TULSIRAMJI GAIKWAD-PATIL College of Engineering and Technology
Wardha Road, Nagpur - 441108
Accredited with NAAC A+ Grade
Approved by AICTE, New Delhi, Govt. of Maharashtra
(**An Autonomous Institution Affiliated to RTM Nagpur University**)
Department of Biotechnology

Teaching Scheme and Syllabus

of

6th Semester B.Tech Biotechnology

(From Academic Year 2026-27)

Vision of Institute

To emerge as a learning Centre of Excellence in the National Ethos in domains of Science, Technology and Management.

Mission of Institute

1. To strive for rearing standard and stature of the students by practicing high standards of professional ethics, transparency and accountability.
2. To provide facilities and services to meet the challenges of Industry and Society.
3. To facilitate socially responsive research, innovation and entrepreneurship.
4. To ascertain holistic development of the students and staff members by inculcating knowledge and profession as work practices.

Vision of the Department

To produce competent Entrepreneurs, Researchers and industry ready Professionals in Biotechnology through quality education

Mission of the Department

1. To impart quality technical education and unique interdisciplinary research by merging science and technology
2. To make students aware about techniques of modern biotechnology and industrial advancements
3. To Inculcate Social and Ethical values in the students and empower them through imparting of knowledge and skills in biotechnology

Program Education Objectives (PEO)

1. Develop Biotechnology graduates as human resource with technical competencies and strong foundation of science and engineering.
2. Acquire fundamental knowledge of mathematics, Biosciences and engineering to analyze, design and implement solutions to the Biotechnological problems.
3. Understand emerging concepts and trends in Biotechnology and allied fields.
4. Apply various tools to develop innovative systems for the bioprocesses.

Program Outcomes (PO)

1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and software tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. **The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment.
7. **Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws
8. **PO8: Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
9. **PO9: Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
10. **PO10: Project Management and Finance**: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
11. **PO11: Life-LongLearning:**Recognizetheneedfor, and have the preparation and ability for i) Independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

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Program Specific Outcomes (PSO)

PSO-1: Ability to apply the acquired knowledge and recent techniques to come up with ideas in the domains of Bioprocess Engineering, Bioinformatics and Biopharmaceuticals.
PSO-2: Ability to utilize their proficiency and skills in solving real life problems in Diagnostics Genetic Engineering and Fermentation Technology using recent technologies.
PSO-3: Analyzing the impact of Biotechnology Engineering solutions in the societal and human context to create productive human resource for the country.

Tulsiramji Gaikwad-Patil College of Engineering &Technology, Nagpur

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SCHEMEOFINSTRUCTION& SYLLABI

Programme: B. Tech Biotechnology

Scheme of Instructions: Third Year B.Tech. in Biotechnology (As Per NEP 2020)

Semester–VI

SN	Sem	Type	BoS/ Dept	Sub Code	Subject	T/P	Contact Hours			Credits	% Weightage			ESE Duration	Total Marks
							L	P	Hrs		CT/IA	CA	ESE		
1	**VI**	PCC	BT	BBT33601	Heat and Mass Transfer in Biotechnology	T	3	0	5	4	30	10	60	3 Hrs	100
2	**VI**	PCC	BT	BBT33602	Bioreaction Engineering	T	3	0	5	3	30	10	60	3 Hrs	100
3	**VI**	PCC	BT	BBT33603	Heat and Mass Transfer in Biotechnology lab	P	0	2	4	1	25	-	25	-	50
4	**VI**	PEC	BT	BBT33605-07	Program Elective II	T	4	0	6	4	30	10	60	3 Hrs	100
5	**VI**	PEC	BT	BBT33608-10	Program Elective III	T	4	0	6	4	30	10	60	3 Hrs	100
6	**VI**	MDM	CE	BCE33615	Environmental Engineering	T	2	0	4	2	14	6	30	2 Hrs	50
7	**VI**	VSEC	BT	BBT33612	Microbial Identification Studies lab	P	0	4	4	2	25	-	25	-	50
8	**VI**	Project	BT	BBT33611	Project (Minor Project)	P	-	2	2	1	-	25	25	-	50
Total							**16**	**8**	**34**	**21**	**184**	**71**	**345**	**16**	**600**

Course Category	BSC/ ESC (Basic Science Course/ Engineering Science Course.)	PCC (Programme Core courses	(MDM) Multidisciplinary Minor/ (OEC) Open Elective Course	VSEC (Skill Course)	Humanities Social Science & Management		Experiential Learning Courses	CC (Co-Curricular Courses)
					AEC(Ability Enhancement Course)	IKS(Indian Knowledge System)		
Credits	00	50	10	6	0	0	0	0
Cumulative Sum	29	66	12	8	8	2	2	4

PROGRESSIVE TOTAL CREDITS: 104+21=125

Chairperson	Dean Academics/Vice Principal	Director Administration	Principal	Date of Release	Version	
Head Department Of Biotechnology Tulsiramji Gaikwad Patil College Engineering & Technology, Nagpur	Vice Principal (Academics) GPCET NAGPUR	Director Administration Dr. Pragati Director (Administration) Tulsiramji Gaikwad - Patil College Of Engineering & Technology, Nagpur.	Principal Tulsiramji Gaikwad Patil College Of Engineering and Technology, Nagpur	October,2026	1.00	Applicable for AY 2026-27 Onwards

