritance of characteristics and variability; phenotypic and genotypic changes; bacterial recombination: conjugation, transduction, and transformation.

Unit V

Introduction to Applied Microbiology: microbial interactions; microbiology of soil; biogeochemical roles of microorganisms; aquatic microbiology; wastewater treatment procedures. Microbial interaction and disease, Anti-microbial resistance.

Text Books:

1. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (2001). *Microbiology* (5th ed.). McGraw Hill Higher Education.
2. Joanne, M. W., Linda, M. S., & Christopher, J. W. (2016). *Prescott, Harley and Klein's microbiology* (10th ed.). McGraw-Hill Higher Education.
3. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2017). *Brock Biology of Microorganisms* (15th ed.). Pearson.
4. Ingraham, J. L., & Ingraham, C. A. (2004). *Introduction to Microbiology - A case History Approach* (3rd ed.). Brooks/Cole Publishers.

BT202	BIOCHEMISTRY	PCC	3-0-0	3 Credits

Prerequisites:

i. PH101 Engineering Physics
ii. CY101 Engineering Chemistry
iii. BT101 Biology for Engineers

Course Outcomes:

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

CO1	Classify bio-molecules
CO2	Understand complex biochemical pathways within living cells
CO3	Understand the physiological functioning of the cells
CO4	Understand anabolic and catabolic metabolism
CO5	Understand the mechanism of enzymatic reactions

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	2	2	1	-	-	-	-	-	-	3	1	-
CO2	3	-	-	-	-	2	1	-	2	1	-	2	2	1	-
CO3	3	-	-	-	-	2	-	1	-	-	-	2	3	1	-
CO4	3	2	2	-	3	-	2	-	-	-	-	1	3	-	1
CO5	3	2	3	2	-	2	3	-	-	-	3	2	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Biochemistry: Chemical foundations of Biology - pH, acids, bases, buffers, weak bonds and covalent bonds. Carbohydrates: Structure, classification and functions of carbohydrates and glycoconjugates. Lipids: Structure of Fats and Oils, Phospholipids, membrane lipids.

Unit II

Amino acids and Peptides: Classification of amino acids, Structure and properties of amino acids, Peptide bond and peptides. Proteins: Structure and Classification of Proteins. Primary structure, Secondary structure, Tertiary structure and Quaternary structure, aggregated proteins, Structural importance in function, Denaturation and Renaturation.

Unit III

Nucleic acids: Structure of nucleic acids, Structure of DNA, specialized secondary structures, kinds of RNA and their structures. Vitamins: Introduction, classification and functions of vitamins, disease of vitamins deficiency.

Unit IV

Metabolism: Glycolysis, Gluconeogenesis, Pentose Phosphate Pathway, Citric Acid Cycle, Oxidative Phosphorylation, Photosynthesis, Amino Acid Oxidation, DNA, RNA, Protein and Fatty acid metabolism. Enzymes and Enzyme Action: Enzymes as biological catalysts, classification, Examples of enzymes catalyzed reactions and mechanism of enzyme action.

Text Books:

1. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman.
2. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2015). *Harper's illustrated biochemistry* (30th ed.). McGraw-Hill Education.
3. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. (2015). *Biochemistry* (8th ed.). WH Freeman.
4. Campbell, M. K., & Farrell, S. O. (2013). *Biochemistry* (8th ed.). Brooks/Cole.Title of the Text Book, Author(s), Publisher, Year and Edition

BT203	BIOPROCESS CALCULATIONS	PCC	3-0-0	3 Credits

Prerequisites:

i. CY101 Engineering Chemistry
ii. BT101 Biology for Engineers

Course Outcomes:

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

CO1	Understand the material and energy balances of bioprocesses
CO2	Perform material and energy balances on biochemical processes/equipment
CO3	Perform unsteady state material and energy balances
CO4	Understand the flow diagram and solve the problems involving recycle, purge and bypass in a bioprocess

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	-	-	3	3	-	3	-	1	-	3	-	-
CO2	-	1	3	2	-	-	1	-	1	-	1	-	3	2	-
CO3	-	1	3	2	-	-	1	-	1	-	1	-	3	-	-
CO4	3	1	3	-	-	-	-	-	1	-	1	-	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Unit and its conversion: Normality, Molality, Molarity, PVT relationship, Gas laws, Partial pressure, and pure component volume methods. Material Balance without chemical reactions: General material balance equations - procedure and calculations; Material balances involving multiple sub-systems; simplifications for steady- state processes without chemical reaction; Material balance for various unit operations

Unit II

Material Balance with chemical reactions: Material Balance with chemical reactions, Concept of limiting; excess reactants; fractional and percentage conversion; Yield and percentage yield; Material balances involving recycle; by-pass; and purge streams and its uses; Stoichiometry of microbial growth and product formation.

Unit III

Steady state energy Balances: General energy balance equations; Enthalpy calculation procedures; enthalpy change in non-reactive processes; steam tables; procedure for energy balance calculations without reaction; enthalpy change due to reaction. Heat of reaction for processes with biomass production; Energy balance equation for cell culture; fermentation energy balances worked examples.

Unit IV

Unsteady-state material and energy balances: Unsteady-state material and energy balance equations; solving differential equations; unsteady-state mass balances; unsteady-state energy

balances; unsteady-state material and energy balances on non-reactive process; heat of mixing and solution; balances on reactive processes; integrated balances.

Text Books:

1. Himmelblau, D. H., & Riggs, J. B. (2012). *Basic principles and calculations in chemical engineering* (8th ed.). Pearson Education.
2. Bhatt, B. I., & Vora S. M. (2005). *Stoichiometry* (4th ed.). McGraw-Hill Higher Education.
3. Hougen, O. A., Watson, K. M., & Ragatz, R. A. (2001). *Chemical processes principles (part-1): material and energy balances* (2nd ed.). Asia Publication House.
4. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.

BT204	CHEMICAL AND BIOCHEMICAL THERMODYNAMICS	PCC	3– 1–0	4 Credits

Prerequisites:

i. PH101 Engineering Physics
ii. CH101 Engineering Chemistry
iii. MA101 Differential & Integral Calculus
iv. MA151 Matrices & Differential Equations

Course Outcomes:

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

CO1	Understand the basic concepts and correlate the relationship of properties in thermodynamics
CO2	Apply power cycles and refrigeration in bio-process systems
CO3	Understand the degrees of freedom, phase and chemical reaction equilibria
CO4	Evaluate thermodynamic parameters involved in biochemical reactions
CO5	Understand the energy kinetics of metabolic pathways and applications in bio-processes

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	-	-	1	-	-	1	2	1	--
CO2	2	1	3	1	1	-	1	-	1	-	1	1	1	1	1
CO3	3	2	1	-	-	-	-	-	-	-	--	1	2	1	-
CO4	3	2	1	2	1	-	1	-	1	-	1	1	2	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Concepts in Engineering Thermodynamics: Introduction to Basic laws, concepts and Terminologies in Thermodynamics- Statement of First law, P-V-T behavior of pure fluids, Heat effects accompanying chemical Reactions - Statements of second law- Clausius Inequality- Mathematical Statement of Second Law-Third Law of Thermodynamics, Work function and Gibbs free energy, fundamental property relations, Maxwell equations, Clapeyron equation, entropy and heat capacity relationship, Power cycles and refrigeration. Statement of Zeroth law of thermodynamics

Unit II

Solution Thermodynamics: Partial Properties, Concepts of Chemical Potential and Fugacity, Ideal and Non-Ideal Solutions, Gibbs – Duhem Equation, Excess Properties of mixture; Activity Coefficients, Activity Coefficient Correlations.

Unit III

Phase and Chemical Reaction Equilibria: Criteria for phase equilibrium, Vapor – Liquid equilibrium calculations for binary mixtures, Liquid – Liquid Equilibria and Solid- Liquid

Equilibria, Introduction to Chemical Reaction Equilibrium, Equilibrium criteria for homogeneous chemical reactions; Evaluation of equilibrium constant and effect of pressure and temperature on equilibrium constant; Calculation of equilibrium conversions and yields for single and multiple chemical reactions.

Unit IV

Biochemical Thermodynamics: Overview of energetics of Metabolic Pathways; Stoichiometry and energetic analysis of Cell Growth and Product Formation – elemental Balances, Degree of reduction concepts; available electron balances; yield coefficients; Thermodynamics of microbial growth, Oxygen consumption and heat evolution in aerobic cultures; thermodynamic efficiency of growth, Energy balance equation for free cell culture; pH dependence of a Biochemical Reaction, Unfolding of a protein as a function of Temperature, ligand-protein binding, entropy and enthalpy calculation.

Text Books

1. Smith, V. N., Ness, H. C. V., Abbott, M. M., & Swihart, M. T. (2018). *Introduction to chemical engineering thermodynamics* (8th ed.). McGraw-Hill Education.
2. Sandler, S. I. (2006). *Chemical, biochemical and engineering thermodynamics* (4th ed.). John Wiley & Sons.
3. von Stockar, U. (2013). *Biothermodynamics: The role of thermodynamics in biochemical engineering* (1st ed.). EPFL Press.

BT205	MICROBIOLOGY LAB	PCC	0–0–3	2 Credits

Prerequisites:

i. BT101 Biology for Engineers

Course Outcomes:

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

CO1	Understand the morphology of microorganism using microscopy
CO2	Understand the culturing techniques and preservation of microorganisms
CO3	Identify and characterize microorganism using biochemical tests
CO4	Understand the growth characteristics of microorganisms
CO5	Apply physical and chemical techniques to control the microbial growth.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	3	-	2	-	-	1	1	1	3	3	3	-
CO2	3	2	2	3	-	2	1	2	1	1	1	3	3	3	2
CO3	3	2	3	3	-	2	-	-	1	1	1	3	3	3	2
CO4	3	2	3	3	-	2	-	-	1	1	1	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Demonstration of Microscope (light, bright-field and phase contrast)
2. Screening of microorganisms from soil and its preservation
3. Bacterial culturing techniques (Spread, pour and streak plate).
4. Microscopic identification of microorganisms (bacteria, fungi, plant and animal) - smear preparation and staining techniques.
5. Bacterial identification using biochemical tests.
6. Estimation of microbial growth and viability test (Spectrophotometric measurement and cell counting)
7. Control of microorganism: physical and chemical agents
8. Antibiotic susceptibility assay

Text Books:

1. Cappuccino, J. G., & Natalie Sherman, N. (2013). *Microbiology: A laboratory manual* (10th ed.). Pearson.
2. Smith, H., & Brown, A. (2022). *Benson's microbiological applications: Laboratory manual* (15th ed.). McGraw-Hill Education.
3. Pollack, R. A., Findlay, L., Mondschein, W., & Modesto, R. R. (2018). *Laboratory exercises in microbiology* (5th ed.). John Wiley & Sons.

BT206	BIOCHEMISTRY LAB	PCC	0–0–3	2 Credits

Prerequisites:

i. BT101- Biology for Engineers

Course Outcomes:

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

CO1	Estimate the concentration of biomolecules
CO2	Identify and characterize biomolecules
CO3	Separate biomolecules using Chromatography and Electrophoresis
CO4	Perform biochemical reactions of proteins, carbohydrates and nucleic acids

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	-	2	-	-	1	3	-	-	-	-	-	-	-
CO2	-	-	1	-	-	1	-	-	1	1	-	-	2	-	-
CO3	-	3	-	-	3	-	-	3	-	-	2	-	-	1	-
CO4	2	-	-	-	-	2	2	-	2	-	-	1	-	-	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Laboratory safety & Hygiene, Units and measurements.
2. Qualitative analysis of Carbohydrates and amino acids & proteins.
3. Quantitative estimation of protein by Biuret method (or) Lowry method
4. Quantitative estimation of reducing sugars by DNS method
5. Quantitative estimation of total sugars by Anthrone method
6. Quantitative estimation of DNA by Diphenylamine method
7. Quantitative estimation of RNA by Orcinol method
8. Determination of purity of biomolecules by UV spectroscopy
9. Separation of amino acids by paper and thin layer chromatography
10. Determination of molecular weight of protein by SDS PAGE

Text Books:

1. Wilson, K., & Walker, J. (2000). *Practical biochemistry: principles and techniques* (5th ed.). Cambridge University Press.
2. Basu, P. (2018). *Biochemistry laboratory manual* (3rd ed.). Academic Publishers.
3. Jayaraman, J. (2011). *Laboratory manual in biochemistry*. New age International.

BT251	COMPUTING FOR BIOTECHNOLOGY	PCC	2–1–2	4 Credits

Prerequisites:

i. CS101 Introduction to Algorithmic Thinking and Programming
ii. CS102 Introduction to Algorithmic Thinking and Programming Lab.

Course Outcomes:

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

CO1	Construct object-oriented programs using python.
CO2	Construct and implement simple linear and non-linear data structures.
CO3	Construct basic programs in R to solve simple data analytic problems.
CO4	Construct database and implement queries using SQL constructs for a given requirement specification.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	-	3	-	-	3	3	2	-	-	2	2	2
CO2	3	2	2	-	3	-	-	3	3	2	-	-	2	2	3
CO3	3	2	2	-	3	-	-	3	3	2	-	-	1	2	2
CO4	3	2	2	-	3	-	-	3	3	2	-	-	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Object Oriented Programming in Python: Procedural and Object-Oriented Programming, Classes and working with instances, Method overloading, Polymorphism, importing internal module as well as external modules in the code Packages understanding and their usage. **Introduction to Data Structures:** Stack, Queue, Linked Lists, Binary Trees

Unit II

Introduction to R Programming: R and Rstudio installation, R components: data types, array and matrices, operators, for and ifelse, functions, data frames, apply and its variants. Input data sets from text files, CSV files, or database systems. Output data by creating tables, text files, or CSV files. Manipulate and store data properly using dplyr. Visualize data and build plots using ggplot2.

Unit III

SQL: Form of a basic SQL Query, Insert, Delete and Update database, Set Operations, Nested queries, Aggregate Functions, Null Values, Integrity Constraints, Join Expressions – Natural join, Equi-join, Inner join, Outer join, Views, Triggers

List of Experiments:

1. Implement a python program to create a singly linked list for the following operations:
   i) Insert a node at a given position.

ii) Delete a Node at a given position.

iii) Search.

iv) Count the number of nodes and display the list.

2. Implement a Python program to create a stack and perform various operations on it.
3. Implement a Python program to create a queue and perform various operations on it.
4. Implement a Python program to create a binary search tree and perform search operations on it.
5. Download and install R-Programming environment and install basic packages using install.packages () command in R.
6. Implement a program to read a csv file and analyze the data in the file in R.
7. Create a data set and perform statistical analysis on the data using R.
8. Familiarization with installation of any database management system.
9. Creation of Data base through implementation of Data Definition Language commands - create, alter, drop, rename and truncate.
10. Querying and modifying the database using Data Manipulation Language commands -select, insert, update, delete.
11. Program to find the length of the given sequence
12. Program to reverse and concatenation of the given sequence
13. Program to complement and reverse complement of DNA sequence
14. Program to calculate GC content in the given DNA sequence
15. Program to translate DNA into Protein Sequence

Text Books:

1. Brown, M. C. (1999). *Python: The complete reference* (4th ed.). McGraw Hill Education.
2. Necaise, R. D. (2011). *Data structures and algorithms using python*. John Wiley & Sons.
3. Matloff, N. (2011). *The art of R programming: A tour of statistical software design* (1st ed.). No Starch Press.
4. Matloff, N. (2009). *The art of R programming*. UC Davis.
5. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2010). *Database system concepts* (7th ed.). McGraw Hill Education.

Web Reference:

1. PostgreSQL, Accessed through: https://www.postgresql.org/, Accessed on August 2021.

BT252	TRANSPORT PHENOMENA IN BIOPROCESS SYSTEMS	PCC	3–0–0	3 Credits

Prerequisites:

i. BT101 Biology for Engineers
ii. PH101 Engineering Physics

Course Outcomes:

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

CO1	Understand various fluid properties, momentum transfer and isothermal systems
CO2	Understand the mechanisms of heat transfer in a bioreactor
CO3	Understand diffusion properties, film theory concepts and mass transfer between various states
CO4	Application of momentum, mass and energy transfer in biological systems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	-	1	-	1	-	1	1	3	1	-
CO2	3	2	1	2	1	-	1	-	1	-	1	1	3	1	-
CO3	2	2	1	1	1	-	-	-	-	-	-	1	2	-	-
CO4	-	2	2	3	2	1	-	-	1	-	-	-	-	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Momentum transport: Mechanism of Momentum Transport: Newton's Law of Viscosity, Non-Newtonian fluids, theory of viscosity of liquids, time dependent viscosity, rheological properties of fermentation broth, velocity distribution in laminar flow and turbulent flow Equation of change for isothermal system (equation of continuity, equation of motion - Bernoulli's equation), boundary layer concepts, interphase transport in isothermal systems (friction factors for flow in tubes and in packed columns).

Unit II

Energy transport: type of heat transfer, Fourier's law, steady state conduction, heat transfer to fluids with and without phase change, heat exchange equipment, temperature distribution in turbulent flow-reference to stirred tank reactor.

Unit III

Mass transport: Diffusivity, theory of diffusion, mass transfer theories, Definition and experimental measurement of mass transfer coefficients, concentration distribution with more than one independent variable- unsteady diffusion, concentration distribution in turbulent flow. Convective mass transfer, liquid-liquid mass transfer, solid-liquid mass transfer, gas-liquid mass transfer.

Analogy between mass, heat and momentum transfer and applications in biological systems

Text Books:

1. Bird, R. B., Stewart, W. E., & Lightfoot, E. N. (2006). *Transport phenomena* (2nd ed.). John Wiley & Sons.
2. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.
3. McCabe, W. L., Smith, J. C., & Harriott, P. (2005). *Unit operations of chemical engineering* (7th ed.). McGraw Hill Education.
4. Treybal, R. E. (1981). *Mass transfer operations* (3rd ed.). McGraw Hill Education.
5. Blanch, H. W., & and Clark, D. S. (2014). *Biochemical engineering* (3rd ed.). CRC Press.
6. Shuler, M. L., Kargi, F., & DeLisa, M. (2017*). Bioprocess engineering: Basic concepts* (3rd ed.). Pearson.

