Scheme of Teaching and Examinations and Syllabus
M.Tech., BIOTECHNOLOGY & BIOCHEMICAL ENGG (BBC)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
Jnana Sangam, Machhe, Belagavi-590018
E Mail: registrar@vtu.ac.in
contact: 0831-2498112

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M.Tech., BIOTECHNOLOGY & BIOCHEMICAL ENGG (BBC)
Choice Based Credit System (CBCS) and Outcome-Based Education(OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical/Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	BSC	22BBC11	Numerical Methods & Biostatistics	03	00	00	03	50	50	100	3
2	IPCC	22BBC12	Principles of Biochemical Engineering +Lab	03	02	00	03	50	50	100	4
3	PCC	22BBC13	Industrial Approaches in Biotechnology	03	00	02	03	50	50	100	4
4	PCC	22BBC14	Molecular Biology and Genetic Engineering	02	00	02	03	50	50	100	3
5	PCC	22BBC15	Bio-analytical Techniques	02	00	02	03	50	50	100	3
6	MCC	22RMI16	Research Methodology and IPR	03	00	00	03	50	50	100	3
7	PCCL	22BBCL17	Molecular Biology and Genetic Engineering Lab	01	02	00	03	50	50	100	2
8	AUD/AEC	22AUD18/ 22AEC18	BOS recommended ONLINE courses (refer ANNEXURE)	Classes and evaluation procedures are as per the policy of the online course providers.							PP
			TOTAL	**17**	**04**	**06**	**21**	**350**	**350**	**700**	**22**

Note: BSC-Basic Science Courses, PCC: Professional core. IPCC-Integrated Professional Core Courses, MCC- Mandatory Credit Course,
AUD/AEC –Audit Course / Ability Enhancement Course(A pass in AUD/AEC is mandatory for the award of the degree), PCCL-Professional Core Course lab,
L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities(Hours are for Interaction between faculty and students)

Integrated Professional Core Course (IPCC): **Integrated Professional Core Course (IPCC)**: Refers to Professional Theory Core Course Integrated with practical of the same course. The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper.

Audit Courses /Ability Enhancement Courses Suggested by BOS (ONLINE courses): Audit Courses: These are prerequisite courses suggested by the concerned Board of Studies. Ability Enhancement Courses will be suggested by the BoS if prerequisite courses are not required for the programs. **Ability Enhancement Courses**:

- These courses are prescribed to help students to enhance their skills in in fields connected to the field of specialisation as well allied fields that leads to employable skills. Involving in learning such courses are impetus to lifelong learning.
- The courses under this category are online courses published in advance and approved by the concerned Board of Studies.
- Registration to Audit /Ability Enhancement Course shall be done in consultation with the mentor and is compulsory during the concerned semester.
- In case a candidate fails to appear for the proctored examination or fails to pass the selected online course, he/she can register and appear for the same course if offered during the next session or register for a new course offered during that session, in consultation with the mentor.
- The Audit Ability Enhancement Course carries no credit and is not counted for vertical progression. However, a pass in such a course is mandatory for the award of the degree.

Skill development activities: Under Skill development activities in a concerning course, the students should

1. Interact with industry (small, medium, and large).
2. Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3. Involve in case studies and field visits/ fieldwork.
4. Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5. Handle advanced instruments to enhance technical talent.
6. Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7. Work on different software/s (tools) to simulate, analyze and authenticate the output to interpret and conclude.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Students and the course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills of the study they have undertaken. The students with the help of the course teacher can take up relevant technical –activities which will enhance their skill. The prepared report shall be evaluated for CIE marks.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M.Tech., BIOTECHNOLOGY & BIOCHEMICAL ENGG (BBC)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	PCC	22BBC21	Bioprocess Engineering	02	00	02	03	50	50	100	3
2	IPCC	22BBC22	Bioprocess control and automation+ Lab	03	02	00	03	50	50	100	4
3	PEC	22BBC23x	Professional elective 1	02	00	02	03	50	50	100	3
4	PEC	22BBC24x	Professional elective 2	02	00	02	03	50	50	100	3
5	MPS	22BBC25	Mini Project with Seminar	00	04	02	--	100	--	100	3
6	PCCL	22BBCL26	Bioprocess Engineering Lab	01	02	00	03	50	50	100	02
7	AUD/ AEC	22AUD27	Suggested ONLINE courses (ANNEXURE)	Classes and evaluation procedures are as per the policy of the online course providers.							PP
TOTAL				**10**	**08**	**08**	**15**	**350**	**250**	**600**	**18**