Programme: B. Tech Biotechnology

List of **Program Electives** offered by The **Biotechnology** Department

Program Elective- I	Program Elective-II	Program Elective-III	Program Elective- IV	Program Elective- V
Semester V	**Semester VI**	**Semester VI**	**Semester VII**	**Semester VIII**
BBT33507- Biopharmaceutical Technology	**BBT33605-** Enzyme Technology	**BBT33608-** Biosimilars Technology	**BBT34703-** Nanotechnology	**BBT34706-** Good Manufacturing and Laboratory Practices
BBT33508- Introduction to Bioinformatics	**BBT33606-** Precision Medicine Technology	**BBT33609-** Stem cell Technology	**BBT34704-** Tissue Engineering and organ Printing	**BBT34707-** Biosensors
BBT33509- Bioremediation and Biodegradation	**BBT33607-** Biofertilizer and Biopesticide technology	**BBT33610-** Bioenergy and Biofules	**BBT34705-** Industrial Microbiology and its Application	**BBT34708-** Pollution control and Remediation

Program: B. Tech Biotechnology

List of **Open Electives** offered by **Biotechnology** Department

Open Elective-I	Open Elective-II	Open Elective-III
Semester-III	**Semester-IV**	**Semester-V**
BBT32309: Food and Nutrition	**BBT32408:** Waste Management	**BBT35310:**Bioterrorism and National Security

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33601: Heat and Mass Transfer in Biotechnology

TeachingScheme		ExaminationScheme	
Lectures	3hr/week	CIE	40 Marks
Tutorials	-	ESE	60 Marks
Practical	-	Total	100 Marks
Total Credits	4	Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To impart knowledge of the fundamental principles of heat transfer and their applications in bioprocess systems.
2	To develop an understanding of mass transfer principles, diffusion, and gas–liquid mass transfer in bioreactors.
3	To familiarize students with mass transfer operations used in the separation, purification, and recovery of biological products.

Course Contents

Unit I	**Fundamentals of Heat Transfer:** Modes of heat transfer: conduction, convection, and radiation; Fourier's law of heat conduction; thermal conductivity; steady-state heat conduction through plane and composite walls; thermal resistance; Newton's law of cooling; natural and forced convection; heat transfer in biological systems and bioprocess equipment.
Unit II	**Heat Transfer in Bioprocess Systems:** Heat exchangers: types, construction, and working principles; parallel-flow and counter-flow heat exchangers; overall heat transfer coefficient; log mean temperature difference (LMTD); basic heat balance calculations; heating and cooling of fermentation media; thermal sterilization of culture media; heat transfer in stirred-tank bioreactors; applications in food, pharmaceutical, and fermentation industries.
Unit III	**Fundamentals of Mass Transfer:** Introduction to mass transfer; molecular diffusion and convective mass transfer; Fick's laws of diffusion; diffusivity; diffusion through stagnant films; concentration gradients; mass transfer coefficients; factors affecting mass transfer; diffusion of oxygen, nutrients, and metabolites in biological systems.
Unit IV	**Gas–Liquid Mass Transfer in Bioreactors:** Gas–liquid mass transfer principles; gas absorption and stripping; Henry's law; two-film theory; liquid-side and gas-side mass transfer coefficients; volumetric oxygen transfer coefficient (k_La); oxygen transfer rate (OTR) and oxygen uptake rate (OUR); factors affecting oxygen transfer; aeration and agitation; scale-up considerations in aerobic fermentation.
Unit V	**Mass Transfer Operations in Downstream Processing:** Principles and applications of extraction, adsorption, membrane separation, filtration, dialysis, drying, distillation, and chromatography; separation and purification of biomolecules and recovery of fermentation products.

Text Books

1	P. K. Nag — Heat and Mass Transfer, McGraw-Hill Education.
2	R. K. Rajput — Heat and Mass Transfer, S. Chand Publishing.

3	McCabe, W. L., Smith, J. C., and Harriott, P. — Unit Operations of Chemical Engineering, McGraw-Hill.
Reference Books	
1	"SeparationProcessPrinciples"byJ.D.Seader,ErnestJ.Henley,andD.KeithRoper
2	"Introduction to Chemical Engineering" by S.K.Ghosaland A. K. Biswas
3	"Introduction to Chemical Engineering" by S.K.Ghosaland A. K. Biswas
Useful Links	
1	https://www.sciencedirect.com/topics/physics-and-astronomy/molecular-diffusion
2	https://www.sciencedirect.com/topics/engineering/interphase-mass-transfer
3	https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Introduction_to_Solid_State_Chemi

BBT33601	CourseOutcomes	CL	Class Sessions
CO1	Explain the fundamental principles and mechanisms of heat transfer	**2**	9
CO2	Analyze heat transfer equipment and applications in bioprocess systems.	**4**	9
CO3	Apply mass transfer principles to biological systems and diffusion processes.	**3**	9
CO4	Analyze gas–liquid mass transfer and oxygen transfer in bioreactors.	**4**	9
CO5	Evaluate suitable mass transfer operations for the separation, purification, and recovery of biological products.	**5**	9

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33602 : Bio Reaction Engineering

Teaching Scheme		ExaminationScheme	
Lectures	3hr/week	CIE	40 Marks
Tutorials	-	ESE	60 Marks
Practical	-	Total	100 Marks
Total Credits	3	Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To introduce the fundamentals of chemical reactor design and different types of ideal and non-ideal reactors.
2	To develop an understanding of reactor design for single and multiple reactions, including selectivity and yield.
3	To study the effects of temperature, pressure, and heat transfer on reactor performance and design.