BT253	CELL BIOLOGY	PCC	3–0–0	3 Credits

Prerequisites:

i. BT101 Biology for Engineers

Course Outcomes:

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

CO1	Understand the cell theory and cellular compartmentalization
CO2	Understand the structure and function of the plasma membrane and cell organelles.
CO3	Understand the molecular mechanisms of cell cycle and signal transduction
CO4	Understand the significance of apoptosis in cellular regulation and relate the importance of cell cycle on cancer development

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-		1	1	-	-	-	-	-	-	-	3	-	-
CO2	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
CO3	3	-	-	1	1	-	-	-	-	-	-	-	3	-	-
CO4	3	2	-	1	-	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Cell structure and function: Discovery of cells & Basic properties of cell, Cell theory; Cell complexity, Different classes of cells; Prokaryotic & Eukaryotic cell. Intracellular Compartments: Structure and functions of Nucleus, Endoplasmic Reticulum, Golgi complex, Mitochondria, Lysosomes, Peroxisomes, Plastids etc.

Unit II

Cell Membranes: Introduces membrane components, phospholipid bilayers, Membrane proteins and their interaction in real membranes, Basics of membrane transport systems (both active and passive). Cell division: Molecular Mechanics of Mitosis & Meiosis, Checkpoint cell cycle control, Activation and control of cyclin dependent kinase activity.

Unit III

Cell signaling: Intracellular signaling and types of signal receptors, Chemoreceptors of Bacteria (Attractants & Repellents), Signal Transduction by hormones - Steroid / Peptide hormones, Concept of Secondary messengers, cAMP, cGMP, Protein Kinases, G Proteins, Receptors & Non-receptors associated tyrosine kinases, Protein kinase receptors (calmodulin, RAS, RAF, MAPK), Cytokine receptor-JAK-STAT signaling pathway.

Unit IV

Cell differentiation, Cancer biology basics, Characteristics of Cancer Cells, Types of Tumors, Molecular Basis of Cancer – Proto oncogene, Tumor Suppressor gene. Concepts of

Apoptosis, Ubiquitin Proteasome Pathway, Autophagy and Mitophagy, Aging and Senescence.

Text Books:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). Garland Science.
2. Cooper, G. M., & Hausman, R. E. (2015). *The cell: A molecular approach* (7th ed.). Oxford University Press.
3. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman.
4. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2015). *Harper's illustrated biochemistry* (30th ed.). McGraw-Hill Education.

BT254	MOLECULAR BIOLOGY AND GENETICS	PCC	3–0–0	3 Credits

Prerequisites:

i. BT201 Microbiology
ii. BT202 Biochemistry

Course Outcomes:

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

CO1	Understand the structure of prokaryotic and eukaryotic genomes
CO2	Understand the mechanism of DNA replication in prokaryotes and eukaryotes
CO3	Understand the molecular mechanisms of central dogma and gene regulation
CO4	Understand Mendelian genetics and determine the recombinant frequencies

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	2	3	-	-	-	-	-	-	3	-	-
CO2	3	-	-	-	2	3	-	-	-	-	2	2	3	1	1
CO3	3	-	-	-	2	3	-	-	-	-	2	2	3	1	1
CO4	3	2	-	3	3	3	-	-	-	-	2	-	3	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Genome Anatomies: Anatomy of Prokaryotic Genome, Anatomy of Eukaryotic Genome, unusual chromosomal types, Eukaryotic Organelle genomes.

Unit II

Genome Replication: DNA Replication mechanisms, issues relevant to genome Replication, topological problem, diverse function of DNA Topoisomerase, Genetic Recombination, transposons, DNA repair processes.

Unit III

Transcription: first step in Gene Expression, Accessing Genome, Assembly of Transcription Initiation Complexes of Prokaryotes and eukaryotes, Regulation of Transcription Initiation. RNA processing: Processing of mRNAs, Synthesis and processing of Non-coding RNAs, Process of pre-RNA by chemical modification, turnover of mRNAs.

Unit IV

Translation: Role of tRNA and ribosome in protein synthesis, Post translational processing of proteins. Gene regulation: Regulation of gene expression in Eukaryotes and Prokaryotes, Conceptof operon structure. Mechanisms of control of Lac and Trp operons.

Unit V

Mendelian Genetics: Principles, Segregation, Independent Assortment, Dominance Relations and Multiple Alleles, Epistasis, Sex Determination and Sex Linkage. Linkage**:** Linkage symbolism, Linkage of Genes on the X Chromosome, Linkage maps, Crossing Over, Chromosomal mapping, Chromosome Variation in Number, Change in Chromosome Structure, Extra Chromosomal Inheritance.

Text Books:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). Garland Science.
2. Freifelder, D. (2004). *Molecular biology* (2nd ed.). Narosa Publishing House.
3. Brown, T. A. (2017). *Genomes 4* (4th ed.). Garland Science.
4. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2008). *Molecular biology of the gene* (6th ed.). CSHL Press.
5. Strickberger, M.W. (2008). *Genetics* (3rd ed.). Prentice Hall of India.

BT255	BIOLOGICAL REACTION ENGINEERING	PCC	3–0–0	3 Credits

Prerequisites:

i. BT203 Bioprocess calculations

Course Outcomes:

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

CO1	Understand the basics of reaction kinetics and reactor design
CO2	Understand the concept of enzyme kinetics and kinetics parameters estimation
CO3	Understand the modelling principles of microbial, substrate and product kinetics
CO4	Understand the concepts of ideal reactors and non-ideality

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	1	3	-	-	-	-	-	-	-	3	-	-
CO2	3	-	-	1	3	-	-	-	-	-	-	-	3	1	-
CO3	3	-	-	1	3	-	-	-	-	-	-	-	3	-	-
CO4	3	-	-	2	3	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to reaction kinetics: Introduction to ideal reactor (batch and continuous reactors), performance equations, Levenspiel plot, elementary and non-elementary reactions, homogenous and heterogenous reactions, the effect of concentration and temperature on rate kinetics. Rate equations, concepts of molecularity, order, and mechanisms; Interpretation of batch reactor data, constant volume batch reactor, integral and differential methods

Unit II

Enzyme kinetics: mechanisms, substrate and product inhibition kinetics, and kinetics parameter estimation, immobilization of enzyme and kinetics

Unit III

Microbial kinetics: modelling of growth curve, balanced growth models, substrate utilization models - Monod equation and its modifications, unstructured and structured models, morphology-based models, product formation kinetics

Unit IV

Ideal reactors and Non-ideality: Batch and plug flow and CSTR reactors, non-ideality, RTD, concept of tracer studies, construction of C, E and F curves, selection of suitable reactor systems for multiple reactions, Models of non-ideal reactors.

Text Books:

1. Levenspiel, O. (1998). *Chemical reaction engineering* (3rd ed.). John Wiley and Sons.
2. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.
3. Bailey, J. E., & Ollis, D. F. (1989). *Biochemical engineering fundamentals* (2nd ed.) Mc Graw Hill Education.
4. Ravi, R., Vinu, R., & Gummadi, S. N. (2017). *Chemical and biochemical reactors and reaction engineering, Volume 3A, Coulson and Richardson's chemical engineering* (4th ed.). Butterworth-Heinemann.
5. Nithya, M. & Seenivasan A. (2022). *Design and kinetics of homogenous biochemical reactors*. In Bioprocess Engineering & Technology: Fundamentals, Upstream and Downstream Processing and Plant Design, Vol-II (Bioprocess Engineering and Technology: Upstream Process). CRC Press.

BT256	TRANSPORT PHENOMENA IN BIOPROCESS SYSTEMS LAB	PCC	0–0–3	2 Credits

Pre-requisites:

i. PH101 Engineering Physics

Course Outcomes:

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

CO1	Estimate various properties of fluids in aspects of industrial application
CO2	Understand the various types of fluid flow and Reynolds number.
CO3	Understand heat transfer mechanisms.
CO4	Understand diffusion in gases and simple mass transfer operations.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	1	1	-	2	-	-	1	-	-	2	1	1
CO2	2	3	3	1	1	-	2	-	-	1	-	-	2	1	1
CO3	2	3	3	1	1	-	2	-	-	1	-	-	2	1	1
CO4	2	3	3	1	1	-	2	-	-	1	-	-	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Determination of dynamic viscosity of liquids.
2. Flow measurement using venturimeter/orificemeter/ Pitot-tube.
3. Reynolds experiment to demonstrate various types of flow.
4. Flow through packed bed and fluidized bed reactor column.
5. Heat conduction experiment to determine the thermal conductivity.
6. Natural and forced convention to correlate theoretical and experiment heat transfer coefficient.
7. Heat transfer characteristics in heat exchange equipment.
8. Estimation of Terminal settling velocity to design a thickener.
9. Separation of liquids using Batch distillation.
10. Extraction mass transfer operation (liquid-liquid /solid-liquid).
11. Drying characteristics of biomass.

Text Books:

1. Penney, W. R., & Clausen, E. C. (2018). *Fluid mechanics and heat transfer: Inexpensive demonstrations and laboratory exercises* (1st ed.). CRC Press.
2. McCabe, W. L., Smith, J. C., & Harriott, P. (2005). *Unit operations of chemical engineering* (7th ed.). McGraw Hill Education.
3. Treybal, R. E. (1981). Mass transfer operations (3rd ed.). McGraw Hill Education.

BT257	CELL AND MOLECULAR BIOLOGY LAB	PCC	0–0–3	2 Credits

Prerequisites:

i. BT205 Microbiology Lab
ii. BT206 Biochemistry Lab.

Course Outcomes:

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

CO1	Demonstrate safe laboratory practices and handle the equipment safely
CO2	Isolation and detection of nucleic acids from different organisms using Gel-electrophoresis
CO3	Microscopic detection of cell counting, staining and cell viability
CO4	Separation and determining various phases of cell division in eukaryotic cell

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	1	-	-	-	3	-	3	-	-	2	2	3	3	1
CO2	2	1	-	1	-	2	-	-	-	-	2	3	3	3	1
CO3	2	1	-	1	-	2	-	-	-	-	2	3	3	3	1
CO4	2	1	-	1	-	3	-	-	2	-	2	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Demonstrate safe laboratory practices and handle the equipment safely
2. Isolation and detection of Genomic DNA from Bacteria
3. Isolation and detection of Plasmid by Alkali Lysis Method
4. Isolation and detection of Genomic DNA from Blood Cells
5. Isolation and detection of genomic DNA from Plant Tissue
6. Cell viability and membrane permeability
7. Separation of RBC, WBC and its microscopic observation
8. Cell counting using hemocytometer
9. Phases of cell division.

Text Books:

1. Sambrook, J. & Russell, D. (2004). *Molecular cloning: A laboratory manual* (3rd ed.). CSHL Press.
2. Gerstein, A. S. (2001). *Molecular biology problem solver: A laboratory guide* (1st ed.). John Wiley & Sons.

BT301	BIOPROCESS ENGINEERING	PCC	3–0–0	3 Credits

Prerequisites:

i. BT203 Bioprocess calculations
ii. BT204 Chemical and Biochemical Thermodynamics

Course Outcomes:

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

CO1	Understand the basis of upstream bioprocessing for batch and continuous processes
CO2	Design batch and continuous bioreactors and scale-up concepts
CO3	Understand the broth rheology and mass transfer concepts
CO4	Understand the importance of controls and instrumentations in the bioreactor

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	-	2	-	-	-	-	-	-	-	-	3	2	-
CO2	3	3	-	3	-	-	-	-	-	-	-	-	3	-	-
CO3	-	3	3	3	-	-	-	1	-	-	-	-	3	-	-
CO4	2	3	3	3	-	-	-	-	-	-	-	-	3	3	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction: Role of a bioprocess engineer, overview of fermentation, primary and secondary metabolites, process parameters (biological, chemical and physical), design and optimization of process parameters, submerged and solid-state fermentation processes.

Unit II

Sterilization: Media sterilization; kinetics of thermal death of cells & spores, design of batch and continuous thermal sterilization, sterilization of air and filter design, Radiation and chemical sterilization.

Unit III

Reactor Design: Batch, fed-batch and continuous processes, CSTR with washout concept and recycling of biomass, Bioreactor considerations for animal and plant cell culture and immobilized enzymes, high density cell culture and algal growth

Unit IV

Rheology of fermentation fluids: Newtonian and non-Newtonian fluids, aeration and agitation, power requirement for gassed and un-gassed systems, gas holdup, mixing calculations.

Unit V

Mass transfer, Scale up concepts and Instrumentation: Types and theories of mass transfer in biological system, role of diffusion, oxygen uptake, factors affecting oxygen transfer, measurement of K_La, Correlations, Scale up and scale down concepts.

Instrumentation in bioreactors: On-line and off-line measurement various types of microbial and enzyme reactors

Text Books:

1. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.
2. Bailey, J. E., & Ollis, D. F. (1989). *Biochemical engineering fundamentals* (2nd ed.). McGraw Hill Education.
3. Shuler, M. L., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson.
4. Vieth, W. R. (1994). *Bioprocess engineering: kinetics, mass transport, reactors and gene expression* (1st ed.). Wiley.
5. Stanbury, P., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3rd ed.). Butterworth-Heinemann.
6. Lee, J. M. (1992). *Biochemical engineering* (1st ed.). Prentice Hall.
7. Clark, D. S., & Blanch, H. W. (1997). *Biochemical engineering* (2nd ed.). CRC Press.

BT302	IMMUNOLOGY	PCC	3–0–0	3 Credits

Prerequisites:

i. BT101 Biology for Engineers
ii. BT254 Molecular Biology & Genetics

Course Outcomes:

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

CO1	Understand cells and components of innate and adaptive immune responses.
CO2	Understand the organization and expression of Immunoglobulins genes.
CO3	Understand the mechanism of antigen and antibody interaction and immune responses
CO4	Comprehend the role of immune system in maintaining health and protecting from diseases

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	-	1	-	-	-	-	1	3	3	1	-
CO2	3	3	1	2	-	1	-	-	-	-	2	3	3	2	-
CO3	3	3	2	3	-	3	-	-	2	1	3	3	3	3	3
CO4	3	3	3	3	-	3	-	-	3	2	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Immune System, Types of immunity: Innate & Adaptive Immunity, Cells and components of Immune system, Organs of Immune system: Primary lymphoid organs: Structure and Functions, Secondary lymphoid organs: Structure and Functions.

Unit II

Immunogen, Haptens & Adjuvants, Epitope, Immunoglobulin Structure, Immunoglobulin Isotypes: Structure and Functions, Molecular basis of gene rearrangement and Immunoglobulin diversity, Monoclonal Antibodies: Hybridoma Technology and Applications, Recombinant & Chimeric Antibodies, Humanized & Bispecific Antibodies, Immunotoxins, Polyclonal antibodies, Abzymes, Antigen-antibody interactions: Agglutination, Precipitation, Immuno diffusion, ELISA, Immuno electrophoresis.

Unit III

B-cell Maturation & activation by thymus-independent (TI) and thymus-dependent (TD) antigens, T Lymphocyte development and activation: Cell mediated cytotoxic responses, MHC: Structure and Functions.

Unit IV

Complement system, Hypersensitivity reactions, Cytokines, Blood transfusion, Immunological tolerance, Autoimmune disorders, Transplantation, Graft rejection & Immunosuppressive Therapy, Vaccines: Types of Vaccines, Tumor Immunology.

Text Books:

1. Punt, J., Stranford, S., Jones, P., & Owen, J. (2019). *Kuby immunology* (8th ed.). Macmillan Education.
2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2021). *Cellular and molecular immunology* (10th ed.). Elsevier.
3. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2016). *Roitt's essential immunology* (13th ed.). Wiley-Blackwell.

BT303	GENETIC ENGINEERING	PCC	3–0–0	3 Credits

Prerequisites:

i. BT201 Microbiology
ii. BT202 Biochemistry
iii. BT254 Molecular Biology & Genetics

Course Outcomes:

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

CO1	Understand the basic components of genetic engineering
CO2	Understand the molecular techniques in genetic engineering.
CO3	Understand the basic principles of DNA sequencing and mutagenesis
CO4	Apply the concepts of genetic engineering for biotechnological applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	-	-	-	-	-	2	3	3	3	1
CO2	3	3	3	3	1	-	-	-	-	-	2	3	3	3	2
CO3	3	3	3	3	1	-	-	-	-	-	2	3	3	2	2
CO4	3	3	3	3	2	-	-	2	2	-	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Components of recombinant DNA technology: restriction and modification enzymes, linkers and adaptors, cloning and expression vectors: Plasmids and Phage Vectors, Vectors for insect, yeast and mammalian system, Prokaryotic and eukaryotic host systems, Introducing DNA into host (bacteria, yeast, animal and plant cell), gene transfer by viral transduction, selection marker.

Unit II

Molecular techniques: Electrophoresis (DNA/Protein), blotting techniques, transformation of *E. coli,* PCR, RT-PCR, Real Time PCR, microarray, gene chip, Hybridization: Radio labeling, Fluorescent in situ hybridization (FISH), gene tagging, DNA finger printing. Genomic and cDNA libraries construction, Screening of libraries and recombinant clone selection, hybridization with differential expression and subtractive techniques

Unit III

Sequencing and Mutagenesis: Basic DNA sequencing, whole genome sequencing, analyzing sequence data, chromosome walking, shotgun sequencing, concept of next generation sequencing technology, changing genes – site directed mutagenesis, reverse mutagenesis, cassette mutagenesis. Molecular markers: non-PCR based (RFLP) and PCR based molecular marker (RAPD, SSR, AFLP), gene knockout, gene mapping.

Unit IV

Advances and applications: Prokaryotic and eukaryotic expression systems, transgenic animals and plants, molecular pharming, gene therapy, Targeted Genome Editing: RNA Interference (RNAi), CRISPR/Cas9.