@# 03112023

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab,
L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities(Hours are for Interaction between faculty and students)

Professional Elective 1		**Professional Elective 2**	
Course Code Under 22BBC23X	**Course title**	**Course Code under 22BBC24X**	**Course title**
22BBC231	Agricultural Biotechnology	22BBC241	Food Biotechnology
22BBC232	Animal Biotechnology	22BBC242	Pharmaceutical Biotechnology
22BBC233	Bioprocess Calculations	22BBC243	Bioprocess Optimisation, Modelling & simulations
22BBC234	Genomics, Proteomics and Bioinformatics	22BBC244	Metabolic Engineering
22BBC235	Environmental Biotechnology	22BBC245	Waste management

Note:

1 Mini Project with Seminar: This may be hands-on practice**,** survey report, data collection and analysis, coding, mobile app development, field visit and report preparation, modelling of system, simulation, analysing and authenticating, case studies, etc.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Students can present the seminar based on the completed mini-project. Participation in the seminar by all postgraduate students of the program shall be mandatory.

The CIE marks awarded for Mini-Project work and Seminar, shall be based on the evaluation of Mini Project work and Report, Presentation skill and performance in Question and Answer session in the ratio 50:25:25. Mini-Project with Seminar shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the Mini Project and Seminar shall be declared as fail in that course and have to complete the same during the subsequent semester. There is no SEE for this course.

2. Internship: All the students shall have to undergo a mandatory internship of **06 weeks** during the vacation of II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted in the same semester. The internship shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in the internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.Tech., BIOTECHNOLOGY & BIOCHEMICAL ENGG (BBC)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini–Project/ Internship	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	22BBC31	Biosafety, Bioethics and Regulatory affairs	03	00	02	03	50	50	100	4
2	PEC	22BBC32X	Professional elective 3	03	00	00	03	50	50	100	3
3	OEC	22BBC33X	Open elective Courses-1	03	00	00	03	50	50	100	3
4	PROJ	22BBC34	Project Work phase -1	00	06	00	--	100	--	100	3
5	SP	22BBC35	Societal Project	00	06	00	--	100	--	100	3
6	INT	22BBCI36	Internship	(06 weeks Internship Completed during the intervening vacation of II and III semesters.)			03	50	50	100	6
TOTAL				**09**	**12**	**03**	**12**	**400**	**200**	**600**	**22**

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students)

@# 03112023

Professional elective 3		Professional elective -4	
Course Code under 22BBC32X	**Course title**	**Course Code under 22BBC33X**	**Course title**
22BBC321	Biosensors Technologies	22BBC331	Ecology and Ecosystem
22BBC322	Protein Engineering & Insilico drug Design	22BBC332	Nutrition and Human Health
22BBC323	Nanobiotechnology	22BBC333	Systems Biology and Medical Informatics
22BBC324	Bioenergy Management	22BBC334	Biobusiness and Entrepreneurship
22BBC325	Biomaterials & Artificial Organs	22BBC335	Vaccine Technology

Note:

1. Project Work Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted.

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

2. Societal Project: Students in consultation with the internal guide as well as with external guide (much preferable) shall involve in applying technology to workout/proposing viable solutions for societal problems.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

Those, who have not pursued /completed the Societal Project, shall be declared as fail in the course and have to complete the same during subsequent semester/s after satisfying the Societal Project requirements. There is no SEE (University examination) for this

3. Internship: Those, who have not pursued /completed the internship, shall be declared as fail in the internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M.Tech., BIOTECHNOLOGY & BIOCHEMICAL ENGG (BBC)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
				L	P					
1	Project	22BBC41	Project work phase -2	--	08	03	100	100	200	18
			TOTAL	--	**08**	**03**	**100**	**100**	**200**	**18**

Note:

1. Project Work Phase-2:

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Total Credits 22+18+22+18 =**80**

Semester- I

Numerical Methods & Biostatistics (BSC)			
Course Code	22BBC11	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

To have insight into basics in statistics and numerical analysis.

To enable the students to tackle live problems in various spheres of bioscience and bioengineering

To learn and design various statistical problems

Module-1

INTRODUCTION TO BIOSTATISTICS:

Introduction to Biostatistics, classification of variables, types of data, sorting of data, sampling methods, representation of data-tabular, diagrammatic (bar diagram, line diagram, pie chart), graphical (Histogram, frequency polygon, frequency curve), box plot and pictorial, Measure of dispersion- standard deviation, quartile deviation, mean deviation, variance and coefficient of variation, logarithmic mean and harmonic mean, kurtosis and skewness. Application of descriptive statistics, case studies.