Course Contents

Unit I	Introduction To Reactor Design: Types of reactors, PFR, CSTR etc., Material & energy balances, single ideal reactor, Space-time and space-velocity, Holding Time, Introduction of non-ideal flow, Problems
Unit II	Ideal Reactors for a Single Reaction: Ideal Batch Reactor, Steady State Mixed Flow Reactor, Steady State Plug Flow Reactor, Problems Design for Single Reactions: Size comparison of single reactors, General graphical comparison, Multiple reactor system, Recycle reactor, Autocatalytic reactions, Problems.
Unit III	Design for Parallel Reactions: Introduction to design of parallel reactions, Qualitative and Quantitative discussion on product distribution, Contacting patterns, Reactor Size and arrangement, Selectivity, Yield, and Problems.
Unit IV	Potpourri of Multiple Reactions: Reversible first order reaction, First order Followed by zero order reaction, Zero order followed by first order reaction, Successive reversible reactions of different orders, reversible reactions, Irreversible series-parallel reactions, Graphical representation, Denbigh reactions and their special cases, Problems
Unit V	Temperature and Pressure Effects: Single and multiple reactions, Heats of reaction from thermodynamics, Equilibrium constant, Temperature, Graphical design procedure, Optimum Temperature Progression, Heat Effects, Adiabatic and Non-adiabatic operations, Problems.

Text Books

1	Chemical Reaction Engineering, Octave Levenspiel, John Wiley & Sons, Singapore, 3rd edition, 1998.
2	Elements of Chemical Reaction Engineering, Fogler H.S., Prentice-Hall, NJ, 4th Edition, 2006.

Reference Books

1	Chemical Reactor Analysis, G.F. Froment and K.B. Bischoff, JohnWiley & Sons, Singapore, 2nd edition, 1990.
2	Chemical Engineering Kinetics, Smith J.M., McGraw-Hill, NY, 3rd edition, 1981

Useful Links

1	http://digimat.in/nptel/courses/video/103106117/L02.html
2	https://enine.digimat.in/nptel/courses/video/103101001/L03.html

BBT33602	Course Outcomes	CL	Class Sessions
CO1	Explain reactor types and perform material/energy balances in Ideal reactors	**3**	9
CO2	Analyze the performance of ideal reactors (Batch, CSTR, PFR) for a single reaction	4	9
CO3	Evaluate parallel reaction systems in terms of selectivity, yield, and product distribution	**5**	9
CO4	Analyze and classify multiple complex reactions and graphical representation	**4**	9
CO5	Apply heat and pressure effects on reaction kinetics and reactor design	3	9

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33603 : Heat & Mass Transfer in Biotechnology Lab

Teaching Scheme	
Lectures	
Tutorials	-
Practical	**2hr/week**
Total Credits	1

ExaminationScheme	
CIE	25 Marks
ESE	25 Marks
Total	50 Marks
Duration of Exam: 2 Hours	

The Objectives of this course are:

1	To understand the principles of heat transfer and determine thermal conductivity and heat transfer coefficients under different conditions.
2	To study mass transfer operations and determine diffusion coefficients, mass transfer coefficients, and drying characteristics.
3	To develop practical skills in heat and mass transfer operations, including absorption, crystallization, distillation, and evaporation.

Sr. No.	Experiments (Minimum 8 experiments should be performed)
1.	To determine the thermal conductivity of a given material.
2.	To study heat transfer through a composite wall.
3.	To determine the heat transfer coefficient under natural convection.
4.	To determine the heat transfer coefficient under forced convection.
5.	To study heat transfer by radiation and verify Stefan–Boltzmann's law.
6.	Determination of diffusion coefficient of an organic vapor (acetone) in air.
7.	Examinationofthedryingcharacteristicsofagivenmaterialunderconstantdrying Conditions and to report equilibrium and critical moisture content.
8.	Determination of the mass transfer coefficient for the absorption of water vapor on silica gel.
9.	Analysis of the variation of mass transfer coefficient as a function of flow rate of air for the vaporization of naphthalene in a packed bed.
10.	Estimationoftherateconstantforthephysicaldissolutionofbenzoicacidinaliquid.
11.	Determination of the diffusion coefficient for the given liquid-liquid system as a function of concentration.
12.	Estimation of Kla for air/oxygen absorption in nature.
13.	Examination of crystallization phenomena in Batch Crystallization
14.	To find the mass transfer coefficient in a wetted wall Column
15.	To verify Rayleigh's Equation for Simple Distillation

Text Books

1	Mass Transfer Operations by *Robert E. Treybal*

2	Mass Transfer: Theory and Applications by *K.V. Narayanan & B. Lakshmikutty*
Reference Books	
1	"SeparationProcessPrinciples"byJ.D.Seader,ErnestJ.Henley,andD.KeithRoper
2	"Introduction to Chemical Engineering "by S.K.Ghosaland A. K. Biswas
Useful Links	
1	https://www.sciencedirect.com/topics/physics-and-astronomy/molecular-diffusion
2	https://www.sciencedirect.com/topics/engineering/interphase-mass-transfer
3	https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Introduction_to_Solid_State_Chemi