Text Books:

1. Primrose, S. B., Tywman, R. M., & Old, R. W. (2001). *Principles of gene manipulation* (6th edition). Blackwell Publishing Company.
2. Glick, B. R., & Patten, C. L. (2017). *Molecular biotechnology: Principles and applications of recombinant DNA* (5th ed.). ASM Press.

BT304	BIOSTATISTICS	PCC	3–0–0	3 Credits

Prerequisites:

i. MA201 Applied Mathematical Methods

Course Outcomes:

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

CO1	Understand the mathematical basis and foundations of probability and statistics
CO2	Apply statistical methods to solve biological problems
CO3	Analyze the big data (biology and clinical) using modern statistical tools

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	3	-	-	-	-	1	-	2	3	-	1
CO2	3	-	-	-	-	-	-	-	2	-	-	1	3	-	-
CO3	3	2	-	-	3	-	-	2	-	-	-	1	3	2	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to biostatistics and organization of data, data type, graphical and pictorial presentation of data, measures of central tendency and dispersion, sampling techniques, sample size, coefficient of variation, means error, relative error, precision and accuracy.

Unit II

Introduction to probability, Bayes' theorem, probability distributions, binomial distribution, poisson distribution, normal distribution. Parametric and Non-parametric tests: Testing hypothesis, types of errors, tests of significance based on normal distribution, Data characteristics and nonparametric procedures, chi square test, sign test.

Unit III

ANOVA, linear and multiple regression and correlation, method of least squares, significance of correlation and regression. Test of significance for correlation coefficients. Experimental design, Randomization, completely randomized and Latin square designs, factorial design, crossover and parallel designs.

Unit IV

Statistical machine learning, Introduction to Big data analytics, data analytics lifecycle: discovery, data preparation, model planning, model building, communicate results, operationalize, applied data science with R.

Text Books:

1. Wayne, W. D, & Cross, C. L. (2018). *Biostatistics: A foundation for analysis in the health sciences* (11th ed.). John Wiley and Sons.
2. Bernard, R. (2011). *Fundamentals of biostatistics* (7th ed.). Brooks/Cole.
3. Motulsky, H. (2017). *Intuitive biostatistics: A nonmathematical guide to statistical thinking* (2nd ed.). Oxford University Press.
4. EMC Education Services. (2015). *Data Science and big data analytics: Discovery, analyzing, visualizing and presenting data* (1st ed.). John Wiley & Sons.

BT305	BIOPROCESS ENGINEERING LABORATORY	PCC	0–0–3	2 Credits

Prerequisites:

i. BT301 Bioprocess Engineering

Course Outcomes:

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

CO1	Predict the kinetics of cell and enzymatic reaction
CO2	Planning, collection and analysis of experimental data
CO3	Calculation of design data for the kinetics and reactor design

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	3	3	-	-	-	-	-	-	-	3	-	-
CO2	2	3	-	3	3	-	-	-	-	-	-	-	3	-	-
CO3	2	3	1	3	1	-	-	-	-	-	-	-	3	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Culturing of bacteria in Batch and Fed-Batch process and its kinetics analysis
2. Sterilization of media and thermal death kinetics
3. Enzyme Immobilization and enzyme kinetics (Free and immobilized)
4. Effect of temperature, pH and substrate concentration on the enzyme activity
5. Inhibition kinetics and estimation of biomass
6. Reactor component and its operations
7. k_{La} determination
8. Determination of mixing time and power number
9. Residence time distribution experiments
10. Estimation of ammonia and phosphate

Text Books:

1. Das, D., & Das, D. (2021). *Biochemical engineering: A laboratory manual* (1st ed.). Jenny Stanford Publishing.
2. Doran, P. M. (2012). *Bioprocess engineering principles* (2nd ed.). Academic Press.

BT306	GENETIC ENGINEERING LABORATORY	PCC	0–0–3	2 Credits

Prerequisites:

i. BT205 Microbiology lab

ii. BT257 Molecular Biology and Genetics lab

Course Outcomes:

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

CO1	Learn basic laboratory practices and proper handling of laboratory equipment
CO2	Understand the methods of DNA amplification and manipulation
CO3	Perform genetic engineering procedures and interpret the experimental data

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	3	2	-	-
CO2	3	3	3	2	1	-	-	-	1	-	2	3	3	1	-
CO3	3	3	3	3	1	1	-	-	2	2	3	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Amplification of DNA fragment by PCR
2. Molecular weight determination of amplified PCR product
3. Gel elution of PCR product
4. Restriction digestion of DNA
5. Ligation of DNA
6. Preparation of competent cell and storage
7. Transformation of recombinant plasmid into competent cell and blue white Screening
8. Analysis of DNA polymorphism using RAPD/RFLP/AFLP marker.

Text Books:

1. Sambrook, J. & Russell, D. (2004). *Molecular cloning: A laboratory manual* (3rd ed.). CSHL Press.
2. Vennison, S. J. (2009). *Laboratory manual for genetic engineering*. PHI Learning.

BT351	DOWNSTREAM PROCESSING TECHNOLOGY	PCC	3–0–0	3 Credits

Prerequisites:

i. BT204 Chemical and Biochemical Thermodynamics
ii. BT252 Transport phenomena in biological system

Course Outcomes:

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

CO1	Understand the basis of separation of biomolecules
CO2	Understand the principles of major unit operations of biopharmaceuticals.
CO3	Design and optimization of downstream processes
CO4	Understand the principles of product purification and storage

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	1	-	-	-	-	-	-	-	-	-
CO2	2	2	2	-	-	-	-	-	-	1	-	-	2	-	-
CO3	3	2	3	-	2	-	-	1	-	-	2	-	-	1	-
CO4	3	2	2	1	1	-	-	-	-	-	-	1	-	-	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Scope of Downstream Processing: Importance of downstream processing (DSP) in biotechnology, Characteristics of products, criteria for selection of bio-separation techniques. Role of DSP methods in bioprocess economics, Role of upstream processing on DSP - microbial protein expression and purification.

Unit II

Cell disruption methods: Various cell disruption methods, need for cell disruption for intracellular products, cell disruption equipment. Applications in bio-processing.

Unit III

Separation techniques: Filtration, Sedimentation, Centrifugation (basket centrifuge, tubular centrifuge, disc-bowl centrifuge), Adsorption, Extraction methods – solid liquid extraction, liquid-liquid extraction, aqueous two-phase extraction, Distillation.

Unit IV

Purification technique: Precipitation, Dialysis, Membrane separation processes, Principles of chromatographic separation methods- ion–exchange chromatography, gel chromatography, affinity chromatography.

Product polishing: Crystallization, drying – spray and freeze drying, formulation and storage.

Text Books:

1. Harrison, R. G., Todd, P., Rudge, S. R., & Petrides, D. P. (2015). *Bioseparations science and engineering* (2nd ed.). Oxford University Press.
2. Belter, P. A., Cussler, E. L., & Hu, W. Bioseparations: *Downstream processing for biotechnology*. Wiley Publications.
3. Ghosh, R. (2006). *Principles of bioseparations engineering*. World Scientific Publishing Company.
4. Weatherley, L. R. (1994). *Engineering processes for bio separations* (1st ed.). Butterworth-Heinemann.
5. BIOTOL. (1992). *Product recovery in bioprocess technology* (1st ed.). Butterworth-Heinemann.
6. Ronald, & Lee, J. (2007). *Principles of downstream processing* (1st ed.). Wiley Publications.
7. Stanbury, P., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3rd ed.). Butterworth-Heinemann.

BT352	ANALYTICAL METHODS IN BIOTECHNOLOGY	PCC	3-0-0	3 Credits

Prerequisites:

i. PH101 Engineering Physics
ii. CH101 Engineering Chemistry
iii. BT202 Biochemistry

Course Outcomes:

At the end of the course, students are able to

CO1	Understand the basics of bioanalysis and types of bioanalytical instruments
CO2	Apply spectroscopic techniques for characterization of biomolecules
CO3	Select the appropriate chromatographic technique for bioanalysis

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-
CO2	3	-	-	2	3	-	-	2	-	-	-	-	3	3	-
CO3	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO4	3	-	-	1	3	-	-	2	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction, Modern approaches in Bioanalysis and Bioassays, Microscopy Techniques- Dark-field, Phase contrast, Fluorescence, Confocal, Polarization microscopy; SPM, AFM, Electron microscopy: TEM & SEM. Radioisotope techniques- Basic concepts, GM and scintillation counter, autoradiography, RIA, Applications in biological science. Detection of biomolecules by Thermal methods.

Unit II

Molecular Spectroscopic techniques: Basic concepts and experimental methods of UV-Visible spectroscopy, Fluorescence spectroscopy, CD spectroscopy, NMR, X-ray, and Mass spectroscopy atomic absorption spectroscopy (AAS, inductively coupled plasma emission (ICP/AES), Fourier transform infrared spectrometry (FTIR).

Unit III

Advanced chromatographic techniques— Mass Spectrometry – various ionization methods – EI, CI, ESI and MALDI methods, HRMS. Gas Chromatography (GC) with detectors—electron capture (ECD), flame ionization (FID), and mass spectrometry (MS), Liquid chromatography with mass spectroscopy (LC-MS), high performance thin layer chromatography (HPTLC).

Text Books:

1. Wilson, K., & Walker, J. (2005). *Principles and techniques of biochemistry and molecular biology* (6th ed.). Cambridge University Press.
2. Pavia, D. L., Lampman, G. M, Kriz, G. S., & Vyvyan, J. R. (2015). *Introduction to spectroscopy* (5th ed.). Cengage Learning.
3. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2018). *Principles of instrumental analysis* (7th ed.). Cengage Learning.

SM355	Engineering Economics and Management	HSC	3 – 0 – 0	3 Credits

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

CO1	Evaluate the economics of the management, operation, and growth and profitability of engineering firms and analyze operations of markets under varying competitive conditions
CO2	Analyze cost/revenue data and carry out economic analyses in the decision-making process to justify existing/finding alternative projects on an economic basis
CO3	Produce a constructive assessment of a social problem by drawing the importance of environmental responsibility and demonstrate knowledge of global factors influencing business and ethical issues.
CO4	Apply models to describe economic phenomena; analyze and make predictions about the impact of government intervention and subsequent changing market conditions on consumer-producer relationship

Syllabus:

General Foundations of Economics: Forms of organizations-Objectives of firms-Opportunity Principle-Discounting-Production possibility frontier-Central problems of an economy- Two sector, Three sector, and Four sector circular flow of income-Demand analysis-Individual, Market and Firm demand- Determinants of demand and supply- Shifts and changes in demand and supply- Market equilibrium, Shortages versus surpluses- Elasticity of demand and business decision making

Production functions in the short and long run-Cost concepts- Short run and long run costs-economies and diseconomies of scale--Product markets- Market structure-Competitive market- Imperfect competition (Monopoly, Monopolistic competition and Oligopoly) Price discrimination- Game Theory--Maximin, Minimax, Saddle point, Nash Equilibrium, Prisoners' Dilemma- Monetary system-Indian stock market- Development Banks-NBFIs- role of Reserve Bank of India, Money Market, Capital market; NIFTY, SENSEX.

Brief introduction to data analytics as a tool in terms of understanding the markets, performances of indexes, performance of various sectoral indexes.
Introduction to Management Theory and Functional Areas-Marketing-HR and Finance-Financial Management-Financial Statements-Profit and Loss Statements-Fund Flow Statement-Balance Sheets-Ratio Analysis-Investment and Financial Decision—Inventory Management-Functions and Objectives of Inventory Management—Decision Models-Break even analysis-Economic Order Quantity (EOQ)-Model Sensitivity Analysis of EOQ model

Reference:

1. K. E. Case, R. C. Fair and S. Oster, *Principles of Economics*. Prentice Hall, 10th ed., 2011.
2. Maheswari,Anil.*Data Analytics*.Mc Graw Hill, 2017
3. N. G. Mankiw,*Principles of Microeconomics*. Cengage Publications,7th ed.,2014.
4. P.A. Samuelson and W.D Nordhaus. *Economics*. Tata Mcgraw Hill, 19th Ed., 2017.
5. R.S. Pindyck, D.L. Rubinfield and P.L. Mehta,*Microeconomics*,Pearson Education, 9th Edition, 2018.
6. R.W.Griffin, *Management,Principles and Practices*. Cengage India,11th ed.,2017.
7. S. B. Gupta. *Monetary Economics: Institutions, Theory & Policy*,New Delhi: S. Chand & Company Ltd., 2013.

BT353	DOWNSTREAM PROCESSING TECHNOLOGY LAB	PCC	0–0–3	2 Credits

Prerequisites:

i. BT202 Biochemistry

Course Outcomes:

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

CO1	Apply the knowledge to select appropriate downstream process
CO2	Plan experiments, collect and analysis the data
CO3	Calculation of design data for separation, purification and polishing operations

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	3	-	-	-	-	-	-	-	-	2	-	-
CO3	3	1	-	3	-	-	-	-	-	-	-	-	-	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Localization of enzyme and cell lysis using physical and chemical methods
2. Solid – liquid separation methods (filtration and centrifugation)
3. Extraction methods (solid-liquid, liquid-liquid and aqueous two phase)
4. Precipitation of protein
5. Dialysis for desalting the macromolecules
6. Chromatography for separation of biological molecules based on charge/size.
7. Membrane separation
9. Lyophilization for preservation of biological product
10. Stability analysis of protein during storage

Text Books:

1. Ahuja, S. (2000). *Handbook of bioseparations – volume 2*. Academic Press.
2. Desai, M. A. (2012). *Downstream processing of proteins: methods and protocols*. Humana Press.
3. Scopes, R. K. (1994). *Protein purification: Principles and practice* (3rd ed.). Springer.
4. Wilson, K. & Walker, J. M. (2000). *Principles and techniques of practical biochemistry* (5th ed.). Cambridge University Press.

BT401	BIOINFORMATICS	PCC	3-0-0	3 Credits

Pre-Requisites:

i. BT202 Biochemistry
ii. BT254 Molecular Biology & Genetics

Course Outcomes:

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

CO1	Understand the biological sequences, algorithms for sequence alignments, and phylogenetic analysis.
CO2	Understand the types of biological databases available in the open-source domain.
CO3	Perform the homology search and sequence evolution identification.
CO4	Understand the principles of protein structure and drug discovery.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	1	3	-	-	2	-	-	-	-	3	1	2
CO2	3	-	-	1	3	-	-	2	-	-	-	-	3	1	-
CO3	3	-	-	1	3	-	-	2	-	-	-	-	3	1	2
CO4	3	-	-	2	3	-	-	2	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Historical Introduction and Overview of Bioinformatics, Collecting and Storing Sequences in the Laboratory, Alignment of Pairs of Sequences, Introduction to Probability and Statistical Analysis of Sequence Alignments, Multiple Sequence Alignment, Sequence Database Searching for Similar Sequences.

Unit II

Genome Analysis, Genome organization and evolution, Alignments and phylogenetic trees, Phylogenetic Prediction, Prediction of RNA Secondary Structure, Gene Prediction and Regulation.

Unit III

Protein Classification and Structure Prediction, Structural bioinformatics in drug discovery, Molecular Docking- Rigid docking, flexible docking, manual Docking, docking based Screening, De novo Drug design, Virtual Screening Techniques-Drug likeness screening, Concept of Pharmacore mapping and pharmacophore-based Screening. Bioinformatics Programming Using Perl and Perl Modules, Introduction to systems biology & Metabolic pathways.

Text Books:

1. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis* (2nd ed.); CSHL Press.
2. Lesk, A. M. (2014). *Introduction to bioinformatics* (4th ed.) Oxford University Press.
3. Baxevanis, A. D. (2004). *Bioinformatics: A practical guide to the analysis of genes and proteins* (3rd ed.). Wiley-Interscience.

4. Leach, A. (2001). *Molecular modelling: Principles and applications* (2nd ed.). Prentice Hall.
5. Whitford, D. (2005). *Proteins: Structure and function* (1st ed.). Wiley.

BT402	BIOPROCESS MODELLING AND SIMULATIONS	PCC	3-0-0	3 Credits

Pre-Requisites:

i. BT301 Bioprocess Engineering

Course Outcomes:

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

CO1	Understand the Modelling Principles
CO2	Develop model equations for microbial growth and enzyme kinetics
CO3	Understand and analyze bioreactor modelling and control
CO4	Simulate biological kinetics and processes

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	1	-	-	-	-	2	1	-	1	2	1	1
CO2	3	2	3	2	3	-	-	1	2	-	-	1	3	1	2
CO3	3	1	3	2	-	-	-	1	2	-	2	1	2	2	2
CO4	3	2	3	2	2	-	-	1	2	2	2	1	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction: Modelling principles, Classification of models, use of models for understanding, design and optimization of bioreactors, simulation tools. Formulation of balance equations, types of mass balance equations, balancing procedure, Component balances for reacting systems, Stoichiometry, elemental balancing, yield coefficient concept.

Unit II

Modeling of bioprocess: Type of kinetic models; Mathematical representation of bioprocess; Modeling of microbial cell growth, substrate uptake and product production, Substrate inhibition and product inhibition, Dynamic simulation of batch, fed-batch, steady and transient culture, Modelling of enzyme kinetics, kinetics of enzyme action (mmkinet), lineweaver-burkplot (lineweav). Determination of kLa using - sulfite oxidation reaction and dynamic method.

Unit III

Optimization, Validation and Sensitivity Analysis: Data smoothing and analysis; Numerical Integration techniques; Numerical optimization of bioprocess using mathematical models. Parameter estimation; Parameter sensitivity analysis; Statistical validity;

Unit IV

Simulations of biological processes: batch fermentation (bat ferm), chemostat fermentation (chemo), fed batch fermentation (fed bat), repeated fed batch culture (rep fed), steady-state chemostat(chemostat), variable volume fermentation (varvol and varvold), penicillin fermentation using elemental balancing (penferm), fluidized bed recycle reactor (fbr). Introduction to MATLAB programming.

Unit V

Simulation of biomanufacturing: Introduction to SuperPro Designer, registration of compounds, selection of unit operation and connections, Simulations of manufacturing of few metabolites.