Teaching-Learning Process	Include traditional teaching learning process such as Chalk and Talk using writing boards. Construct graphical and pictorial representation of the subject in the form of Chart, hand-outs or use of Microsoft office tools for data entry and computation.

	Integrate real time case reports.
Module-2	
BI-VARIATE ANALYSIS Statistical Correlation, types of correlation, methods of correlation, Karl Pearson correlation coefficient, Spearman Rank correlation Coefficient, regression analysis- linear and non-linear, curve fitting, linearization and its application in biological studies, Baye's theorem, binomial distribution, poisson distribution, normal distribution, Significance of statistics to biological problems, case studies.	
Teaching-Learning Process	Include traditional teaching learning process such as Chalk and Talk using writing boards. Use of real time case data to understand the problems.
Module-3	
STUDY DESIGN AND ANALYSIS OF EXPERIMENTS: Basics of study design, selectivity, specificity and sensitivity with problems, biases, limitations, multiple sources of variation, replication, randomisation and blocking, experimental studies- Randomized controlled studies, historically controlled studies, cross over, cohort studies, case-control studies, outcomes, odd ratio and relative risks, factorial design- main effect and interaction effect, cluster design, stratified design, randomization, single blind and double blind experiments, Randomized controlled studies- Random block design, Completely randomized design, Ethical considerations, case studies	

Teaching-Learning Process	PowerPoint presentations. Collaborate with students to understand and solve experimental design. Integrate real time case studies example COVID-19 case study for problem analysis.

Module-4

INFERENTIAL STATISTICS:

Point estimation, interval estimation- single mean and two mean, sample size estimation, testing of hypothesis, Test statistics- z-test, t-test, F-test, chi-squared test, Wilcoxon Signed Rank Test, Wilcoxon-Mann-Whitney Test, ANOVA- One-way and Two way, T-tests; application of inferential statistics in epidemiology, type 1 error and type II error, Case studies.

Teaching-Learning Process	Reflective approaches on analyzing how and why the tools are used in self-reflected or published data. Use of epidemiological data, field study and experiments.

Module-5

STATISTICS IN MICROARRAY:

Microarray tool for gene expression analysis, Types of microarrays, fabrication of microarray, digital image processing of microarrays, microarray analysis and visualisation tools-box plots, gene pies, scatter plot, data pre-processing techniques, ANOVA for data analysis

Teaching-Learning Process	PowerPoint presentations. Use of real time data to analyze the problem.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Statistics and Numerical Methods in BASIC for Biologists, D. Lee and T.D. Lee, Van Nostrand Reinhold Company, 1982

Numerical Methods, Wolfgang Boehm and Hartmut Prautzsch, CRC Press, 1993 Numerical Methods of Statistics, John F. Monahan, Cambridge University Press, 2011 Numerical Methods for Engineers and Joe D. Hoffman CRC Press 2001

Statistical Methods in Bioinformatics: An Introduction Warren, J. Ewensregory Grant, Springer Science & Business Media, 2005.

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/102/106/102106051/
2. https://archive.nptel.ac.in/courses/111/102/111102112/ https://archive.nptel.ac.in/courses/103/106/103106120/
3. https://www.youtube.com/watch?v=KhjM8YI3agk
4. https://nptel.ac.in/courses/102106065

Skill Development Activities Suggested

1. NGS and Microarray data Analysis
2. Proteomic data network analysis.
3. AV presentation by students (on specific topics).
4. Discussion of case studies based on research findings.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Perform uni-variate and bi-variate analysis of data	L3
CO2	Draw inferences about the characteristics of population from the samples using parametric and non-parametric tests.	L5
CO3	Analyze the statistically designed biological experiments.	L4

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
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	PO3
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.	PO4

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**										
CO2		**3**										
CO3		**3**	**2**	**2**								

Semester - I

Principles of Biochemical Engineering +Lab (IPCC)			
Course Code	**22BBC12**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	4	Exam Hours	3

Course objectives:

- Apply the basics of Engineering concepts in bioprocesses.
- Solve live problems in various spheres of biochemical engineering.
- To gather information from relevant data hand books to design and execute the experiments using bioreactors

MODULE-1

HISTORICAL DEVELOPMENT OF BIOPROCESS TECHNOLOGY:

An overview of traditional and modern applications of biotechnological processes, Roles and responsibilities of a Chemical engineer in bioprocess industry, Steps in bioprocess development. Biology of the cell, classification, construction, and cell nutrients. Industrial enzymes, Nomenclature and Classification of enzymes, structure, and functions of enzymes with relevant case studies.