BBT33603	Course Outcomes	CL	Class Sessions
CO1	**Apply** diffusion and mass transfer principles to estimate key transport parameters in gas, liquid, and solid systems.	**3**	9
CO2	**Apply** experimental methods to determine drying behavior, dissolution rates, and oxygen transfer characteristics.	**3**	9
CO3	**Analyze** mass transfer operations such as absorption, extraction, and distillation using experimental data.	**4**	9
CO4	**Evaluate** the performance of packed beds, fluidized beds, membranes, and wetted-wall columns.	**5**	9
CO5	**Assess** crystallization and phase-change experiments to derive critical process parameters.	**5**	9

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33605:PE-II: Enzyme Technology

Teaching Scheme		Examination Scheme	
Lectures	4hr/week	CIE	40 Marks
Tutorials	-	ESE	60 Marks
Practical	-	Total	100 Marks
Total Credits	4	Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To understand enzyme classification, structure, mechanisms, and kinetics.
2	To study enzyme immobilization, extraction, purification, and their applications in bioprocesses.
3	To explore industrial and clinical applications of enzymes, including enzyme engineering and designer enzymes.

Course Contents

Unit I	**Introduction of Enzyme:** Brief history, nomenclature & classification, Coenzyme and Cofactors, Induced & Lock-Key hypothesis, Transition-state stabilization hypothesis, Zymogen, Ribozyme & Abzymes, Allosteric enzymes.
Unit II	**Enzyme Kinetics:** Single substrate steady state kinetics; Michaelis Menten equation, Linear plots, King-Altman's method; Inhibitors and activators; Multi substrate systems; ping-pong mechanism, Alberty equation, Sigmoidal kinetics and Allosteric enzymes.
Unit III	**Enzyme immobilization:** Methods of immobilization of enzymes-physical & chemical techniques, Kinetics of immobilized enzyme, Effect of external mass transfer & intra- particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme.
Unit IV	**Extraction and Purification of Enzymes:** Methods of production of enzymes, Extraction of Enzymes –soluble enzymes – membrane bound enzymes – Nature of extraction medium – purification of enzyme –criteria of purity –Determination of molecular weight of enzymes.
Unit V	**Industrial and Clinical uses of Enzymes (Applied Enzymology):** Industrial Enzymes- Thermophilic enzymes, amylases, lipases, proteolytic enzymes in meat and leather industry, enzymes used in various fermentation processes. Clinical enzymes- Enzymes as thrombolytic agents, Anti-inflammatory agents, asparaginase, Isoenzymes like CK and LDH, Amylases, Cholinesterases, Phosphatases. Immobilization of enzymes, ELIZA. Enzyme Engineering and site directed mutagenesis, Designer enzymes

Text Books

1	"Enzyme Technology" by Martin F. Chaplin and Christopher Bucke Cambridge University Press
2	"Biotechnology: Enzymes and Bioprocessing" by H.J. Rehm and G. Reed (Vol. 7a & 7b of Biotechnology series)

Reference Books

1	Biocatalysis and Enzyme Technology" by Klaus Buchholz, Volker Kasche, and Uwe Theo Bornscheuer.

2	Biocatalysis and Enzyme Technology" by Klaus Buchholz, Volker Kasche, and Uwe Theo Bornscheuer
Useful Links	
1	https://pubmed.ncbi.nlm.nih.gov/37945176/
2	https://www.ncbi.nlm.nih.gov/books/NBK554481/
3	https://pubs.acs.org/doi/10.1021/acsomega.2c07560
4	https://pmc.ncbi.nlm.nih.gov/articles/PMC4692135/

After completion of this course students will able to:

BBT33605	Course Outcomes	CL	Class Sessions
CO1	**Explain** enzyme classification, components, and basic mechanisms of enzyme action.	**2**	9
CO2	**Illustrate** enzyme kinetic principles, including Michaelis–Menten behavior, inhibition, and allosteric regulation.	**3**	9
CO3	**Analyze** enzyme immobilization methods and mass-transfer effects in bioreactor applications.	**4**	9
CO4	**Classify** enzyme production, extraction, and purification techniques using biochemical analytical methods.	**4**	9
CO5	**Summarize industrial** and clinical applications of enzymes and basic enzyme engineering strategies.	**5**	9

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33606: PEII:Precision Medicine & Wellness

Teaching Scheme	
Lectures	4hr/week
Tutorials	-
Practical	-
Total Credits	4

Examination Scheme	
CIE	40 Marks
ESE	60 Marks
Total	100 Marks
Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To understand omics technologies and their applications in disease diagnosis and biomarker identification.
2	To study genome projects, genetic variations, genetic screening, and pharmacogenomic testing.
3	To explore rare diseases, precision medicine, and the ethical, legal, and social implications of personalized healthcare.

Course Contents

Unit I	Use of genomics, transcriptomics, proteomics and metabolomics in understanding disease conditions. Biomarker identification and validation of a disease state.
Unit II	Human Genome project. Cancer genome project. Different types of genetic and non-genetic variations.
Unit III	Genetic screening and diagnosis: prenatal carrier testing and newborn screening for Mendelian diseases. Pharmacogenomic testing for drug selection, dosing and Predicting adverse effects of commonly prescribed drugs,
Unit IV	Concept of rare and Orphan disorders, Importance of focus to rare diseases, Classification and types of rare disorders, representative cases rare disorders viz. Epidermolysis Bullosa, Pompe, Fabry, Friedreich's Ataxi. Modern approaches to target rare disorders, Globaland National Policy for research on rare diseases.
Unit V	Ethical, legal, and social implications of health privacy and policy laws for precision medicine. Ayurveda system of *Prakriti* and *Agni*.