Text Books:

1. Heinzle, E., Dunn, I. J., Ingham, J., & Přenosil, J. E. (2021). *Biological reaction engineering: Dynamic modelling fundamentals with simulation examples* (3rd ed.). Wiley-VCH.
2. Harrison, R. G., Todd, P., Rudge, S. R., & Petrides, D. P. (2015). *Bioseparations science and engineering* (2nd ed.). Oxford University Press.
3. Leigh, J. R. (1987). *Modeling and control of fermentation processes*. Peter Peregrinus.
4. Sablani, S. S., Datta, A. K., Rahman, M. S., & Mujumdar, A. S. (2006). *Hand book of food and bioprocess modelling techniques* (1st ed.). CRC Press.Lesk, A. M. (2014). Introduction to bioinformatics (4th ed.) Oxford University Press.

BT403	ALGAL BIOTECHNOLOGY	PCC	2-0-0	2 Credits

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the Basics of algae technology
CO2	Isolate, Identify, culture and store algae
CO3	Design algal cultivation system for industrial and environmental applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	2	1	3	3	1	-	-	2	-	1	2	1
CO2	3	3	-	-	-	-	1	-	-	-	-	-	-	2	-
CO3	-	2	1	3	3	3	3	-	3	3	3	-	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to algal biotechnology: Resource potential of algae; General characteristics of Algae; Classification of algae; Ecology of algae: Freshwater algae, marine algae, soil algae. Reproduction in algae (vegetative, asexual and sexual methods); lifecycle pattern in Algae; Phylogeny and inter-relationship of algae.

Unit II

Methods of sampling, Isolation - Strain selection, Algal growth curve, Culture media, Measurement of algal growth and conservation of algae. Algal production systems: Outdoor and indoor cultivation methods for large scaling up and its Process parameters. Evaporation and uniform dispersal of nutrients; Downstream processing of algal biomass recovery. Cryopreservation of Algae and its value.

Unit III

Algae in Future Green fuel; Algae in Phycoremediation; Algae and its value added product in Food, Pharmaceutical and Nutraceutical industries, Algae in Carbon sequestration.

Text Books:

1. Becker, E. W. (1994). *Microalgae: Biotechnology and microbiology.* Cambridge University Press.
2. Bold, H. C. & Wyne, M. J. (1978). *Introduction of algae: Structure and reproduction* (1st ed.). Prentice Hall.
3. Chapman, C. J. & Chapman, D. J. (1981). *The algae* (2nd ed.). Macmillan Publishers.
4. Darley, W. M. (1982). *Algal biology: A physiological approach.* Blackwell Scientific Publications.
5. Fritsch, F. E. (1976). *Structure and reproduction of the Algae (Vol. I & II)*. Cambridge University Press.
6. Round, F. E. (1981). *The ecology of algae* (1st ed.). Cambridge University Press.
7. Sharma, O. P. (1986). *Textbook of algae*. Tata McGraw Hill.
8. Smith, G. M. (1976). *Cryptogamic botany: Algae and fungi (Vol. I.)*. Tata McGraw Hill.
9. Trivedi, P. C. (2001). *Algal biotechnology.* Pointer Publishers.

10. Venkataraman, L. V. & Becker, E.W. (1985). *Biotechnology and utilization of algae – The Indian experience.* Dept. of Science and Technology, New Delhi and Central Food Technological Research Institute, Mysore.Harrison, R. G., Todd, P., Rudge, S. R., & Petrides, D. P. (2015). Bioseparations science and engineering (2nd ed.). Oxford University Press.

BT404	BIOINFORMATICS LABORATORY	PCC	0-0-3	2 Credits

Pre-Requisites: None

Course Outcomes:

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

CO1	Retrieve data from open-source biological databases.
CO2	Use open-source tools for biological sequence analysis.
CO3	Identify the evolutionary relationships using biological sequences.
CO4	Construct and analyze protein models, function, and interaction using bioinformatic tools.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	-	-	3	1	2	-	-	-	-	-	3	1	-
CO2	2	2	2	3	3	2	2	-	-	-	-	-	-	2	-
CO3	2	1	1	3	2	3	1	-	-	-	-	-	3	3	-
CO4	3	3	3	3	3	3	3	-	-	-	-	-	3	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Overview of Biological Databases
2. Sequence Retrieval from NCBI
3. Structure Retrieval from PDB
4. Pairwise Alignment (LOCAL and GLOBAL ALIGNMENT)
5. Multiple Sequence Alignment and Phylogenetic Tree Building (CLUSTAL O)
6. Finding homologues sequence in a database using BLAST
7. Designing of primer for a nucleotide sequence
8. Gene Prediction (GENSCAN)
9. Finding the restriction sites
10. Protein Structure Visualization (RASMOL/PYMOL)
11. Protein Homology Modelling
12. Molecular Docking and interaction Analysis (using iGEMDOCK)

Text Books:

1. Craig, P. Bioinformatics exercises. Rochester Institute of Technology.

Online Resources:

1. Website tutorials @ NCBI, PDB.

DEPARTMENT ELECTIVE COURSES

BT361	INDUSTRIAL BIOTECHNOLOGY	DEC	3–0–0	3 Credits

Prerequisites:

i. BT201 Microbiology

ii. BT301 Bioprocess Engineering

Course Outcomes:

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

CO1	Understand the use of living cells in industry
CO2	Understand the commercial production processes in the biotechnology industry
CO3	Understand and apply the industrial level production processes for economically valuable products
CO4	Develop the bioprocess for production of industrial products

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	1	-	2	3	1	-	-	-	-	3	1	2
CO2	1	3	1	1	-	2	2	1	-	-	-	-	3	2	1
CO3	2	2	3	1	2	2	2	1	-	-	-	-	3	3	1
CO4	1	2	3	3	3	3	2	1	-	-	1	1	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to industrial biotechnology, Outline of industrial biotechnological process. Production of biomass, primary and secondary metabolities: Commercial production of Organic Acids and bulk organics (ethanol). Commercial production of Antibiotics, Extra cellular poly saccharides (Xanthan Gum), Pigments (Shikonin).

Unit II

Microbial production of industrial enzymes: glucose isomerase, cellulase, lipases, amylase, protease, Production of Fermented Foods, Single Cell Protein.

Unit III

Commercial production of recombinant therapeutic proteins, Microbial Transformations (Steroids), Transformation of steroids and sterols, Transformation of non-steroidal compounds, Applications of bioconversions. Screening strategies for new products.

Text Books:

1. Okafor, N. (2007). *Modern industrial microbiology and biotechnology* (1st ed.) Science Publishers.
2. Stanbury, P., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3rd ed.). Butterworth-Heinemann.

BT362	NANOBIOTECHNOLOGY	DEC	3–0–0	3 Credits

Prerequisites:

i. PH101 Engineering Physics
ii. CY101 Engineering Chemistry
iii. BT101 Biology for Engineers

Course Outcomes:

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

CO1	Understand the basic principles of nanotechnology
CO2	Understand physical, chemical and biological methods for synthesis of nano materials
CO3	Apply the concepts of nanotechnology for biosensors
CO4	Apply the concepts of nanotechnology for drug delivery and gene therapy.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	-	2	-	2	-	-	-	-	-	-	3	1	-
CO2	1	2	-	2	2	1	-	-	-	-	-	-	3	-	-
CO3	2	1	1	2	2	-	-	-	1	-	-	-	3	-	-
CO4	3	1	-	1	1	-	1	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Nanotechnology: Top down and bottom up approaches- Nano-biotechnology, Types of nanomaterials: Nanoparticles, Nanowires, Nanotubes, Thin films and Multilayers, Properties of Nanomaterials, Biomolecules as Nanostructures, Molecular Motors.

Unit II

Methods of preparation of nanomaterials, Nanoparticle synthesis using microbes, Basic characterization techniques: Electron microscopy, Atomic force microscopy, Photon correlation spectroscopy, X-ray diffraction analysis, Thermogravimetric analysis. Functionalization of nanomaterials for biological applications.

Unit III

Applications of nanomaterials in optical biosensors and imaging, quantum dots, Nanomaterials in electrochemical biosensors, Nanomaterials in bio separation.

Unit IV

Nanostructures for drug delivery, Nanovesicles; Nanospheres; Nano capsules, Magnetic nanoparticles; Liposomes; Dendrimers, Concepts, Targeting, Routes of delivery and advantages, Drug-Photodynamic therapy, gene therapy. Recent trends in nanobiotechnology.

Text Books:

1. Ratner, M., & Ratner, D. (2003). *Nanotechnology – a gentle introduction to the next big idea* (1st ed.), Pearson education.
2. Niemeyer, C. M., & Chad A. Mirkin, C. A. (2004). *Nanobiotechnology: Concepts, applications and perspectives* (1st ed.). John Wiley & Sons.
3. Foster, L. E. (2005). *Nanotechnology - science, innovation and opportunity*. Person Education.

BT363	BIOPHARMACEUTICAL TECHNOLOGY	DEC	3–0–0	3 Credits

Pre-requisites:

i. BT201 Microbiology
ii. BT202 Biochemistry
iii. BT253 Cell Biology

Course Outcomes:

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

CO1	Understand the different forms of drugs and their delivery
CO2	Understand the pharmacodynamics and pharmacokinetics of drugs
CO3	Classify biopharmaceutical and their manufacturing process
CO4	Apply recombinant DNA technology for the production biopharmaceuticals

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	1	-	3	2	1	-	-	-	3	3	2	3
CO2	2	3	3	2	3	1	-	1	-	-	-	1	3	1	2
CO3	2	3	3	3	2	2	2	1	-	-	-	1	3	-	2
CO4	2	3	3	3	2	2	2	2	2	2	2	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

History and definition of drugs, Sources of drugs: plants, animals, microbes and minerals, concepts of drug dosage of solid, semi-solid, liquid, aerosol, tablets and capsules, routes of drug administration, controlled and sustained drug delivery, Biomaterials for drug delivery, liposome mediated drug delivery.

Unit II

Pharmacodynamics and pharmacokinetics of drugs, Absorption, Distribution of drugs, Biotransformation and bioavailability of drugs, Dose-response relationships, mechanism of action of drug, theory of drug-receptor, compartment modeling, half-life of drug, Apparent volume, Renal-Plasma clearance, Total-body clearance.

Unit III

Biopharmaceutical products and their importance, manufacture of tablets, compressed tablets wet and dry granulation; slugging or direct compression direct compression, coating of pills, capsules, parental solution, oral liquids, ointment, Laxatives, Analgesics, non-steroidal contraceptives, analytical and testing methods used in drug manufacture, packing techniques; quality management; Good manufacturing practices.

Unit IV

Monoclonal antibodies, production of monoclonal antibodies, Biological Hormones: insulin, glucagon, human growth hormone, gonadotrophins, human growth hormone, Cytokines, Interferons, Tumor Necrosis Factor (TNF), transgenic animals and plants, recombinant DNA technology and its application in biopharmaceutical industry.

Text Books:

1. Walsh, G. (2003). *Biopharmaceuticals: Biochemistry and biotechnology* (2nd edn.). John Wiley and Sons.
2. Brunton, L. L., Hilal-Dandan, R., & Knollmann, B. C. (2018). *Goodman & Gilman's the pharmacological basis of therapeutics* (13th ed.). McGraw-Hill Education.
3. Primrose, S. B., Tywman, R. M., & Old, R. W. (2001). *Principles of gene manipulation* (6th edition). Blackwell Publishing Company.

BT372	METABOLIC REGULATION AND ENGINEERING	DEC	3– 0–0	3 Credits

Prerequisites:

i. BT202 Biochemistry
ii. BT255 Biological Reaction Engineering

Course Outcomes:

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

CO1	Understand the overview of cellular metabolism and its regulation
CO2	Understand regulatory mechanisms involved in biosynthesis of metabolites
CO3	Apply the concept of auxotrophic mutations for the synthesis of metabolites
CO4	Understand the pathway manipulation and apply the modeling tools for metabolic engineering

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	-	2	-	-	-	-	-	-	-	-	3	2	2
CO2	3	-	-	3	-	2	-	-	-	-	-	-	3	2	2
CO3	3	-	-	3	-	2	-	-	-	-	-	-	3	3	3
CO4	2	2	3	2	-		-	3	1	3	-	-	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Basic concepts of Metabolic Engineering – Overview of cellular metabolism – Different models for cellular reactions, induction – Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feedback regulation.

Unit II

Synthesis of primary and secondary metabolites: Amino acid synthesis pathways and its regulation at enzyme level and whole cell level, Alteration of feedback regulation, Limiting accumulation of end products. Regulation of secondary metabolite pathways, precursor effects, prophase, idiophase relationship, Catabolite regulation by passing control of secondary metabolism, producers of secondary metabolites, applications of secondary metabolites.

Unit III

Regulation of enzyme production: Strain selection, Genetic improvement of strains, Gene dosage, metabolic pathway manipulations to improve fermentation, Feedback repression, Catabolite Repression, optimization and control of metabolic activities. **Pathway manipulations:** The modification of existing - or the introduction of entirely new - metabolic pathways

Unit IV

Modeling Tools for Metabolic Engineering: Metabolic Flux and Control Analysis, Modelling of metabolic networks.

Text Books:

1. Wang, D. I. C., Lilly, M. D., Humphrey, A. E., Dunnill, D., Demain, A. L. (2005). *Fermentation and enzyme technology* (1st ed.; Reprint). John Wiley& Sons.
2. Stephanopoulos, G. N., A. Aristidou, A. A. & Nielsen, J. (1998). *Metabolic engineering principles and methodologies*. Academic Press.
3. Smolke, C. (2009). *The metabolic pathway engineering handbook: Tools and applications* (1st ed.). CRC Press.

BT371	PLANT BIOTECHNOLOGY	DEC	3-0-0	3 Credits

Prerequisites:

i. BT202 Biochemistry
ii. BT253 Molecular Biology & Genetics
iii. BT204 Cell Biology
iv. BT304 Genetic engineering

Course Outcomes:

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

CO1	Comprehend the concepts of plant tissue culture techniques
CO2	Understand the technology of plant transformation
CO3	Understand *in vitro* techniques for production of plant secondary metabolites
CO4	Understand the phytochemical production and assessment of transgenic plants

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	-	-	3	2	3	-	-	-	1	2	3	-	2
CO2	-	-	3	-	3	-	3	-	-	-	1	-	-	-	-
CO3	-	3	-	2	-	-	3	-	-	-	1	2	-	3	2
CO4	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Plant Biotechnology, Plant Tissue Culture, Media, Plant growth regulators and elicitors, culture conditions, Sterilization Methods, Totipotency, callus culture and Organogenesis - Expression and importance of totipotency, Principle of callus culture, characteristics and importance of callus culture; principle and factors affecting organogenesis, Applications of organogenesis

Unit II

Regeneration methods of plants in PT cultures, cryopreservation techniques, importance of greenhouse in PTC, cell suspension culture, Anther, protoplast (isolation, culturing and viability), Somatic hybrids and cybrids, Soma clonal variations, Applications of cell and tissue culture.

Unit III

Different plant metabolites and their production methods, Hairy root cultures, immobilized cell systems, Elicitation and Biotransformation. Successful gene transfer mechanism, Direct and Indirect methods, Invitro mutant selection, Agrobacterium mediated gene transfer. Applications of Transgenic plants, Insecticidal, herbicidal and viral resistance, Other applications of Transgenic plants.

Unit IV

Engineering considerations for production of phytochemicals, Alkaloids, useful enzymes, therapeutic proteins, custom-made Antibodies, Edible Vaccines. Transgenic Plant Analysis,

Initial screens, Definitive molecular characterization, Field Testing of Transgenic Plants, Environmental risk assessment, Controversy on transgenic plants.

Text Books:

1. Slator, A., Scott, N. W., & Fowler, M. R. (2008). *Plant biotechnology: The genetic manipulation of plants* (2nd ed.). Oxford University Press.
2. Stewart, C. N. (2008). *Plant biotechnology and genetics: Principles, techniques and applications* (2nd ed.). John Wiley and Sons.
3. Srivastava, P. S., Narula, A., & Srivastava, S. (2005). *Plant biotechnology and molecular markers*. Springer.
4. Chawla, H. S. (2009). *Introduction to plant biotechnology* (3rd ed.). Science Publishers.
5. Taiz, L. & Zeiger, E. (2010). *Plant physiology* (5th ed.). Oxford University Press.

BT373	ENVIRONMENTAL BIOTECHNOLOGY	DEC	3–0–0	3 Credits

Prerequisites:

i. BT201 Microbiology
ii. BT301 Bioprocess engineering

Course Outcomes:

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

CO1	Understand the biological processes for wastewater treatment
CO2	Understand the biological approaches for solid and hazardous waste management
CO3	Understand the principle and types of bioremediation
CO4	Apply the concepts of biotechnology for metal extraction and remediation

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	1	3	2	-	-	-	-	1	2	-	-
CO2	2	2	2	-	-	2	2	-	-	-	-	1	2	-	-
CO3	2	2	-	-	-	3	2	-	-	-	-	1	2	-	-
CO4	2	2	2	-	-	2	2	-	-	-	-	1	2	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Overview of domestic and industrial waste. Biological Treatment of Wastewater: Introduction – wastewater characteristics and microbial aspects of treatment; Bioreactor systems - activated sludge process, aerated lagoons, trickling filters, Fluidized bed reactor, UASB. Biological removal of nutrients. Micro-pollutants in wastewater, Detection and removal of micropollutants (pesticides, pharmaceuticals and personal care products).

Unit II

Solid waste management: Nature and composition of municipal solid waste. Basic concept of landfill for waste disposal. Biological methods of solid waste management – aerobic (microbial composting and vermicomposting) and anaerobic (anaerobic digestion) methods. Hazardous waste: Introduction, characteristics and management of waste.

Unit III

Bioremediation: Introduction - constraints and priorities of Bioremediation. Engineering strategies employed for microbial bioremediation: *in situ* and *ex situ* strategies. Phytoremediation – introduction and mechanisms. Case study of bioremediation.