Teaching-Learning Process	✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments).

MODULE-2	
Unit Operations : Mixing-Power requirement (Calculation of power no), Mixing equipment's (Banbury mixers, Muller Mixers), Size Reduction(laws of size reduction, Mechanical efficiency and crushing efficiency), Concept of Sphericity and Proof for sphericity is unity for regular objects), Construction and working principle of Crushing equipment's (Jaw crusher, Garyatory crusher, Ball mill), Filteration Equipment's (Rotary drum filters, Plate and frame filters and Leaf filters), Settling and its type (free and hindered settling: equations for Newton's, Intermediate Stokes regimes and Criteria for selection of the equation) Numerical Problems on Settling and Size reduction	
Teaching-Learning Process	✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments).
MODULE-3	
Fluid Mechanics: Flow pattern in agitated vessel, Role of shear in fermentation broth, bubble shear, rheological behavior of fermentation broth,-Ungassed and gassed fluids, factors affecting the broth viscosity,3-D Continuity equation, Flow of compressible fluids, Time to empty the liquid from a tank (Rectangle Tank),Numericals, construction and working principle of orifice venturi meter and centrifugal pump(No numericals), calculation of resultant velocity and resultant acceleration of fluid on space ordinates (x, y, z) and Numerical .	

Teaching-Learning Process	✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments).

MODULE-4

BASICS OF THERMODYNAMICS:

Procedure for Energy balance for cell culture, Concept of Internal energy, Enthalpy and Entropy, Enthalpy and internal energy calculations using first law of Thermodynamics, calculations of Entropy changes for constant Temperature, Constant volume, constant pressure, work lost due to irreversibility, Differential equations of Entropy, Problems on entropy and Its calculations, work lost due to irreversibility, Thermodynamic work functions, Fundamental property relationship and Maxwell relationship, Modified equations of enthalpy and internal energy, Discussion of case studies in terms of problems.

Teaching-Learning Process	✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments).

MODULE 5	
HEAT TRANSFER: Overview of Industrial Heat Exchangers, Discussion of design strategies (Construction and working principle of DPHE, STHE with design equation), Scaling and fouling in heat exchangers and various methods to eliminate it, Concept of LMTD, Boiling Condensation, Nucleate and film boiling (Regimes of pool boiling), Transient growth kinetics, measurement of microbial population by turbidometry and factors affecting microbial growth, Heat generation during microbial growth, and case studies	
Teaching-Learning Process	✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments).

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	Settling studies of spherical objects of various dimensions
2	To determine the Volume surface mean diameter of mixture of particle using Screen analysis
3	Screen Effectiveness, for the given screen
4	Ball mill Studies
5	Batch Sedimentation studies

6	Pipe Friction Flow studies
7	Plate and Frame filtration
8	Studies on Orificemeter
9	Studies on Venturimeter
10	Batch growth kinetics
11	Centrifugal pump studies (Demonstration Experiments For CIE)
12	Leaf Filter (Demonstration Experiments For CIE)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks**

Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**

Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.

The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

.**SEE for IPCC**

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

The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.

The question paper will have ten questions. Each question is set for 20 marks.

There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

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

The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in

component of IPCC, the total marks of all questions should not be more than the 20 marks.

SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

Books

Bioprocess Engineering and principles, 2nd Edition, Paulin and M Doran, Wiley, 2006.

R.M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd Edition, J. Wiley, 2000.

SC Arrora and Domkundar, Process Heat Transfer 3rd edition, Wiley, 2006.

K.V. Narayan Engineering Thermodynamics 3rd edition, 2010.

R.K. Bansal, Fluid Mechanics 3rd edition, 2010.

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/102/105/102105058/
2. https://www.youtube.com/watch?v=vBPX29vbHqg
3. https://archive.nptel.ac.in/courses/103/106/103106070/ https://archive.nptel.ac.in/courses/103/103/103103031/
4. https://www.digimat.in/nptel/courses/video/103103136/L01.html
5. https://onlinecourses.nptel.ac.in/noc22_me139/preview

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

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate strong basics in principles of bioengineering.	L1, L2, L3
CO2	Analyse various problems in various spheres of biochemical engineering.	L4, L5
CO3	Search for information, which is required for the design and execution of experiments related to fluid mechanics, Unit operations and Heat transfer.	L4, L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
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	PO3
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.	PO4
5	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO9
6	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

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

Semester- I

Industrial Approaches in Biotechnology (PCC)			
Course Code	**22BBC13**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	4	Exam Hours	3

Course Learning objectives:

- To apply basics of biology in cellular processes
- Apply the basics of microbiology in disease and their association with diseases
- Understand microbiology and apply the same in industrially relevant processes.