Text Books

1	"Introduction to Genomics" by Arthur M. Lesk
2	"The Human Genome Project: What Does Decoding DNA Mean for Us?" by Tanya Lewis

Reference Books

1	"Transcriptomics: Methods and Protocols " edited by Michael J. Dyer
2	"Principles of Proteomics " by Richard Twyman
3	"Metabolomics: From Fundamentals to Clinical Applications" edited by Alessandra Sacco

Useful Links

1	https://www.genome.gov/human-genome-project
2	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2860823/
3	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3221079/

After completion of this course students will able to:

BBT33606	Course Outcomes	CL	Class Sessions
CO1	**Explain** the fundamental concepts of major genome projects and differentiate between the various types of genetic variations.	**2**	9
CO2	**Apply** omics technologies (genomics, proteomics, etc.) to investigate disease mechanisms and stratify patients based on biomarkers.	**3**	9
CO3	**Analyze** the concept, classification, and representative examples (e.g., Pompe, Fabry) of rare and orphan disorders, including modern therapeutic approaches and global research policies.	**4**	9
CO4	**Evaluate** genetic screening and pharmacogenomic testing strategies for diagnosing and personalizing treatment for Mendelian diseases.	**5**	9
CO5	**Justify** the ethical, legal, and social implications (ELSI) of health privacy laws and compare them with Ayurvedic principles in precision medicine.	**5**	9

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33607:PE-II: Biofertilizer and Biopesticide Technology

Teaching Scheme	
Lectures	4hr/week
Tutorials	-
Practical	-
Total Credits	4

Examination Scheme	
CIE	40 Marks
ESE	60 Marks
Total	100 Marks
Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To develop an understanding of the classification, physiology, and plant interactions of beneficial microorganisms used as biofertilizers, including Rhizobium, Frankia, Azospirillum, Azotobacter, and mycorrhizal fungi.
2	To impart knowledge of the isolation, identification, cultivation, maintenance, inoculum preparation, and large-scale production of biofertilizers for sustainable agriculture and organic farming.
3	To explain the principles, types, mechanisms of action, and agricultural applications of microbial biopesticides, including Bacillus thuringiensis, insect viruses, and entomopathogenic fungi, for environmentally responsible pest management.

Course Contents

Unit I	Biofertilizers – Definition, kinds, microbes as biofertilizers, Symbiotic associates – Rhizobium taxonomy, Physiology, Host cell – Rhizobium interactions, mass cultivation, inoculants and serology.
Unit II	Frankia woodland and Actinorhizal nitrogen fixing plants and its host plants, characteristics, identification, cultural method and maintenance of Azospirillum, Azotobacter, Azolla and anabaena.
Unit III	Mycorrhiza - VAM association, types, occurrence, Collection, isolation and inoculum production.
Unit IV	Large scale production of biofertilizer, Organic farming Carrier materials, general outline of microbes as fertilizers, Rhizosphere effect microbial products influencing plant growth.
Unit V	Biopesticides–Definition, kinds and commerce of biopesticide, Bacillus thuringiensis, insect viruses and entomo pathogenic fungi – its characteristics, physiology, mechanism of action and application.

Text Books

1	Subba Rao, N. S. (2005). Soil Microbiology (Fourth Edition of Soil Microorganisms and Plant Growth). Oxford & IBH Publishing Co. Pvt. Ltd.
2	Subba Rao, N. S. (1988). Biofertilizers in Agriculture. 2nd edition. Oxford & IBH Publishing Co. Pvt. Ltd.
3	Smith, S. E., & Read, D. J. (1997). Mycorrhizal Symbiosis. 2nd edition. Academic Press

Reference Books

1	1. Kannaiyan, S. (2002). Biotechnology of Biofertilizers. Springer, Netherlands.
2	Atlas, R. M., & Bartha, R. (1998). Microbial Ecology: Fundamentals and Applications. 4th edition. Benjamin/Cummings.

3	Aneja, K. R. (2017). Experiments in Microbiology, Plant Pathology and Biotechnology. 5th edition. New Age International Publishers.
Useful Links	
1	http://www.digimat.in/nptel/courses/video/102105058/L55.html
2	https://archive.nptel.ac.in/courses/102/105/102105058/
3	https://ggsestc.digimat.in/nptel/courses/video/102103555/L25.html

After completion of this course students will able to:

BBT33607	Course Outcomes	CL	Class Sessions
CO1	**Discuss** the classification, physiology, and interactions of biofertilizer microbes such as *Rhizobium*, *Frankia*, and *Azospirillum* with host plants.	**2**	9
CO2	**Illustrate** the cultural methods and maintenance techniques for effective cultivation of *Azotobacter*, *Azolla*, and *Anabaena*.	**3**	9
CO3	**Apply** techniques for the isolation, inoculum production, and large-scale cultivation of mycorrhizae and other biofertilizer organisms.	**3**	9
CO4	**Examine** the role of rhizosphere microbial products and carrier materials in organic farming practices and plant growth promotion.	**4**	9
CO5	**Analyze** the characteristics, physiology, and mechanism of action of biopesticides like *Bacillus thuringiensis* and insect viruses for pest management.	**4**	9

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33608:PE-III: Bio similar Technology

Teaching Scheme	
Lectures	4hr/week
Tutorials	-
Practical	-
Total Credits	4

Examination Scheme	
CIE	40 Marks
ESE	60 Marks
Total	100 Marks
Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To understand the fundamentals of biosimilars, biotherapeutics, and their applications in healthcare.
2	To study biosimilar development, manufacturing processes, analytical characterization, and regulatory requirements.
3	To evaluate challenges, market opportunities, and future trends in biosimilars for affordable healthcare.