Unit IV

Metal Biotechnology: Microbial remediation of heavy metals: fundamental concepts of microbial transformation, accumulation and immobilization of metals. Bioleaching -

Introduction, microorganism involved in bioleaching, bioleaching mechanisms, examples of bioleaching, Biological recovery of metals from e-waste.

Text Books:

1. Rittmann, B. E., & McCarty P. L. (2003). *Environmental biotechnology: principles and applications* (1st ed.). Tata McGraw-Hill Education.
2. Metcalf & Eddy, Inc. (2003). *Waste water engineering treatment and reuse* (4th ed.). McGraw Hill Education.
3. Worrell, W. A., & Vesilind, P. A., & Ludwig, C. (2012). *Solid waste engineering* (2nd ed.). Cengage Learning.
4. Maulin, S. P. (2020). *Microbial bioremediation & biodegradation* (1st ed.). Springer.
5. Natarajan, K. A. (2018). *Biotechnology of metals: principles, recovery methods and environmental concerns* (1st ed.). Elsevier.
6. Kanaujiya, D. K., Paul, T., Sinharoy, A., & Pakshirajan, K. (2019). Biological treatment processes for the removal of organic micropollutants from wastewater: a review. Current pollution reports, 5(3), 112-128.

BT411	ANIMAL BIOTECHNOLOGY	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT253 Cell Biology

Course Outcomes:

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

CO1	Understand the basics of animal cell culture
CO2	Design cell culture media for cell growth and product development
CO3	Characterize the animal cell using biochemical and molecular biology techniques
CO4	Apply the principles of genetic engineering to modify animal cell for research and industrial use

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	3	3	2	-	-	-	1	1	1	3	3	3	1
CO2	3	3	3	3	2	-	1	3	2	-	2	3	3	3	3
CO3	3	3	3	2	1	-	2	2	2	-	2	3	3	3	2
CO4	3	3	3	3	3	1	1	3	2	1	2	3	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to animal biotechnology: Historical background, advantages and limitations, Essential Equipment's, General Safety Measures, Aseptic Techniques, Risk Assessment. Cryopreservation.

Unit II

Media for culturing cells and tissues: natural and defined media; serum free and serum-based media. Isolation of Cells and Tissues, primary and secondary cell cultures, development and maintenance of cell lines.

Unit III

Characteristics of animal cells: Morphological, Nucleic acid (DNA and RNA), Enzyme Activity, Antigenic Markers. Animal cell transformation: Immortalization, Aberrant Growth, Tumorigenicity. Transformation Assay, Cell counting, Cell Proliferation and Viability assay.

Unit IV

Application of animal cell cultures: Recombinant protein production and purification; Testing of drugs, Vaccine production. Embryonic cell culture and development, In vitro fertilization, Animal Breeds, Embryonic Stem Cell method, Transgenic Animal Production: Microinjection method, retroviral vector method; and applications of transgenic animals: Animal cloning, Knock-out and knock-in animals.

Text Books:

1. Butler, M. (2003). *Animal cell culture and technology* (2nd ed.). Taylor & Francis.
2. Freshney, R. I. (2010). *Culture of animal cells: A manual of basic technique and specialized applications* (6th ed.). John Wiley & Sons.
3. Pörtner, R. (2007). *Animal cell biotechnology: Methods and protocols* (2nd ed.). Humana Publishers.

BT412	ENZYME TECHNOLOGY	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT202 Biochemistry
ii. BT255 Biological Reaction Engineering

Course Outcomes:

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

CO1	Understand basics and principles of enzyme technology
CO2	Understand concepts of enzyme kinetics and inhibition
CO3	Understand the immobilization techniques and their industrial applications
CO4	Comprehend the strategies for production of industrial enzymes and their applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	-	1	-	-	-	-	-	-	-	-	2	-	-
CO2	2	-	-		-	-	-	-	-	-	-	-	2	-	-
CO3	1	-	-	1	1	-	-	-	-	-	-	-	-	2	-
CO4	1	3	2	3	-	-	-	-	-	-	-	-	1	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Enzymes: General introduction, Nomenclature and Classification of enzymes, Biological Roles, Activation energy, Coenzymes, Cofactors, Prosthetic group, Metalloenzymes, Enzyme activity, Specificity and Selectivity, Identification of binding and catalytic sites**.**

Unit II

Enzyme kinetics: Enzyme-substrate interaction: Lock and Key mechanism, Induced Fit mechanism and Transition state Hypotheses, Factors affecting the enzyme action-Concentration, temperature and pH, Enzyme Kinetics, Kinetics of multi-substrate reaction: Sequential reactions and ping-pong reactions. Multienzyme complex and multifunctional enzymes, Enzyme inhibition: Reversible (competitive, uncompetitive and mixed) and irreversible, Allosteric regulation of enzyme activity.

Unit III

Enzyme immobilization: Enzymes in free and immobilized forms, stabilization of soluble enzymes; Principles & techniques of immobilization, Immobilized enzyme reactions; Damkohler number, Analysis of mass transfer effects, Analysis of film and Pore diffusion effects, Calculation of effectiveness factors of immobilized enzyme systems, Design of enzyme electrodes.

Unit IV

Industrial production of Enzymes: Sources of industrial enzymes (natural & recombinant), Large-scale enzyme production, Strategies of isolation and purification of enzymes from different sources, Modification of enzymes: Methods in enzyme engineering, Site directed mutagenesis.

Unit V

Applications of enzymes: Enzymes for industrial processes and manufacture of commercial products, Industrial Enzymes: Proteases, Lipases, Carbohydrate active enzymes, Nucleic acid enzymes, artificial enzymes, Applications of enzymes in food industry, detergents, energy, waste treatment, pharmaceutical, medical and analytical purpose.

Text Books:

1. Palmer, T., & Bonner, P. (2007). *Enzymes: Biochemistry, biotechnology, clinical chemistry* (2nd ed.). Woodhead Publishing.
2. Buchholz, K., Kasche, V., & Bornscheuer, U. T. (2012). *Biocatalysts and enzyme technology* (2nd ed.). Wiley Publishing.
3. Copeland, R. A. (2000). *Enzymes: A practical introduction to structure, mechanism, and data analysis* (2nd ed.). Wiley–VCH.

BT413	BIOREACTOR DESIGN AND ANALYSIS	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT203 Bioprocess Calculations
ii. BT255 Biological Reaction Engineering

Course Outcomes:

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

CO1	Understand the general consideration of various types of bioreactors and their design
CO2	Design batch, fed batch and continuous bioreactors for enzymes and cells
CO3	Understand the non-ideality and model selection
CO4	Understand the concept of scale up and scale down

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	-	-	-	-	-	-	-	-	3	2	-
CO2	2	2	3	2	-	1	-	1	-	-	-	-	3	2	-
CO3	2	2	3	2	2	1	-	1	-	-	-	-	3	2	-
CO4	3	2	3	2	2	-	-	-	-	-	-	-	3	3	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction: Overview of submerged liquid fermentation process (SLF) and Solid-state fermentation (SSF), General design information; Mechanical design of reactors, heat transfer and mass transfer equipment; Design considerations for maintaining sterility of process streams and process equipment; Piping and instrumentation; Materials of construction for bioreactors, Cleaning aspects of bioreactors.

Unit II

Overview on various Reactor Types: Bioreactors for microbial (bacteria and fungi), plant and animal cultivation, Photobioreactors for algal cell cultivation, Bioreactors for immobilized cell cultivation and solid state fermentation. Process parameters for monitoring and control of bioreactors.

Unit III

Biochemical aspects of bioreactor analysis for cells and enzymatic reactions: Batch reactor- calculation of batch time, quantitative evaluation of batch processes, sources of non-ideality; continuous flow bioreactors- CFSTBR including chemostat and turbidostat, mean residence time, washout condition; recycle bioreactors; combination of bioreactors; Semi-continuous bioreactors: fed-batch cultivation.

Unit IV

Non-ideal behavior in bioreactors: Non-ideal parameters, models for non-ideal flow including single parameter and multi parameters; transient behavior- characterization of transient state, stability analysis including inhibition systems; phase plane and bifurcation analyses.

Unit V

Scale up and scale down: Effect of scale-up on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply; Bioreactor scale up strategies: constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer coefficients; Scale down; Process economics.

Text Books:

1. Panda, T. (2011). *Bioreactors analysis and design* (1st ed.). Tata McGraw Hill.
2. Schuegerl, K. (1987). *Bioreaction engineering (Vol I)*. John Wiley and Sons.
3. Ghose, T. K. (1990). *Bioprocess computations for biotechnology (Vol I).* Pearson Education.
4. McDuffie, N. G. (1991). *Bioreactor design fundamentals* (1st ed.). Butterworth-Heinemann.
5. Ravi, R., Vinu, R., & Gummadi, S. N. (2017). *Chemical and biochemical reactors and reaction engineering, Volume 3A*, Coulson and Richardson's chemical engineering (4th ed.). Butterworth-Heinemann.
6. Asenjo, J. A., & Merchuk, J. C. (1994). *Bioreactor system design* (1st ed.). CRC Press.

BT421	BIOPROCESS INSTRUMENTATION AND CONTROL	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT301 Bioprocess Engineering

Course Outcomes:

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

CO1	Understand various bioprocess instrumentation and their dynamic behavior
CO2	Understand the closed loop control system and its components
CO3	Analyze stability of feedback control system

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	3	2	-	-	-	1	1	2	2	2	3	2
CO2	3	3	3	3	3	-	-	-	1	1	2	2	3	3	2
CO3	3	2	3	2	3	-	-	-	1	1	1	1	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Bioprocess Instrumentation: Temperature, pH, Level, Flow, Pressure, DO sensors. Response of First order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Physical examples of First and second order systems: Examples of First order systems, Linearization, Transportation Lag.

Unit II

Control Systems: Components of a Control System, Block Diagram, Development of Block Diagram, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols, Transfer Functions for Single-Loop Systems and Multi-loop Systems. Transient response of simple control systems: Servo Problem, Regulatory Problem, Controllers: Proportional, Proportional-Integral, PID Controllers. Ziegler-Nichols Controller Settings. Stability: Routh Test for Stability, Root Locus.

Unit III

Frequency Response: Introduction, Substitution Rule, Bode Diagrams. Control system design based on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.

Text Books:

1. Coughanowr, D., & Leblanc, S. (2009). *Process systems analysis and control* (3rd ed.). McGraw-Hill.
2. Eckman, D. P. (1985*). Industrial Instrumentation*. Wiley.
3. Shuler, M. L., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson.
4. Bailey, J. E., & Ollis, D. F. (2006). *Biochemical engineering fundamentals* (2nd ed.). McGraw-Hill.
5. Ghosh, T. (2004). *Biotechnology and bioprocess engineering: Proceedings*, VII International biotechnology symposium. Delhi.
6. Stephanopoulos, G. (2015). *Chemical process control*. Pearson India.

BT422	FOOD BIOTECHNOLOGY	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT201 Microbiology
ii. BT202 Biochemistry

Course Outcomes:

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

CO1	Understand the components and nutritional value of food
CO2	Understand the concepts of fermented food production process
CO3	Understand the food processing methods and regulations

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	3	-	-	-	3	2	1	1	1	2	3	3	-	2
CO2	-	-	1	3	1	3	2	2	2	1	2	2	2	3	2
CO3	1	2	3	3	2	2	1	3	2	2	1	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Food biochemistry and microbiology: Components of food: carbohydrates, proteins, fats, vitamins, minerals, Antinutrients; Balanced diet; Prebiotics; Probiotics; Phyto-nutraceuticals; Nutraceuticals Vs Pharmaceuticals; Microbial Spoilage: food, milk and milk products, meat and meat products; Bacterial pathogens and Non-bacterial pathogens; food preservation.

Unit II

Production of fermented food: Overview of diverse fermented foods; Starter cultures in food industry; Production process of selected fermented foods (Soya sauce, Sauerkraut, Peanut milk, Idly, Beer, Wine, Yogurt, Cheese, Sausages); Concept of SCP, mushrooms, food yeasts, algal protein, GM foods; bio-fortification, food additives, food sweeteners and colours.

Unit III

Food processing methods and regulations: Product development; Processing techniques; Toxicology studies; clinical trials associate with product development; Hygiene and sanitation in food sector; Concepts of GMP, GHP and GLP; Food Laws and Organizations: Food Safety Standards Rules & Regulations, 2011, Essential commodities Act; International Organizations: EFSA, FDA, FAO.

Text Books:

1. Lee, B. H. (2015). *Fundamentals of food biotechnology* (2nd ed.), Wiley-Blackwell.
2. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). *Modern food microbiology* (7th ed.). Springer.
3. Green, P. J. (2002). *Introduction to food biotechnology* (1st ed.) CRC Press.
4. Shetty, K., Paliyath, G., Pometto, A., & Levin, R. E. (2005). *Food biotechnology* (2nd ed.), CRC Press.

BT423	BIOPROCESS DESIGN & ECONOMICS	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT203 Bioprocess Calculations
ii. BT301 Bioprocess Engineering

Course Outcomes:

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

CO1	Understand the principles of bioprocess plant design
CO2	Understand the design concepts of bioreactor
CO3	Design various unit operations of bioindustries

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1	3	-	1	-	-	-	-	2	2	1	1
CO2	3	2	3	-	-	-	-	-	-	-	-	-	2	1	-
CO3	3	3	3	-	3	-	-	-	-	-	-	3	3	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Bioprocess Plant design and Economics- Introduction, Objectives, Design estimate of life cycle of a product

Unit II

Economics analysis of Bioprocess plants- Bio-manufacturing of industrial bioproducts (organic acids, alcohols, ketones, amino acids, antibiotics, vitamins, enzymes, proteins, SCP etc.), Bioproducts recovery (primary, intra &extracellular, intermediates), final purification, operation integration, Components of Cost estimate, Process flow sheets, Material & Energy balances, Equipment sizing, Equipment cost and design methods, Cost estimates (Capital, Manufacturing, fixed & Overhead), Profitability Analysis, Case studies for Penicillin & Recombinant protein production, etc.

Unit III

Process scheduling and analysis, Simulation in SuperPro designer for Process analysis and economic evaluation of bioproducts (Citric acid, Insulin, Therapeutic proteins etc.)

Text Books:

1. Clark, D. S., & Blanch, H. W. (1997). *Biochemical engineering* (2nd ed.). CRC Press.
2. Harrison, R. G., Todd, P., Rudge, S. R., & Petrides, D. P. (2015). *Bioseparations science and engineering* (2nd ed.). Oxford University Press.
3. Mahajani, V. V., & Umarji, S. B. (2016). *Joshi's process equipment design* (5th ed.). Trinity Press.
4. Green, D. W., & Southard, M. Z. (2019). *Perry's chemical engineers' handbook* (9th ed.). McGraw-Hill Education.
5. Asenjo, J. A., & Merchuk, J. C. (1994*). Bioreactor system design* (1st ed.). CRC Press.
6. Couper, J. R., Penney, W. R., Fair, J. R., & Stanley M. Walas, S. M. (2010) *Chemical process equipment: Selection and design* (3rd ed.). Elsevier.
7. Henley, E. J., & Kumamoto, H. (1985). *Designing for Reliability and Safety Control*. Prentice Hall.

BT461	BIOSAFETY, BIOETHICS AND IPR	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT101 Biology for Engineers
ii. BT201 Microbiology

Course Outcomes:

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

CO1	Understand the basics of biosafety, bioethics and IPR
CO2	Role of biosafety committees in risk assessment and management
CO3	Review international agreements and protocols for biosafety
CO4	Anaylse the procedures involved in patent filing and licensing

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3
CO2	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3
CO3	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3
CO4	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Biosafety: Historical Background, Introduction to Biological Safety Cabinets, Primary Containment for Biohazards, Biosafety Levels, Bioethics: Necessity of bioethics, Origin and Evolution of ethics into bioethics, Ethical reasoning and the justification of moral beliefs, Different paradigms of bioethics - National and International.

Unit II

Definition of GMOs & LMOs, Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture, Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication.

Unit III

Overview of National Regulations and relevant International Agreements including Cartagena Protocol. Agreements and Treaties, History of GATT & TRIPS Agreement, Madrid Agreement; Hague Agreement, WIPO Treaties; Budapest Treaty; PCT.

Unit IV

Indian Patent Act 1970 & recent amendments. Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition, Specifications: Provisional & complete. Patent databases- Patent filing procedures, Time frame& cost; Status of patent applications filed, Precautions while patenting – disclosure/non-disclosure, Financial assistance for patenting , Patent licensing and agreement, Patent infringement.

Text Books:

1. Fleming, D. O., & Hunt, D. A. (2006). Biological safety: Principles and practices (4th ed.). ASM Press.
2. Kankanala, K. C. (2007). Genetic patent law and strategy (1st ed.). Manupatra Publishers.

3. Jecker, N. A. S., Jonsen, A. R., & Pearlman, R. A. (2007). Bioethics: An introduction to history, methods, and practice (2nd ed.). Jones and Bartlett Publishers.
4. Traavik, T. & Ching, L. L. (2007). Biosafety first: Holistic approaches to risk and uncertainty in genetic engineering and genetically modified organisms. Tapir Academic Press.
5. US Government. (2004). 21st Century Complete Guide to Biosafety and Biosecurity. Progressive Management.
6. Bare Act. (2007). Indian Patent Act 1970 Acts & Rules. Universal Law Publishing.
7. Steinbock, B. (2009). The oxford handbook of bioethics (1st ed.). Oxford University Press.