Module-1	
INTRODUCTION TO BIOMOLECULES: Macromolecules; Carbon chemistry; Proteins: Structure, folding, catalysis; Nucleic acids: DNA & RNA; storage and transfer of genetic information; Lipids: membranes, structure & function; Carbohydrate chemistry, energy storage, building blocks. Industrial applications of Biomolecules.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-2	
CELL STRUCTURES AND ITS FUNCTIONS: Eukaryotic and Prokaryotic cells, plant and animal cells, structure of nucleus, mitochondria, ribosomes, Golgi bodies, Lysosomes, endoplasmic reticulum, chloroplast, vacuoles; Cell cycle and cell division: Different phases of cell cycle, cell division: Mitosis and meiosis. Mendelian law of inheritance: Monohybrid and dihybrid inheritance, law of segregation and independent assortment; Gene Interaction; Multiple alleles, supplementary and complementary genes, epistasis. Identification of genetic material: classical experiments; chromosome structure and organization, chemical composition of chromatin, structural organization of nucleosomes, heterochromatin, polytene and lamp-brush chromosomes, human chromosomes, chromosomal disorders.	

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work.

Module-3

SCOPE OF MICROBIOLOGY AND IMMUNOLOGY:

Introduction to the structure and functions of microorganism: Bacteria, Viruses, Fungi and Protozoan's. Microscopy and microbial techniques: Study of microscopes; sterilization techniques: Heat, steam, Radiation, Filtration and chemical methods; Pure culture techniques: Serial Dilution, Streak, Spread, Pour Plate. Industrially important micro organisms, strain improvement and preservation techniques. Immune System, Innate and adaptive immunity, antigens and antibodies; types of immune response, hypersensitivity. Humoral immunity: B- lymphocytes, Immunoglobulin classes, Major Histocompatibility Complex (MHC). Cell mediated immunity. Thymus derived lymphocytes (T-cells), Antigen presenting cells (APC); Immunity to infection, Cytokines..

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work.

Module-4

SCOPE OF AGRICULTURAL BIOTECHNOLOGY:

Role of Microbes in agriculture, Bio-pesticides, Bio fertilizers (Nitrogen fixing microbes), GM crops. Plant metabolic engineering and

Metabolic engineering of plants for the production of fatty acids, industrial oils, flavonoids etc. Basic aspects of Food & Nutrition. Discussion of case studies for addressing health and malnutrition, via Agriculture BT.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work.
Module-5	
INDUSTRIALLY IMPORTANT PROCESS AND ENVIRONMENT: Different media for fermentation, basic structure of fermenter and different types. Types of fermentation processes (surface, submerged, and solid state) and their products (ethanol, citric acid, lactic acid, enzymes, antibiotics) Biological treatment of waste water, primary, secondary and tertiary treatments. Bio-indicators, bioremediation of xenobiotic compounds, Bioleaching of minerals from ores, Biosorption of toxic metals. Solid waste management. Biofuel production from agricultural wastes. Case studies and solutions for current issues of waste management.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Bioprocess Engineering Principles, Pauline M. Doran, Elsevier Science & Technology Books , 2006
2. Elementary Principles of Chemical Processes, Richard M. Felder, Ronald W. Rousseau, Lisa G. Bullard, Wiley, 2018
3. Principles of Genetics, Gardner, Simmonns and Snustad, Wiley India Pvt. Ltd, 2005
4. Cell Biology, Genetics, Evolution and Ecology, P S Verma, V R Agarwal, New Publisher, Delhi, 2007
5. Plant biotechnology in Agriculture, K. Lindsey and M.G.K. Jones, Prentice Hall, 1989

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/102/107/102107086/
2. https://archive.nptel.ac.in/courses/102/108/102108086/
3. https://onlinecourses.swayam2.ac.in/cec22_bt18/preview
4. https://archive.nptel.ac.in/courses/102/101/102101068/
5. https://www.youtube.com/watch?v=cfF-qDnbRa0.