Course Contents

Unit I	Introduction to Biosimilars: Definition and overview of biosimilars, History and evolution of biosimilars, The concept of biological equivalence, Comparison of Biologics and small molecule drugs.
Unit II	Biotherapeutics and Their Applications: Types of biotherapeutics (peptides, antibodies, enzymes etc.), Applications of biotherapeutics in various diseases, Limitations and challenges in biotherapeutic development.
Unit III	Biosimilar Development Process: Overview of the biosimilar development process, Key steps in biosimilar development (characterization, optimization, manufacturing, and clinical trials), Comparison of biosimilar development with small molecule drug development, Regulatory aspects of Biosimilar development.
Unit IV	Challenges and Opportunities in Biosimilar Development: Market competition and competition for biosimilars, Regulatory challenges and approval processes, Manufacturing and analytical methods for biosimilars, Patent landscape and Intellectual property considerations.
Unit V	Case Studies and Future Prospects: Case studies of successful and failed biosimilar development programs, Emerging trends and future prospects in biosimilar technology, The role of biosimilars in access to affordable Health care and sustainability of the biopharmaceutical industry.

Text Books

1	"Biosimilars: A New Generation of Biologics" by Sarfaraz K. Niazi
2	"Biopharmaceuticals: Biochemistry and Biotechnology" by Gary Walsh

Reference Books

1	"Biosimilars and Interchangeable Biologics: Tactical Elements" by Sarfaraz K. Niazi
2	"Biosimilars and Follow-On Biologics: Regulatory, Clinical, and Biopharmaceutical Development" by Sarfaraz K. Niazi

Useful Links

1	https://www.iqvia.com/solutions/therapeutics/biosimilars
2	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5423073/
3	https://www.nature.com/articles/d42473-019-00145-0

After completion of this course students will able to:

BBT33608	Course Outcomes	CL	Class Sessions
CO1	**Describe** the concept of biosimilars, their revolution, and comparison with small molecule drugs.	**2**	9
CO2	**Classify** biotherapeutics types, their applications, and recognize Development challenges.	**2**	9
CO3	**Comprehend** biosimilar development steps, regulatory aspects, and compare with small molecule drugs.	**3**	9
CO4	**Analyze** biosimilar development challenges, including market Competition and regulatory hurdles.	**4**	9
CO5	**Evaluate** biosimilar case studies, prospects, and their role in healthcare accessibility.	**5**	9

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Third Year (Semester-VI) B.Tech. Biotechnology

BBT33609: PEIII: Stem Cell Technology

Teaching Scheme		Examination Scheme	
Lectures	4hr/week	CIE	40 Marks
Tutorials	-	ESE	60 Marks
Practical	-	Total	100 Marks
Total Credits	4	Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To understand the principles, properties, types, and niches of stem cells.
2	To study stem cell isolation, differentiation, cryopreservation, and transplantation techniques.
3	To explore stem cell applications in regenerative medicine and understand related ethical and regulatory issues.

Course Contents

Unit I	Introduction to Stem Cells: Principles & Properties of Stem Cells, Types of Stem cells, Comparison of Embryonic & Adult stem cells.
Unit II	Stem cell niche: Introduction to stem cell niches in gut epithelium, bone marrow, epidermis, testis & neural tissues.
Unit III	Types of regeneration- Stem cells derived from amniotic fluid, extra embryonic membrane, germ cells, hematopoietic organs, neurons & kidney. Bone marrow & cord blood collection procedures, cryopreservation, & their applications. Cord blood transplantation, donor selection, HLA matching, Patient selection, peripheral & bone marrow transplantation.
Unit IV	Experimental Methods- isolation & differentiation of human adult stem cells, embryonic stem cells, mouse stem cells. Stem cell techniques- FACS, GFP tagging.
Unit V	Applications of stem cells: Stem cell applications in cancer, diabetes, heart disease, muscular dystrophy, stem cell regulations- debate, social & ethical concerns.

Text Books

1	Stem cells by C.S Potten., Elsevier, 2006.Essentials of Stem Cell Biology by Robert Lanza., fourth edition. Elsevier 2014.
2	PottenCS,"StemCells,"Elsevier,1996.

Reference Books

1	Ariff Bongso, Eng Hin Lee, "Stem Cells: From Bench to Bedside," World Scientific, 2011.
2	Daniel R. Marshak, "Stem cell biology," Cold Spring Harbor Laboratory Press, 2001.