BT462	BIOFUEL TECHNOLOGY	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT101 Biology for Engineers
ii. BT202 Biochemistry

Course Outcomes:

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

CO1	Identify potential biomass sources and differentiate various generations of biofuels
CO2	Understand the production process of various biofuels
CO3	Apply the concept of strain engineering for biofuel production
CO4	Understand bio refinery concepts and forecast the entrepreneurial opportunities

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	3	2	2	3	3	2	-	-	3	3	3	1
CO2	3	3	3	2	3	2	3	3	2	-	2	3	3	3	3
CO3	3	3	3	2	3	2	1	3	-	-	3	2	2	3	3
CO4	3	3	3	2	3	1	2	3	3	-	3	2	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction: Global Scenario of energy production and fossil fuel depletion and its hazardous effects, oil economy, Renewable energy, alternative sources, National Biofuel Policy and law, basic concepts about biomass derived energy, potential biomass feedstocks including energy crops, biomass Types and their formation: photosynthesis, chemistry and composition of biomass

Unit II

Biomass conversion to Biofuels: An overview, first generation, second generation and advance biofuels, Biomass conversion technologies and Pretreatment methods, Thermal, chemical and biological conversions, Biomass to liquid fuels. Biomass degrading enzymes and microorganisms.

Unit III

Bioethanol and Biodiesel production; Bioethanol production from lignocellulosic feedstocks, algae and sea weeds. Lignocellulose-Based Chemical Products, Genetic and metabolic engineering of bacteria and yeast for bioethanol production. Strain engineering for ethanol and inhibitor tolerance. Biodiesel: Vegetable oils and chemically processed biofuels, Biodiesel composition and production processes, Fischer-Tropsch Diesel: Chemical Biomass–to Liquid Fuel Transformations. Algae biomass, Technical challenges in biodiesel production.

Unit IV

Biorefining: Biomass to Biogas, Bio hydrogen and bioelectrochemical systems such as Microbial fuel cell, Microbial desalination cell. Energy recovery from waste, Concept of Bio refinery, techno-economic analyses of biofuel conversion technologies, Entrepreneurial Opportunities in Bioenergy.

Text Books:

1. Gupta, V., Tuohy, M., Kubicek, C., Saddler, J., & Xu, F. (2013). Bioenergy research: Advances and applications (1st ed.). Elsevier.
2. Dahiya, A. (2015). Bioenergy: Biomass to biofuels (1st ed.). Academic Press.
3. Nelson, V. C., & Starcher, K. L. (2016). Introduction to bioenergy (1st ed.). CRC Press.
4. Gupta, V. K., & Tuohy, M. G. (2013). Biofuel technologies - recent developments (1st ed.). Springer.
5. Shimizu, K. (2017). Metabolic regulation and metabolic engineering for biofuel and biochemical production (1st ed.). CRC Press.
6. Mousdale, D. M. (2008). Biofuel - biotechnology, chemistry, and sustainable development (1st ed.). CRC Press.
7. Demirbas, A. (2009). Biofuels: Securing the planet's future energy needs (1st ed.). Springer.

BT463	DRUG DESIGN AND DEVELOPMENT	DEC	3-0-0	3 Credits

Pre-Requisites:

i. BT401 Bioinformatics

Course Outcomes:

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

CO1	Understand the concept of structure-function relationship of lead molecules in drug discovery
CO2	Understand the target identification in drug discovery
CO3	Apply proteomics and genomics techniques in drug discovery and design process
CO4	Apply computational approaches for drug design

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	2	2	2	-	-	1	0	-	1	3	2	-
CO2	-	3	3	3	3	1	-	-	1	-	1	-	3	2	-
CO3	-	2	2	3	3	2	-	-	1	0	-	-	3	-	2
CO4	-	2	3	3	3	3	2	-	1	0	1	1	3	-	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Economic importance of drug discovery, Stages of drug discovery, Phases in drug discovery, identification, validation and diversity of drug targets, Structure and function of different targets enzymes, ion channels and receptors. Molecular recognition in Ligand - Protein Binding. Structure – Based and Ligand – Based Drug Design. Functional selectivity of receptors.

Unit II

Stereochemistry in Drug Design, Peptides and Peptidomimetics. Bonded and non - bonded interactions, Drug delivery systems for proteins and peptides with special reference to oral & nasal routes. Delivery consideration of Biotechnological products: Stability profile, Barriers to peptides and protein delivery, Delivery of protein and peptide drugs, Site specific protein modification, Toxicity profile characterization (ADMET-SAR).

Unit III

High-Throughput Screening, Lipinski rule of 5, Pharmacogenomics, Proteomics, Array technology and Recombinant DNA technology of drugs. Disease targets for gene therapy. Monoclonal antibodies for diseases such as Diabetes, Cancer and neurodegenerative disorders. Study of pharmacokinetics and pharmacodynamics of the ligands.

Unit IV

Computational approaches for the quantification of Molecular diversity and design of compound libraries, physicochemical concept of in drug design. History of QSAR, 2D-QSAR; 3D-QSAR, descriptors of QSAR, Tools and techniques of QSAR, Parameters Used in QSAR, Applications of QSAR, 3D pharmacophore hypothesis.

Text Books:

1. Stromgaard, K., Krogsgaard-Larsen, P., & Madsen, U. (2009*). Textbook of drug design and discovery* (4th ed.). CRC Press.
2. Giersiefen, H., Hilgenfeld, R., & Hillisch, A. (2003). *Modern methods of drug discovery* (1st ed.). Birkhäuser Basel.
3. Knablein, J. (2005). *Modern biopharmaceuticals: Design, development and optimization* (1st ed.). Wiley-Blackwell.
4. Leach, A. R. (2001). *Molecular modeling: Principles and applications* (2nd ed.). Pearson Publications.
5. Kourounakis, P. N. (1994). *Advanced drug design and development: A medicinal chemistry approach* (1st ed.). Taylor and Francis.

OPEN ELECTIVE COURSES

BT341	ENVIRONMENTAL TECHNOLOGY	OPC	3–0–0	3 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the importance of water quality and treatment of wastewater
CO2	Understand the types of solid waste and their management
CO3	Understand the fundamental aspects of air pollution and its control
CO4	Apply biological methods for remediation of contaminated soil

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	1	-	2	3	1	-	-	1	2	3	-	-
CO2	2	2	3	1	-	2	3	1	-	-	1	2	3	-	-
CO3	2	2	3	1	-	2	3	1	-	-	1	2	3	-	-
CO4	3	3	3	1	-	2	3	-	-	-	1	2	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction of environmental technology. water and wastewater: Water quality and control – Sources of water pollution, Water quality standards for potable water, Health effects of water pollutants, Fundamentals of water treatment process; wastewater characterization, Fundamentals of wastewater treatment (primary, secondary and tertiary treatment).

Unit II

Solid and hazardous Waste Management: Municipal Solid waste management **-** Sources and classification. Management and methods of processing of waste. Hazardous waste management – sources, classification, treatment and disposal methods. Plastic waste – sources and types, management practices. Microplastics and its impact on environment.

Unit III

Air pollution and control: Sources, classification and health effects, Air quality standards, control of air pollution. Techniques for air pollution control - cyclones, wet dust scrubbers and fabric filters for particulate matter, gas absorption, Biological control of gaseous pollutants.

Unit IV

Bioremediation of contaminated sites: Introduction, engineering strategies of bioremediation: site characterization, *in situ* and *ex situ* strategies. Phytoremediation – introduction and mechanisms of phytoremediation.

Text Books:

1. Garg, S. K. (1999). *Water supply engineering – environmental engineering (Vol.I)*. Khanna Publishers.
2. Metcalf & Eddy, Inc. (2003). *Waste water engineering treatment and reuse* (4th ed.). McGraw Hill Education.
3. Masters, G. M., & Ela, W. P. (2007). *Introduction to Environmental Engineering and Science* (3rd ed.), Pearson Education.
4. Rittmann, B. E., & McCarty P. L. (2003). *Environmental biotechnology: principles and applications* (1st ed.). Tata McGraw-Hill Education.
5. Hale, R. C., Seeley, M. E., La Guardia, M. J., Mai, L., & Zeng, E. Y. (2020). A global perspective on microplastics. *Journal of Geophysical Research: Oceans*, *125*(1), e2018JC014719.

BT391	BIOENERGY AND BIOFUELS	OPC	3–0–0	3 Credits

Prerequisites:

i. BT101 Engineering Biology

Course Outcomes:

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

CO1	Classify feedstocks for generation of bioenergy
CO2	Understand various bioenergy production processes
CO3	Understand various biofuels and technology involved in their production
CO4	Understand the concepts of biological production of hydrogen

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	3	3	2	-	-	3	3	2	1
CO2	3	3	3	2	3	2	3	3	2	-	2	3	3	3	3
CO3	3	3	3	2	3	2	1	3	-	-	3	2	2	3	3
CO4	3	3	3	2	3	1	2	3	-	-	2	2	3	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction: Classification of energy based on sources, bio-based energy, bioenergy types, Biopower, Bioheat, Biofuels, advanced liquid fuels, drop-in fuels, Syngas, biohydrogen, bio-based products. Feedstocks: Conventional and dedicated biomass feedstock. Residual Feedstocks: Agricultural wastes, forestry wastes, farm waste, organic components of residential, commercial, institutional and industrial waste.

Unit II

Bioconversion processes: Thermochemical processes, Direct Combustion, Pyrolysis, Gasification; Biochemical conversion – hydrolysis, enzyme and acid hydrolysis, fermentation, anaerobic digestion; other techniques: trans-esterification

Unit III

Biofuels: First generation biofuels, Second generation biofuels, third generation biofuels; Pros and cons of Biofuels, Algal biofuels, Cyanobacteria and producers of biofuels, Biodiesel composition and production processes, Bioethanol, Biomethane, biobutanol, Engineering aspects of biofuels, Economics of biofuels,

Unit IV

Biohydrogen: Bioproduction of gases, Production of H_2 by photosynthetic organisms, Emergence of the hydrogen economy, Microbial Fuel Cells and other technological advancements.

Text Books:

1. Brown, R. C., & Brown, T. R. (2014). *Biorenewable resources: Engineering new products from agriculture* (2nd ed.). Wiley-Blackwell.

2. Soetaert, W., & Vandamme, E. J. (2009). *Biofuels* (1st ed.). Wiley.
3. Klass, D. L. (1998). *Biomass for renewable energy, fuels and chemicals* (1st ed.). Academic press.
4. Nelson, V. C., & Starcher, K. L. (2016). *Introduction to bioenergy* (1st ed.). CRC Press.
5. Dahiya, A. (2015). *Bioenergy: Biomass to biofuels* (1st ed.). Academic Press.

BT491	ETHICS AND IPR	OPC	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes:

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

CO1	Understand the concept of engineering ethics
CO2	Understand the agreements, treaties and the procedures involved in patent filing
CO3	Analyze the databases and formalities pertaining to patent agreements

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	3	3	-	-	2	-	-	3	2	3
CO2	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3
CO3	2	-	-	-	-	3	3	-	-	2	-	-	3	-	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Engineering Ethics :Senses of 'Engineering Ethics' – Variety of moral issues – Types of inquiry – Moral dilemmas – Moral Autonomy – Kohlberg's theory – Gilligan's theory – Consensus and Controversy – Models of professional roles - Theories about right action – Self-interest – Customs and Religion – Uses of Ethical Theories.

Unit II

Agreements and Treaties, History of GATT & TRIPS Agreement, Madrid Agreement; Hague Agreement, WIPO Treaties; Budapest Treaty; PCT, Indian Patent Act 1970 & recent amendments, Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition, Specifications: Provisional & complete.

Unit III

Patent databases- Patent filing procedures, Time frame& cost; Status of patent applications filed, Precautions while patenting – disclosure/non-disclosure, Financial assistance for patenting , Patent licensing and agreement, Patent infringement.

Text Books:

1. Martin, M. W., & Schinzinger, R. (2005). *Ethics in engineering* (4th ed.). McGraw Hill Higher Education.
2. Govindarajan, M., Natarajan, S., & Senthil Kumar, V. S. (2004). *Engineering ethics*. PHI Learning.
3. Wadhera, B. L. (2010). *Law relating to intellectual property* (5th ed.). Universal Law Publishing.
4. Bansal, P. (2015). *IPR handbook for pharma students and researchers*. Pharma Med Press.Dahiya, A. (2015). Bioenergy: Biomass to biofuels (1st ed.). Academic Press.

MINOR COURSES

Minor in Food Science and Technology

BTM251	ESSENTIALS OF FOOD TECHNOLOGY	PCC	3–1–0	4 Credits

Prerequisites: BT101 Biology for Engineers

Course Outcomes:

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

CO1	Understand the basics of biomolecules relevant to food biochemistry
CO2	Understand the characteristics of food related microorganisms
CO3	Learn the basics of nutrition and importance of sensory evaluation

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	-	-	-	-	-	2	1	3	-	2
CO2	3	1	1	-	-	2	-	-	-	-	2	1	3	-	2
CO3	2	1	1	-	-	2	-	-	-	-	2	1	3	-	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Basics of Food Chemistry: Overview of structure and functional properties of carbohydrates, proteins, lipids, vitamins, minerals and pigments.

Unit II

Basics of Food Microbiology: Characteristics of food related microorganisms, spoilage microorganisms in different food products including milk, fish, meat, egg, cereals and their products; Toxins from microbes: *Staphylococcus, Salmonella, Escherichia, Bacillus, Clostridium*, and *Aspergillus* genera.

Unit III

Basics of Nutrition: Relation of food with nutrition; Balanced diet; Energy value of foods, physiological fuel value, estimation of energy value of foods from proximate composition, calorie needs for Basal metabolism.

Unit IV

Sensory evaluation of food: Objectives, type of food panels, layout of sensory evaluation laboratory, sensitivity tests, threshold value, Amoore's classification of odorous compounds. Sherman and Sczezniak classification of food texture.

Text Books:

1. Eskin, N. A. M., & Shahidi, F. (2012). *Biochemistry of foods* (3rd ed.). Academic Press.
2. Damodaran, S., & Parkin, K. (2017). *Fennema's food chemistry* (5th ed.). CRC Press.
3. Shils, Maurice Edward, and V. R. Young. *Modern nutrition in health and disease*. Clinical Nutrition Insight 15, no. 4 (1989): 5.
4. Krause, M., and L. K. Mahan. *Food, Nutrition and Diet Therapy*. Clinical Nutrition Insight 6, no. 7 (1980): 5.

BTM301	FOOD PROCESSING AND PRESERVATION	PCC	3–1–0	4 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the principles of various food processing methods
CO2	Understand the concepts of drying and irradiation based preservation of foods
CO3	Understand the strategies towards safe packaging of food materials

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	-	-	-	3	-	-	-	2	1	3	-	2
CO2	3	2	2	-	1	-	3	-	-	-	2	1	3	-	2
CO3	3	2	2	-	1	-	3	1	-	-	2	1	3	-	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Food Processing: Thermal process - pasteurization, sterilization, blanching, canning; freezing and thawing process: Air freezing, plate freezing, liquid immersion freezing and cryogenic freezing; Freezer selection; Freezing curve concepts.

Unit II

Food Drying/Dehydration: Concept of water activity, factors affecting drying, drying curve, moisture content; drying equipment: solar dryer, spray dryer, freeze dryer.

Unit III

Irradiation preservation of foods: Sources, dose rate, effect on quality of food, regulation; chemical and biochemical changes in foods during different processing.

Unit IV

Food Packaging: Packaging materials and their physico-chemical characteristics. Selection and evaluation of quality of packaging materials; package design for food products; Test procedures for packages; Pre-packaging. Modern packaging techniques.

Text Books:

1. Austin, G. T. (1984). *Shreve's chemical process industries* (1st ed.). McGraw-Hill.
2. Robertson, G. L. (2013). *Food packaging: principles and practice* (3rd ed.). CRC Press.
3. Lee, D. S., Yam, K. L., & Piergiovanni, L. (2008). *Food packaging science and technology* (1st ed.). CRC Press.

BTM351	FOOD PRODUCT DEVELOPMENT	PCC	3–0–0	3 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the approaches and methodology for food product development
CO2	Gain knowledge on market and economic analysis of food product development
CO3	Understand the principles of unit operations used in development of food products

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	-	1	1	3	-	-	-	2	1	3	-	2
CO2	3	2	3	-	1	-	3	-	-	-	2	1	3	-	2
CO3	3	2	3	-	1	-	3	-	-	-	2	1	3	-	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Food Product Development: Need, importance and objectives of product development in food industry; factors affecting food product development - extrinsic and intrinsic; steps and methodology involved in food product development; process control parameters and scale up of developed products.

Unit II

Market testing and marketing plans for developed products; costing and economic evaluation of developed products.

Unit III

Food Product Technology: Oil products - expelling, solvent extraction, refining and hydrogenation; Fruits and vegetables products - extraction, clarification, concentration and packaging of fruit juice, jam, tomato sauce, potato chips, pickles, pectin from fruit wastes; Milk and milk products - pasteurization and sterilization, butter, cheese and milk powder; Animal products: drying, canning, and freezing of fish and meat; production of egg powder.

Text Books:

1. Beckley, J. H., Herzog, L. J., & Foley, M. M. (2017). *Accelerating new food product design and development* (2nd ed.). Wiley-Blackwell.
2. Moskowitz, H. R., Beckley, J. H., & Resurreccion, A. V. A. (2012). *Sensory and consumer research in food product design and development* (2nd ed.). John Wiley & Sons.

BTM352	FOOD PROCESSING LAB	PCC	0–0–3	2 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Estimate the concentration of food based biomolecules through quantitative assays
CO2	Design experiments for the extraction of bioactive compounds for food applications
CO3	Understand the thermal processing of food and perform bioreactor cultivation for the production of food based molecules

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	2	1	1	3	1	2	1	2	1	3	2	2
CO2	3	2	3	2	1	2	3	1	2	1	2	1	3	2	2
CO3	3	2	3	2	1	2	3	1	2	1	2	1	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1) Quantitative estimation of total carbohydrates from different food samples.
2) Quantitative estimation of total proteins from different food samples.
3) Quantitative estimation of lipids from different food samples.
4) Solvent extraction and quantification of pigments from plant sources (β-carotene, lycopene, anthocyanin) using using spectrophotometer
5) Microwave assisted extraction of pectin from plant sources
6) Effect of process parameters on blanching and drying of vegetables/fruits.
7) Estimation of shelf life of seasonal fresh vegetables & fruits.
8) Clarification of fruit juice using crude pectinase / polygalacturonase activity
9) Effect of process parameters on baking of bread / biscuits
10) Batch production of citric acid

Text Books:

1. Sehgal, S. (2016). *A Laboratory Manual of Food Analysis*. I. K. International Publishing.
2. Barbosa-Canovas, G. V., Ma, L., & Barletta, B. J. (1997). *Food engineering laboratory manual* (1st ed.). CRC Press.

BTM401	FOOD SAFETY SYSTEMS	PCC	3–0–0	3 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the importance of food safety management systems
CO2	Understand the food laws and regulatory bodies governing the food safety
CO3	Understand the procedures and operational modes of food quality assuring bodies

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	-	-	-	1	3	-	-	1	1	3	-	2
CO2	2	1	1	-	-	-	1	3	-	-	1	1	3	-	2
CO3	2	2	1	-	-	-	1	3	-	-	1	1	3	-	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Concept of food safety and standards, food safety strategies. Preventive food safety systems - monitoring of safety, wholesomeness and nutritional quality of food. Prevention and control of microbiological and chemical hazards.

Unit II

Introduction to food laws, need for enforcing the laws and various types of laws. Mandatory food laws and FSSAI 2006.

Unit III

Labeling - Nutritional labeling - Specification - rules and regulation- ISI certification- Principles - Role of AGMARK, FPO, BIS and PFA. Food hygiene auditing- Monitoring environmental quality in food industries- Rules and regulation for setting a food processing unit.

Text Books:

1. Entis, P. (2007). *Food safety: Old habits, new perspectives*. ASM Press.
2. Mortimore, S., & Wallace, C. (2013). *HACCP: A practical approach* (3rd ed.). Springer.
3. Schmidt, R. H., & Rodrick, G. E. (2003). *Food safety handbook*. John Wiley & Sons.
4. Mehta, R., & George, J. (2005). *Food safety regulation concerns and trade*. Macmillan India.
5. Paster, T. (2007). *The HACCP food safety training manual*. John Wiley & Sons.

BTM402	FERMENTED FOODS	PCC	3–0–0	3 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Learn the basics of fermented foods
CO2	Understand the microorganisms involved in food fermentation and their applications
CO3	Apply the knowledge of biotechnology for the production of fermented foods

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	-	1	-	-	-	1	1	3	-	2
CO2	3	2	1	-	-	-	2	-	-	-	1	1	3	-	2
CO3	3	2	1	-	-	-	2	-	-	-	1	1	3	-	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

History of food fermentations; types of fermented foods and substrates/raw materials used, traditional fermented foods, major biotransformation of raw materials during fermentation, Modern fermented foods industry, Properties of fermented foods.

Unit II

Microbes of importance in food fermentations: homo & hetero-fermentative bacteria, yeasts & fungi; lactic acid bacteria fermentation and starter cultures. Alcoholic fermentations - yeast fermentations, fungal fermentations. Microbes associated with typical food fermentations-yoghurt, cheese, fermented milks, breads, idli, soy products, fermented vegetables and meats. Basics of solid state fermentation and its application in production of fermented foods.

Unit III

Microbial production of oils and fats. Microbial production of food flavours. Microbial production of carotenoids. Alcoholic beverages. Biotechnological production of alternate sugars.

Text Books:

1. Frazier, W. C., & Westhoff, D. C. (1998). *Food microbiology* (4th ed.). McGraw Hill Education.
2. Belitz, H-D., Grosch, W., & Schieberle, P. (2009). *Food chemistry* (4th ed.). Springer.
3. Vaclavik, V. A., & Christian, E. W. (2008). *Essentials of food science* (3rd ed.). Springer.

BTM403	ADVANCES IN FOOD ENGINEERING	PCC	3–0–0	3 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the concept of transport phenomena in food engineering
CO2	Understand the rheological behavior of different foods in processing
CO3	Understand various food processing techniques

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	-	1	-	2	-	-	-	1	1	3	-	2
CO2	3	3	2	-	1	-	2	-	-	-	1	1	3	-	2
CO3	3	3	2	-	1	-	2	-	-	-	1	1	3	-	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Transport phenomenon; heat transfer, mass transfer in food processing; problems of equipment design with reference to common food processing unit operations such as drying, freezing, evaporation, membrane filtration.

Unit II

Application of Transport Phenomena for food systems. Flow behaviour of non-Newtonian fluids. Rheology of dough with special reference to wheat. Unsteady state Heat Transfer with phase change. Heat transfer during freezing and thawing.

Unit III

Advances in food processing techniques both thermal and non-thermal. Newer techniques in thermal processing - Retort processing, UHT, Extrusion - hot and cold Ohmic heating, pulsed electric field, high-intensity light pulses, radio-frequency heating, microwave, thermo-sonication, modified atmosphere, enzymic processing and hurdle technology.

Text Books:

1. Ibarz, A., & Barbosa-Cánovas, G. V. (2002). *Unit operations in food engineering* (1st ed.). CRC Press.
2. Berk, Z. (2018). *Food process engineering and technology* (3rd ed.). Academic Press.
3. Tadeusz, K., & Mujumdar, A. S. (2009). *Advanced drying technologies* (2nd ed.). CRC Press.

Minor in Computational Drug Design

BTM252	OMICS TECHNOLOGIES	PCC	3–1–0	4 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the basics of genomics and transcriptomics
CO2	Understand the methods and approaches involved in proteomics and metabolomics
CO3	Understanding the principles and methods of data integration from different OMICS technologies

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	-	1	-	-	-	-	-	-	3	-	-
CO2	3	3	3	2	-	1	-	-	-	-	-	-	3	-	-
CO3	3	3	3	3	-	-	-	-	-	-	-	-	3	-	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Overview and general principles: Omics domains: Genomics, Proteomics, and Metabolomics, Genomics: Introduction to genome structure, DNA microarray, whole genome sequencing, Concept of next generation sequencing technology, Large scale genome sequencing strategies, Transcriptomics (RNA sequencing) & analysis of transcriptomic data, Concepts and principles of genome annotation, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs.

Unit II

Proteomics: Mass spectrometry – ionization methods (MALDI, electrospray), mass analyzers, fragmentation, intact protein analysis, protease digestion, peptide mass fingerprinting, tandem mass spectrometry, Introduction to quantitative proteomics- Differential proteomics, post-translational modifications. Computational methods for identification of polypeptides from mass spectrometry Protein arrays: basic principles, bioinformatics-based tools for analysis of proteomics data. Protein-protein interaction, Surface plasmon resonance.

Unit III

Metabolomics: Metabolomics-an overview, Analytical techniques for metabolomics; Mass spectrometry in metabolomics, Metabolic pathway analysis; Metabolomics data analysis - case studies- workflow for lipidomic, NMR based metabolomics.

Unit IV

OMICS and Big Data management: Big data industry standards, Data acquisition, cleaning,

distribution, and best practices, Visualization and design principles of big data, Biological databases for big data management, High-Performance Computing, grid, and cloud computing for omics sciences.

Text Books:

1. Primrose, S. B., & Twyman, R. M. (2002). *Principles of genome analysis and genomics* (3rd ed.). Wiley-Blackwell
2. Liebler, D. C. (2002). *Introduction to Proteomics – Tools for the new biology* (1st ed.). Humana Press.
3. Pevsner, J. (2015). *Bioinformatics and functional genomics* (3rd ed.). Wiley-Blackwell.
4. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis* (2nd ed.). CSHL Press.

BTM302	PEPTIDE THERAPEUTICS	PCC	3–0–0	3 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand classification, synthesis and purification of peptides
CO2	Understand the therapeutic applications of peptides
CO3	Understand formulation and characterization of therapeutic peptides

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	2	1	-	-	-	-	-	-	-	-	1	1	-
CO2	1	1	2	1	-	-	-	-	-	-	-	-	1	1	-
CO3	1	2	1	1	1	-	1	-	-	1	-	-	2	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Peptides, synthetic peptides & their classification based on structure, engineering bioactive peptide based therapeutic molecules, Principle and practice of solid phase peptide synthesis, solid, support, protection scheme, peptide acid and amide, Purification of peptides, quality control of peptides.

Unit II

Antimicrobial host defence peptides, Anticancer peptides, Opioid Peptides, Antihypertensive Peptides, Peptides in clinical trial, chemical biology of Oxytocin, valinomycin and enkephalins.

Unit III

Pre-formulation studies, Formulation development, Aggregation in protein formulation, novel formulation approaches, Lyophilization, Pharmaceutical Processing and Handling of Therapeutic Peptides and Proteins, Circular dichroism, UV, IR, Mass and fluorescence spectroscopy of peptides.

Text Books:

1. Banga, A. K. (2015). *Therapeutic peptides and protein: Formulation processing and delivery system* (2nd ed.). CRC Press.
2. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman.
3. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. (2015). *Biochemistry* (8th ed.). WH Freeman.

BTM303	PYTHON FOR BIOINFORMATICS	PCC	3–0–0	3 Credits

Prerequisites:

i. CS101 Introduction to Algorithmic Thinking and Programming

Course Outcomes:

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

CO1	Understand the basics of python
CO2	Understand exception, testing and debugging using python
CO3	Understand the concepts of object oriented programming

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO12	PSO1	PSO2	PS O3
CO1	3	3	3	3	3	-	2	2	-	-	-	2	3	3	1
CO2	3	3	3	3	3	-	2	1	-	-	-	1	3	3	1
CO3	1	2	2	3	3	-	3	1	-	1	-	2	3	2	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Basics of Python: python variables, data types, operators, python blocks, structure types and mutability: conditional blocks using if, else and elif, looping with range, list and dictionaries. Python code with function.

Unit II

Exception, Testing and Debugging: Handling if exceptions to handle the code cracks, handling and helping file operations, coding with the exceptional handling and testing Anonymous method, Properties, Indexers, Exception Handling.

Unit III

Classes and OOPs Concepts: Procedural and Object-Oriented Programming, Classes and working with instances, Method overloading, Polymorphism, importing internal module as well as external modules in the code Packages understanding and their usage, hands-on with Lamba function in python coding with the use of functions, modules and external packages. Algorithm and Data Structure: Stack, Queue, Tree, ordered list, Introduction to Recursion, Divide and Conquer Strategy, Greedy Strategy, Graph Algorithms

Text Books:

1. Model, M. L. (2009). *Bioinformatics programming using python* (1st ed.). O'Reilly.
2. Grus, J. (2019). Data science from scratch: First principles with python. (2nd ed.). O'Reilly.
3. Matthes, E. (2019). *Python crash course: A hands-on project-based introduction to programming* (2nd ed.). No Starch Press.

BTM304	MACHINE LEARNING METHODS AND BIOLOGICAL NETWORKS	PCC	3–0–0	3 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the machine learning approaches
CO2	Understand the genetic, deep learning algorithms and phylogenetic approaches
CO3	Understand the biological networks and their applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	3	3	3	-	3	-	-	-	-	1	2	2	-
CO2	2	2	3	3	3	1	3	-	-	-	1	¤	2	2	-
CO3	3	3	2	3	3	-	2	-	1	-	1	1	1	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Machine learning (ML): Datascience Pipeline, Data lifecycle, Important terms related to ML, Different steps involved in ML, Types of Machine Learning: Supervised algorithms (classification): Linear regression, Random forest, Support vector machine (SVM); and Unsupervised learning (Clustering): Exclusive clustering-K-means clustering, Hierarchical clustering, Apriori algorithm, Principal component analysis (PCA). Applications of ML in biological systems.

Unit II

Genetic algorithm, Deep learning: Artificial neural network and their applications in biological systems. *Molecular Phylogenetics*: Introduction, rooted and unrooted trees; Nodes, branches, Topology of a tree, Methods: Maximum parsimony; Distance-based (UPGMA and NJ) and Maximum likelihood; Boot-strapping method.

Unit III

Network Biology: Introduction to graph theory, Types of networks, Adjacency matrix, Network diameter & Scale, Power law & Scale free networks, Network parameters, Applications: Protein-Protein interaction mapping (String Database and Cytoscape introduction) and System biology.

Text Books:

1. Theobald, O. (2017). *Machine learning for absolute beginners* (2nd ed.). Scatterplot Press.
2. Ghosh, S., & Dasgupta, R. (2022). *Machine Learning in Biological Sciences* (1st ed.). Springer.

3. Ramsundar, B., Eastman, P., Walters, P., & Pande, V. (2019). *Deep learning for the life sciences* (1st ed.). O'Reilly.
4. Durbin, R., Eddy, S., Krogh, A., & Mitchison, G. (1998). *Biological sequence analysis: Probabilistic models of proteins and nucleic acids*. Cambridge University Press.
5. Keedwell, E., & Narayanan, A. (2005). Intelligent bioinformatics: The application of artificial intelligence techniques to bioinformatics problems (1st ed.). John Wiley & Sons.
6. Baldi, P., & Brunak, S. (2001). *Bioinformatics: The machine learning approach* (2nd ed.). MIT Press.
7. Zhang, W. (2018). *Fundamentals of network biology* (1st ed.). World Scientific Publishing.
8. Voit, E. (2017). *A first course in systems biology* (2nd ed.). Taylor and Francis.
9. Greener, J. G., Kandathil, S. M., Moffat, L., & Jones, D. T. (2022). A guide to machine learning for biologists. *Nature Reviews Molecular Cell Biology*, *23*(1), 40-55.

BTM353	STRUCTURAL BIOINFORMATICS	PCC	3–0–0	3 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the relationship between protein sequence and protein structure
CO2	Understand protein modelling and its validation
CO3	Study molecular docking and its application in drug design

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	3	3	1	-	-	-	-	-	-	1	3	1	-
CO2	3	3	3	2	1	-	-	-	-	-	-	1	2	1	-
CO3	3	3	3	3	1	-	-	-	-	-	-	-	3	1	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction to Protein Structure and Classification: Properties of amino acids and peptide bonds, Ramachandran plot, Secondary structures, motifs and folds. Protein Structure Visualization: tools and analysis of protein structures. Protein Databank, Concepts of B-factor and R-factor.

Unit II

Protein Structural Alignment and Superposition: Protein Fold Classification, CATH, SCOP and FSSP Databases. Secondary structure prediction methods. Tertiary structure Prediction methods (Homology modelling, Fold recognition and ab-initio method). Model validation; VERIFY 3D and PROCHECK.

Unit III

Molecular Docking: Basic concepts. Molecular dynamics and simulation study of protein, Force field concepts. Drug target identification and Drug design.

Text Books:

1. Wilkins, M. R., Williams, K. L., Appel, R. D., & Hochstrasser, D. F. (1997). *Proteome research: New frontiers in functional genomics* (1st ed.). Springer.
2. Baxevanis, A. D., & Ouellette, B. F. F. (2004). *Bioinformatics: A practical guide to theanalysis of genes and proteins* (2nd ed.). John Wiley & Sons.
3. Graur, D., & Li, W-H. (2000). *Fundamentals of molecular evolution* (2nd ed.). Sinauer Associates.
4. Tisdall, J. D. (2003). *Mastering perl for bioinformatics* (1st ed.). O'Reilly.

5. Lesk, A. M. (2014). *Introduction to bioinformatics* (4th ed.) Oxford University Press.
6. Fogel, G. B., & Corne, D. W. (2003). *Evolutionary computation in bioinformatics* (1st ed.). Morgan Kaufmann Publishing.
7. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis* (2nd ed.); CSHL Press.
8. Gu, J., & Bourne, P. E. (2009). *Structural bioinformatics* (2nd ed.). Wiley-Blackwell.
9. Leach, A. (2001). *Molecular modelling: Principles and applications* (2nd ed.). Prentice Hall.
10. Hinchliff, A. (2008). *Molecular modeling for beginners* (2nd ed.). John Wiley & Sons.

BTM354	PRINCIPLES OF BIOINFORMATICS LABORATORY	PCC	0–0–3	2 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand biological databases and data retrival
CO2	Predict protein structure from sequence and validate its accuracy
CO3	Understand the ligand receptor interactions and virtual screening

. Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	2	1	2	1	1	-	-	-	-	-	1	1	-
CO2	1	1	2	1	1	-	-	-	-	-	-	-	1	1	-
CO3	1	1	1	1	1	-	2	-	-	-	-	-	1	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1) Exploration of biological databases
2) Biological sequence retrieval and its analysis
3) Prediction of secondary and tertiary structure of proteins
4) Protein primary structure analysis
5) Quality Analysis of protein tertiary structure
6) Free energy minimization
7) Ligand receptor interactions
8) Biomolecular interaction analysis
9) Virtual Screening for the generation of HIT molecules

Text books:

1. Mount, D. W. (2004). Bioinformatics: Sequence and genome analysis (2nd ed.). CSHL Press.
2. Korf, I., Yandel, M., & Bedell, J. (2003). *Blast*. O'Reilly Media.

Web references:

1. http://hmmer.org/.
2. https://blast.ncbi.nlm.nih.gov/Blast.cgi
3. https://www.genome.jp/tools-bin/clustalw
4. http://meme-suite.org/
5. http://evolution.genetics.washington.edu/phylip.html
6. https://www.rcsb.org/

BTM404	MOLECULAR SIMULATION AND DRUG DESIGN	PCC	3–1–0	4 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the molecular mechanics of biomolecules
CO2	Understand various energy minimization methods for biomolecule structural modelling
CO3	Understand the molecular dynamics of biomolecules
CO4	Understand the various stages of drug discovery and development

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	1	1	-	-	-	-	-	3	2	-
CO2	3	3	3	3	3	1	1	-	-	-	-	-	3	2	-
CO3	3	3	3	3	3	1	1	-	-	-	-	-	3	2	-
CO4	3	3	3	3	3	1	1	-	-	-	-	-	3	2	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Molecular Mechanics: empirical potential functions; ball-and-spring model, harmonic approximation, bond length, angle, torsional, out-of-Plane and cross-terms, popular, force field parameterization and various approaches for the problem, validation of force field, force fields and programs - MM, AMBER, CHARMM, OPLS, GROMOS, GROMACS, CVFF, Deriding and Universal force field, other methods of molecular energy calculations - ab initio, semi-empirical, density functional analysis.