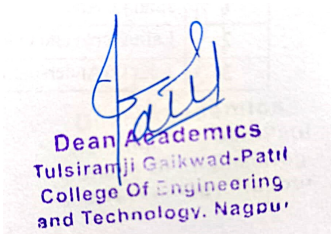
Useful Links

1	https://nptel.ac.in/courses/102106068
2	https://nptel.ac.in/courses/102106035
3	https://nptel.ac.in/courses/102106083

After completion of this course students will able to:

BBT33609	Course Outcomes	CL	Class Sessions
CO1	**Interpret** the basic concepts of stem cells.	**2**	9
CO2	**Comprehend** the microenvironments or niches that support stem cell maintenance and differentiation	**3**	9
CO3	**Acquire** the knowledge of the transformation and protein expression in chloroplasts	**2**	9
CO4	**Demonstrate** the experimental Methods, isolation& Differentiation of stem cells	**3**	9
CO5	**Interpret** the knowledge of stem cells in treating various diseases such as cancer, diabetes,	**3**	9





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BBT33610: PEIII: Bioenergy and Biofuels

Teaching Scheme	
Lectures	**4hr/week**
Tutorials	**-**
Practical	**-**
Total Credits	4

Examination Scheme	
CIE	40 Marks
ESE	60 Marks
Total	100 Marks
Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To understand bioenergy resources, biomass types, and conversion technologies for renewable energy production.
2	To study the production of biogas, biohydrogen, bioethanol, and biodiesel using biological and thermochemical processes.
3	To evaluate bioenergy applications, sustainability, environmental impacts, and emerging trends in biofuel technologies.

Course Contents

Unit I	**Introduction to Bioenergy** Overview of global energy demand and the role of renewable energy, Classification of bioenergy resources – solid, liquid, and gaseous fuels, Types of biomass – lignocellulosic biomass, algae, energy crops, and agricultural residues, Thermochemical and biochemical conversion technologies for bioenergy production, Advantages and limitations of bioenergy systems.
Unit II	**Biomass Conversion Technologies** Thermochemical conversion – combustion, pyrolysis, and gasification processes, Biochemical conversion – anaerobic digestion and fermentation, Characteristics and preprocessing of biomass feed stocks, Comparison of conversion technologies in terms of efficiency and environmental impact, Recent advancements in integrated bio refineries.
Unit III	**Biogas and Bio hydrogen Production** Principles of anaerobic digestion, Microbial consortia involved and stages of biogas production, Factors affecting biogas yield – temperature, pH, C:N ratio, substrates, Bio hydrogen production methods – bio-photolysis, photo-fermentation, and dark fermentation, Applications and challenges in scaling up gaseous biofuel technologies.
Unit IV	**Liquid Biofuels – Bio ethanol and Bio diesel** Bioethanol production from sugar, starch, and lignocellulosic materials, Pretreatment, hydrolysis, fermentation and distillation techniques, Biodiesel production through transesterification of vegetable oils and waste cooking oil, Process parameters affecting biodiesel yield and quality, Fuel properties, blending, and standards for bioethanol and biodiesel.
Unit V	**Applications, Sustainability, and Future Perspectives** Applications of biofuels in transport, power generation, and rural energy systems, Environmental impact and life cycle assessment (LCA) of biofuels, Socio-economic and policy issues related to bioenergy adoption, Global bioenergy scenario and case studies, Recent trends and future scope of bioenergy technologies.

Text Books

1	Anju Dahiya, *Bioenergy: Biomass to Biofuels and Waste to Energy,* 2nd Edition, Academic Press, 2020

2	Godfrey Boyle, *Renewable Energy: Power for a Sustainable Future*, 4th Edition, Oxford University Press, 2017
Reference Books	
1	Jay Cheng (Ed.), *Biomass to Renewable Energy Processes*, 2nd Edition, CRC Press, 2017
2	Ashok Pandey, Christian Larroche, Steven C. Ricke, Claude-Gilles Dussap, Edgard Gnansounou (Eds.), *Biofuels: Alternative Feedstocks and Conversion Processes for the Production of Liquid and Gaseous Biofuels*, 2nd Edition, Academic Press, 2019
Useful Links	
1	https://link.springer.com/article/10.1007/s10311-021-01273-2
2	https://pmc.ncbi.nlm.nih.gov/articles/PMC6045967/
3	https://link.springer.com/chapter/10.1007/978-3-319-11906-9_6

After completion of this course students will able to:

BBT33610	Course Outcomes	CL	Class Sessions
CO1	**Understand** the types and importance of bioenergy and biomass resources	**2**	9
CO2	**Explain** various biomass conversion technologies and their industrial relevance	**2**	9
CO3	**Analyze** the microbial processes involved in biogas and bio hydrogen production	**4**	9
CO4	**Compare** the production methods of bioethanol and biodiesel	**4**	9
CO5	**Evaluate** the sustainability and applications of biofuels in real- world scenarios	**5**	9

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BCE33615: Environmental Engineering

Teaching Scheme	
Lectures	**2hr/week**
Tutorials	**-**
Practical	**-**
Total Credits	2

Examination Scheme	
CIE	20 Marks
ESE	30 Marks
Total	50 Marks
Duration of Exam: 3 Hours	

The Objectives of this course are:

1	To understand the importance and necessity of water supply schemes
2	To identify and evaluate different sources of water and intake structures
3	To assess the physical, chemical, and bacteriological quality of water