Unit II

Energy minimization: Optimization methods, gradient (derivative methods), Steepest descent, Conjugate gradient and Newton methods, constraint minimization, SHAKE and Tethering algorithms, Criteria fortruncating minimization.

Unit III

Molecular Dynamics: Steps in typical MD simulations, minimization, equilibration and data collection, velocity scaling, periodic boundary condition, Numerical integrators verlet algorithm, analysis of trajectories, water and membrane models for simulation, Monte Carlo (MC) methods, conformation search procedure, protein folding problem, Anfinsen paradigm, folding pathway, Levinthal paradox and Folding Funnel.

Unit IV

Drug discovery and development: target identification and validation, lead optimization, biochemical testing and clinical trials, structure-based and ligand-based approaches, molecular docking, scoring functions, introduction to Gold, autodock and Surflexdoc, virtual screening, structure similarity search, concept of pharmacophore, *de novo* ligand design, Quantitative, structure an activity relationship, 2D/3D/4D/5D QSAR, Calculation of low energy pathways for reactions – structure refinement – computation of properties, Reactions of drugs and approaches for toxicity predictions. Drug design case studies.

Text Books:

1. Lewars, E. G. (2016). *Computational chemistry* (3rd ed.). Springer.
2. Rappé, A. K., & Casewit, C. J. (1997). *Molecular mechanics across chemistry*. University Science Books.
3. Young, D. C. (2001). *Computational chemistry: A practical guide for applying techniques to real world problems*. John Wiley & Sons.
4. Jensen, F. (2017). *Introduction to computational chemistry* (3rd ed.). John Wiley & Sons.
5. Nocedal, J., & Wright, S. J. (2006). *Numerical optimization* (2nd ed.). Springer.
6. Tildesley, D. J., & Allen, M. P. (2017). *Computer simulation of liquids* (2nd ed.). Oxford University Press.
7. Schleyer, P. V. R. (1998). *Encyclopedia of computational chemistry* (1st ed.). John Wiley & Sons.
8. Gasteiger, J., & Engel, T. (2003). *Chemoinformatics* (1st ed.). Wiley-VCH.
9. Merz, K. M., Ringe, D., & Reynolds, C. H. (2010). *Drug design: Structure- and ligand-based approaches* (1st ed.). CambridgeUniversity Press.

HONOR COURSES

BTH301	CELL AND TISSUE CULTURE TECHNOLOGY	PCC	3–1–0	4 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the concept of fermentation, strain improvement, nutritional requirements and design consideration for various cell culture techniques
CO2	Familiarize with the culture techniques for mammalian cells for therapeutic applications
CO3	Design the experiment, control and optimize the fermentation process
CO4	Develop strategies for animal and plant culturing techniques
CO5	Expose to latest trends in monoclonal antibody production and therapeutics

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	-	-	2	-	-	1	1	-	3	2	1
CO2	3	2	1	1	-	-	2	-	-	-	1	-	3	1	1
CO3	3	3	2	2	1	1	2	-	-	1	2	-	3	3	1
CO4	3	2	1	1	1	1	1	-	-	-	1	-	3	2	1
CO5	3	2	1	1	1	-	1	-	-	-	1	-	3	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction: Nature of fermentation processes, Nutritional requirements in fermentation process, Strain Construction and Strain Improvement, Seed and production culture.

Unit II

Microbial Fermentation: Modern Experimental Techniques: Extractive Fermentation, Highcell-density and High-Performance Bioreactors, Quantitative Physiological Studies. Aerobic and anaerobic fermentation, surface, submerged and solid-state fermentation technology, Statistical methods for fermentation optimization, Instrumentation and Control Systems,

Unit III

Animal Culture Technology: Characteristics of animal cell, metabolism, regulations and nutritional requirements, Kinetics of cell growth and product formation and effect of sheer force, product and substrate transport, Perfusion bioreactor, hollow fiber bioreactor, operational strategies and integrated approach, Micro and macro carrier culture; hybridoma technology, Genetic engineering in animal cell culture, Scale up and large-scale operations, Tissue culture techniques.

Unit IV

Plant Culture Technology: Culturing techniques and media consideration, Plant cell reactor, comparison of reactor performance. Immobilized plant cells and cell retention reactors. Hairy root culture and their cultivation, Tissue culture techniques.

Unit V

Optimization and Control: Culture Improving the production of recombinant DNA proteins through fermentation development, Automation, optimization and Control of fermentation processes, Fermentation design and Cost, Design considerations for aseptic fermentation.

Unit VI

Current trends and case studies: Case studies with respect to monoclonal antibodies (Mabs), Insulin and therapeutics.

Text Books:

1. Brian McNeil, Linda M. Harvey. Practical Fermentation Technology, Wiley, 2008
2. Ali Cinar, Satish J. Parulekar, Cenk Undey, Gulnur Birol, Batch fermentation: modeling, monitoring, and control, 2003, Marcel Dekker
3. P. F. Stanbury, A. Whitaker, and S. J. Hall, Principles of Fermentation Technology, 2016, 3rd Edition, Butterworth-Heinemann
4. Barry C. Buckland (auth.), Barry C. Buckland, John G. Aunins, Theodora A. Bibila, Cell Culture Engineering IV: Improvements of Human Health, Current Applications of Cell Culture Engineering 1, 1995, Springer Netherlands
5. Barua, Alok; Saha, Goutam; Sinha, Satyabroto, Bioreactors: animal cell culture control for bioprocess engineering, 2015, CRC Press, Boca Raton.
6. Suzanne S. Farid (auth.), Wei-Shou Hu (eds.) Cell Culture Engineering, Advances in Biochemical Engineering/Biotechnology 101, 2006, Springer-Verlag Berlin Heidelberg.

BTH302	BIOREACTION ENGINEERING	PCC	3–1–0	4 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the concepts of kinetics of chemical reactions and basic reactors with its performance equations
CO2	Understand and analyze the mechanisms of enzymatic reactions and different approaches to derive kinetics of the reaction
CO3	Evaluate the kinetic constants, influence of temperature and concentration of substrate on kinetics.
CO4	Interpret the free and immobilized enzyme performance with various types of inhibitions.
CO5	Design and develop kinetic models for microbial growth and other biological processes

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	-	2	-	-	-	1	-	3	1	1
CO2	3	2	2	-	2	-	2	-	-	-	1	-	3	1	1
CO3	3	2	-	-	2	-	2	-	-	-	-	-	3	1	1
CO4	3	2	-	-	2	-	2	-	-	-	-	-	3	1	1
CO5	3	2	2	2	3	1	1	-	-	1	1	-	3	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Concepts of chemical reaction engineering: Reaction kinetics, laws of mass action, rate equations, ideal reactors: batch, mixed flow and plug flow reactors, performance equation of basic reactors, reactor sizing, multiple reactor systems, irreversible and reversible reactions of different order, temperature and pressure effects.

Unit II

Concepts of enzymatic reactions: The enzyme, introduction, nomenclature and classification, specific activity, turnover number, Enzyme kinetics, Michaelis-Menten equation, Brigg's-Haldane equation & estimation of constants using graphical technique, Basis of enzymatic reaction, collision theory and transition state theory and role of entropy in catalysis.

Unit III

Enzyme kinetics: Hydrolytic, covalent, acid-base, electrostatic and metal ion involved catalysis. Energetic of substrate binding. Enzyme inhibition kinetics, substrate, product and toxic substance inhibition.

Estimation of kinetic data: Pre-steady–state kinetics, determination of rate constants, rapid mixing, stopped flow and relaxation technique. Enzyme kinetics at limiting condition, enzyme kinetics at interface and kinetics of multi substrate reactions. Temperature dependence of rate constants of enzymatic reaction, thermal deactivation, pH effect on rate constants.

Unit IV

Immobilization kinetics: Immobilization of biocatalysts an introduction, Electrostatic Effect, effect of charged and uncharged support, Effect of external mass transfer, Damkohler number, effectiveness factor, Intraparticle diffusion kinetics, Biot number.

Unit V

Bioenergetics: Stoichiometry of bioreaction and energetics of microbial growth, ATP and redox potential balance. Yield coefficients and their correlation with the stoichiometry. Maintenance and endogenous respiration.

Unit VI

Microbial kinetics: Unstructured model for microbial growth. The development of different microbial growth kinetics like Malthus, Pearl and Read, Monod model, Konak Model. The limitation of Monod model and development of other constitutive models. Multi substrate model, inhibition models. Product formation models, Development of logistic equation. Maintenance and endogenous metabolism kinetics.

Unit VII

Kinetic models: Structured models, a few example, single cell model, Product formation kinetics based on molecular mechanism, Model for plasmid Expression and Replication, Model of gene expression, Segregated model, an example. Models on plasmid stability. Thermal death kinetics of cells and spores.

Text Books:

1. Bisswanger H. Enzyme Kinetics: Principles and Methods. 2nd edn. Weinheim, Germany: Wiley-VCH; 2008.
2. Buchholz K., Kasche V., Bornscheuer U.T. Biocatalysts and Enzyme Technology.2nd Edn. Weinheim, Germany: Wiley-VCH; 2012.
3. Bailey, JE; Ollis, DF: Biochemical Engineering Fundamentals 1986
4. Blanch, HW and Clark, DS: Biochemical Engineering, Marcel Decker 1997
5. Wiseman, A: Handbook of Enzyme Biotechnology, 3rd Edition, Ellis Horwood Publication1999
6. Moser, A: Bioprocess technology, kinetics and reactors: Springer Verlag 1988
7. Schugerl, K., Bellgart, KH (Eds): Bioreaction Engineering, modeling and control: Springer-Verlag, Berlin 2000
8. Octave Levenspiel. Chemical Reaction Engineering. 3rd eds. 2006, Wiley.

BTH451	BIOREACTOR DESIGN AND ANALYSIS	PCC	3–1–0	4 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the different component and specific instrumentation required for the efficient monitoring and control of bioreactor.
CO2	Design and analyse batch, continuous flow, and fed batch reactors.
CO3	Elucidate heat and mass transfer, ancillary equipment required for the aseptic feeding, sampling and processing of bioreactor fluids.
CO4	Design biological reactors with cell recycle streams.
CO5	Apply the scale up concepts for the large-scale design of bioreactor

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	3	2	-	-	-	1	1	2	2	2	3	2
CO2	3	2	2	1	-	-	-	-	-	-	-	-	3	2	-
CO3	3	2	3	3	2	-	-	-	1	1	2	2	2	3	2
CO4	2	2	3	2	2	1	-	1	-	-	-	-	3	2	-
CO5	3	2	3	2	2	-	-	-	-	-	-	-	3	3	-

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction: Different types of Bioreactor, Disposable reactors, Different modes of operation. Main components of the bioreactor and their function. **Bioreactor design:** Batch reactor, Cell death in batch reactor, chemostat, endogenous metabolism, maintenance, product and substrate inhibition on chemostat, multiple steady state, enzyme catalysis in CSTR, cascade reactor, PFR, Fed batch reactor, Chemostat with cell recycle and feed forward control.

Unit II

Mass transfer in bioreactor: Gas-liquid mass transfer in cellular systems, Basic mass transfer concepts, solubility of gases (O2, CO2) in biological media, Mass balances for two phase bioreactor, Mass transfer in agitated tanks, correlations with kla in Newtonian and non-Newtonian liquid, power number, experimental determination of kla, static method, dynamic method, chemical method and electrochemical method, Power requirement for mixing in aerated and non-aerated tanks, agitated and non-agitated tanks for Newtonian and non-Newtonian fluid. Mixing time in agitated reactor, Residence time distribution, non-ideal reactor and multiphase bioreactor.

Unit III

Bubble column reactors: bubble generation at an orifice, bubble coalescence and breakup, gas holdup, interfacial area, Immobile and mobile gas liquid interface, Regimes of bubbles, Design of bubble columns. **Heat transfer and sterilization**: In-situ sterilization of bioreactor, medium sterilization, Decimal reduction time, kinetics of thermal death of the microbial cells. Batch sterilization, sterilizer design, continuous sterilizer design. Heat transfer in agitated tank.

Unit IV

Scaling up: Scaling up and design considerations, process scaling up, scaling up of mass of transfer equipment's. **Control of bioreactor:** Sensor used in the bioreactor; pH, temperature, dissolved O_2, dissolved CO_2 electrode, redox potential, level, antifoam, pressure. On line sensors for cell properties. Direct regulatory control and cascade control mechanism.

Text Books:

1. T. Panda, Bioreactors: Process and Analysis, Tata McGraw-Hill Education, 2011
2. Bailey JE, Ollis, DF: Biochemical Engineering Fundamentals 1986
3. Blanch HW and Clark DS: Biochemical Engineering, Marcel Decker 1997
4. Wiseman, A: Handbook of Enzyme Biotechnlogy, 3rd Edition, Ellis Horwood Publication 1999
5. Moser, A: Bioprocess technology, kinetics and reactors: Springer Verlag 1988
6. Schugerl K., Bellgart KH (Eds): Biorection Engineering, modeling and control: Springer-Verlag, Berlin 2000

BTH452	DOWNSTREAM BIOPROCESSING	PCC	3–1–0	4 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the importance of downstream bioprocessing and parameters that determine the selection of separation operations and economics of the process
CO2	To enhance problem solving techniques required in multi-factorial manufacturing environment in a structured and logical fashion.
CO3	Evaluate the critical process parameters in various unit operations in the purification process
CO4	Define advanced downstream processing methods for product recovery

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	-	1	-	-	-	-	1	-	3	-	1
CO2	2	2	2	2	-	-	-	-	-	-	1	-	3	1	-
CO3	3	2	3	2	1	-	-	1	-	-	2	-	3	1	1
CO4	3	2	2	2	1	-	-	-	-	-	1	-	3	-	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Introduction: Role and importance of Downstream Processing in Biotechnology, Problems, economics, and requirements of purification, selection of unit operation with due consideration of physical, chemical and biochemical aspect of biomolecules, basic review of bioprocess designing, Process design criteria (high volume, low value products and low volume, high value products), Influence of upstream processing.

Unit II

Cell disruption: Dyanomill & bead beater, sonication, chemical processes, Enzyme Processes. **Separation of insoluble:** filtration, sedimentation, centrifugation, centrifugal filtration. **Product isolation:** Adsorption, adsorption isotherms, salt precipitation, extraction, In-situ product removal, dialysis, electro-dialysis, Ultra-filtration and other membrane separation techniques, Distillation.

Unit III

Product purification: Theory of Chromatography, gel filtration, affinity, ion-exchange, and HIC chromatography, gel electrophoresis, fractional precipitation, HPLC, GC, FPLC, Hybrid separation techniques (Electrochromatography), scale-up operations in chromatography.

Unit IV

Molecular techniques: SDS PAGE, Southern blot, northern blot, western blot, ELISA, Microarray technique. **Product polishing:** Crystallization, evaporation and drying, **Case studies and Current trends -** Penicillin, Recombinant Streptokinase, Mab, and Interferon. Introduction to Process Analytical Technology (PAT) and Quality by Design (QbD).

Text Books:

1. Belter PA, Cussler EL and Wei-Houhu: Bioseparation, downstream processing & Biotechnology, John-Wiley Interscience Pub., 1988
2. Jenkins RO: Product Recovery in Bioprocess Technology (Biotechnology by open learning series): Butterworth Heinemann 1992
3. Janson JC and Ryden L: Protein purification: principles High Resolution Methods and Applications, VCH Publication 1989
4. Scopes RK, Protein purification: principles and practice, 3rd Edition, Narosa Pub,1994
5. Mc.Cabe WL, Smith JC: Unit opearations in chemical engineering, 6th Edition, Mc.Graw-Hill 2001
6. Asenjo Juan A.: Separation Processes in Biotechnology (Biotechnology and Bioprocessing), CRC Press 1990
7. Fredreich Dechow, Separation and purification techniques in biotechnology 1989
8. Simon Roy. Protein purification applications Second Edition A Practical Approach 2001.

BTH453	MOLECULAR GENETICS	PCC	3–1–0	4 Credits

Prerequisites: None

Course Outcomes:

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

CO1	Understand the basic concept of genetics and Mendelian inheritance
CO2	Study the flow of genetic information through central dogma, mapping of genes
CO3	Interpret the effect of mutations and ploidy levels in different chromosomes
CO4	Understand the mechanism of replication and gene regulation in prokaryotes and eukaryotes

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	1	1	2	-	-	-	-	2	-	3	1	1
CO2	3	1	-	1	1	2	-	-	-	-	1	-	3	1	1
CO3	3	1	-	1	1	2	-	-	-	-	1	-	3	1	1
CO4	3	1	-	-	1	2	-	-	-	-	2	2	3	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Unit I

Basic Concepts of Genetics: Mendelian genetics: concept of gene, chromosomal and extrachromosomal inheritance, linkage and crossing over, Mendelian genetic diseases (Cystic fibrosis, Thalassaemias, Hemophilia and Muscular dystrophies)

Unit II

Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, microbial genetics, methods of gene transfer, mapping genes by interrupted mating, fine structure analysis of genes, types of mutation, causes and detection, mutant types – germinal verses somatic mutants.

Unit III

Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping, homologous and nonhomologous recombination including transposition, immunoglobulin genes, structural and numerical alterations of chromosomes, deletion, duplication, inversion, translocation, ploidy and their genetic implications.

Unit IV

DNA: Replication in prokaryote and eukaryotes, enzymes and accessory proteins, telomere replication. **Transcription:** Transcription process in prokaryote and eukaryote, types of RNAs, transcriptional factors, regulation of transcription; RNA processing and RNPs spliceosome, splicing of mRNA, tRNA and rRNA; Nuclear export and stability o fmRNA., regulation of gene regulation. **Translation:** Process, genetic code, translation mechanism of prokaryote and eukaryotes, translational control, post translation modification.

Text Books:

1. Simmons, Principles of Genetics, 8 th edition, Wiley student edition. 2010
2. Griffith, Wessler, Lewontin and Carroll, Introduction to Genetic analysis; 9th Edition 2007
3. Watson, J.D., “Molecular Biology of The Cell”, Taylor & Francis 2006