Course Contents

Unit I	**Unit I – Air Pollution and Control Engineering** **Sources of Air Pollution:** Natural and anthropogenic sources, point vs. non-point sources, indoor air pollution. **Air Quality:** Types of pollutants – particulate & gaseous; Air quality standards (WHO,CPCB,EPA); Health and environmental impacts; Greenhouse effect, ozone depletion, smog formation. **Air Pollution Monitoring:** Principles of sampling, high-volume dust samplers, stack sampling, gas analyzers. **Applications / Design Aspects:** Basic design criteria for ESP, cyclone separator efficiency, selection of control systems.
Unit II	**Unit II – Water Pollution & Water Treatment Engineering** **Water Supply Basics:** Safe drinking water, demand estimation, sources (surface & groundwater). **Intake & Distribution:** Intake structures, conveyance systems (pipes, valves, fittings). **Hydraulics & Pumps:** Head loss equations, rising mains, pump types and selection. **Water Quality:** Key parameters; drinking water standards; waterborne diseases. **Treatment Systems:** Unit operations/processes; conventional vs. decentralized treatment; plant flow sheet. **Treatment Steps:** Aeration, coagulation–flocculation, sedimentation, filtration, disinfection
Unit III	**Unit III – Soil Pollution & Environmental Biotechnology** **Soil Pollution Sources:** Industrial waste, pesticides, fertilizers, biomedical waste, landfill leachates, heavy metals. **Soil Quality Assessment:** Soil pH, salinity, nutrient content, organic matter, heavy metal testing, microbial activity. **Solid Waste Management:** Classification, collection, disposal methods, composting, sanitary landfill principles and siting criteria. **Soil Remediation: Bioremediation:** bioaugmentation, bio stimulation**, Phytoremediation**: hyperaccumulators**, Biodegradation of pesticides & hydrocarbons:** Vermicomposting & organic remediation**, Sustainable Practices:** Waste minimization, agricultural sustainability, rainwater recharge, eco-restoration.

Text Books

1	Water supply & Sanitary Engineering - B.C. Punmia, Laxmi Publication, 2016 edition
2	Water, Wastewater, Soil and Groundwater Treatment and Remediation – Nemerow, Agardy & Salvato 6th Edition, 2009

3	Environmental Engg. I-P.N.Modi, Standard BookHouse,5th edition,2018
Reference Books	
1	Water Supply and Sanitary Engineering–S.C. Rangwala, Charotar Publishing House, 2005 edition
2	Water supply and sewage-M.J.Mcghee,Mc.GrawHill,6th edition,1991
3	Environmental Pollution Control Engg. -C.S.Rao, New Age International Publishers,3rd edition, 2018
Useful Links	
1	https://nptel.ac.in/courses/105/105/105105201/
2	https://nptel.ac.in/courses/105/106/105106119/

After completion of this course students will able to:

BCE33615	Course Outcomes	CL	Class Sessions
CO1	**Explain** the sources, impacts, and control principles of air pollution and air quality management.	**2**	10
CO2	**Analyze** water quality parameters and treatment processes to assess their suitability for safe water supply.	**3**	10
CO3	**Evaluate** appropriate soil pollution mitigation and remediation strategies for sustainable environmental management.	**4**	10

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BBT33612: Microbial Identification studies Lab

Teaching Scheme	
Lectures	
Tutorials	-
Practical	**2hr/week**
Total Credits	1

ExaminationScheme	
CIE	25 Marks
ESE	25 Marks
Total	50 Marks
Duration of Exam: 2 Hours	

The Objectives of this course are:

1	To develop practical skills in bacterial staining, identification, and biochemical testing.
2	To perform microbial enumeration, antibiotic sensitivity testing, and antimicrobial efficacy evaluation.
3	To understand microbiological quality control of pharmaceutical products, including sterility, endotoxin, and water testing.

Sr. No.	Experiments (Minimum 8 experiments should be performed)
1.	Endospore staining of given bacterial culture.
2.	Catalase test for production of catalase enzymes.
3.	Coagulase test for staphylococcus.
4.	Acid fast staining for mycobacterium.(Ziehl- Neelson staining)
5.	Oxidase test for detection of cytochrome c oxidase.
6.	Capsule staining of given bacterial culture
7.	Simple staining of given bacterial culture.
8.	Dot ELISA test for detection of antigen.
9.	Total viable count of bacteria in given sample.
10.	An antibiotic sensitivity assay.
11.	Test of sterility of given pharmaceutical product using membrane filtration.
12.	Minimum inhibitory concentration (MIC) testing.
13.	Bacterial endotoxin testing in given pharmaceutical product
14.	To evaluate efficacy of preservatives in pharmaceutical product
15.	Enumeration of microorganisms in water used in pharmaceutical industry.

Text Books

1	Prescott'sMicrobiology-JoanneWilley,LindaSherwood,ChristopherWoolverton
2	Microbiology: An Introduction- Gerard J. Tortora, Berdell R. Funke, Christine L. Case
2	Fundamentals of Microbiology-Jeffrey C. Pommerville

Reference Books	
1	Bergey's Manual of Systematic Bacteriology-George M. Garrityetal.
2	Manual of Clinical Microbiology-American Society for Microbiology(ASM)
Useful Links	
1	https://www.sciencedirect.com/topics/physics-and-astronomy/molecular-diffusion
2	https://www.sciencedirect.com/topics/engineering/interphase-mass-transfer
3	https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Introduction_to_Solid_State_Chemi

After completion of this course students will able to:

BBT33612	Course Outcomes	CL	Class Sessions
CO1	**Explain** the significance of microbial identification and describe the major groups of microorganisms including Bacteria, Archaea, Fungi, Protozoa, and Viruses using appropriate classification systems such as Bergey's Manual.	**2**	10
CO2	**Illustrate** and apply appropriate culture media (selective, differential, enrichment, minimal) and techniques (aerobic/anaerobic) for the isolation and growth of microorganisms.	**3**	10
CO3	**Classify** standard biochemical tests(e.g., IMViC, TSI, catalase, oxidase, urease, etc.) to identify and characterize Unknown microbial isolates.	**4**	10

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