Skill Development Activities Suggested

1. Class Presentations and discussions of research articles from publications.
2. Online tools for surprise quizzes.
3. Collection of case studies via Newspapers/Journal articles, on topics covered.

Group discussions on recent advancements and case studies.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply the basics of cell biology in genetics	L1, L2, L3, L4
CO2	Comprehend the basics of microbiology and immunology and apply the same in pathogenesis	L1, L2, L3, L4
CO3	Understand the use of microorganisms in industrially relevant processes, Food and Agriculture	L1, L2, L3, L4

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**					**3**	**3**					
CO2	**3**					**2**	**3**					
CO3	**3**					**2**	**3**					

Semester- I

Molecular Biology and Genetic Engineering (PCC)			
Course Code	**22BBC14**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To Acquire the fundamentals of molecular biology and genetic engineering principles.
- To Learn the strategies for gene manipulation, editing technologies and its applications.

Module-1

Central Dogma of Molecular Biology - DNA Replication, transcription, and translation:

DNA replication: Comparative account on initiation, elongation and termination in prokaryotes and eukaryotes. Transcription: Prokaryotic & Eukaryotic Mechanisms; Significance of Promoters, Enhancers, Silencers, Transcription factors, Activators and repressors; Post transcriptional modifications; Transcription inhibitors. Translation: Genetic Code and Wobble hypothesis, Role of Ribosomes &tRNA; Mechanism of translation: Activation of amino acids, initiation complex formation, elongation of polypeptide, termination and release of polypeptide; Post-translational modifications; Transport of proteins and molecular chaperones.

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes).

	✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-2	
Regulation of Gene expression, DNA damage & repair, DNA recombination Transcriptional regulation in Prokaryotes: General mechanism of positive and negative control; Operon concept: lac, trp, and gal operons; Transcriptional control in Eukaryotes: Chromatin remodeling: Acetylation and deacetylation of histone proteins; Regulatory proteins: DNA binding transactivators, co-activators; Homeotic gene and their role in gene regulation.DNA Damage: Causative agents and outcomes; DNA Repair: Mismatch correction, Mechanisms in thymine-dimer repair: Photo reactivation, Nucleotide excision repair, SOS repair. DNA Recombination: Homologous and non- homologous recombination; Holliday Model; Site specific recombination: General mechanism, Examples: SSR in Bacteria bacteriophage, FLP/FRT and Cre/Lox recombination.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

<table>
<tr><th colspan="2">Module-3</th></tr>
<tr><td colspan="2">Tools and Techniques in recombinant DNA technology

Vectors: Cloning & Expression vectors, Plasmids,, Phagemids, Cosmids, YACs and BACs;. Enzymes in genetic engineering: Restriction Enzymes, DNA ligase, Polynucleotide kinase, Alkaline phosphatase. Methods in construction of recombinant vectors: Linkers, Adaptors, Homopolymeric tailing. Techniques in Genetic Engineering: Construction of libraries: Genomic and cDNA libraries. Hybridization techniques: Northern and Southern hybridizations. Polymerase Chain Reaction: General mechanism and applications; Variants of PCR; In vitro mutagenesis.</td></tr>
<tr><td>Teaching-
Learning Process</td><td>✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective
and questioning /inquiry based teaching.
✓ Instructions with interactions in classroom lectures (physical/hybrid).
✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
✓ Flipped classroom sessions (~10% of the classes).
✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus.
✓ Students' participation through audio-video based content creation for the syllabus (as assignments).
✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
✓ Students' seminars (in solo or group) /oral presentations.</td></tr>
<tr><th colspan="2">Module-4</th></tr>
<tr><td colspan="2">GENE TRANSFER and GENE EDITING TECHNIQUES:

Gene transfer into plant cells: Microprojectile bombardment; Agrobacterium transformation, Ti plasmid: structure and functions, Ti plasmid based vectors, Chloroplast transformation; Gene transfer techniques into microbial cells: transformation, electroporation, lipofection, calcium phosphate mediated; Gene transfer techniques into animal/mammalian cells – retrovirus mediated transfection techniques. Gene editing techniques: types, Principles and Applications; CRISPR- associated protein – Cas 9.</td></tr>
</table>

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

Module-5

Applications of Genetic engineering:

Engineering microbes for the production of antibiotics, enzymes, insulin and monoclonal antibodies. Transgenic technology for plant and animal improvement, Over expression and Knock out/ knock down studies, RNAi. Bio pharming- Animals and plants as bioreactors for recombinant proteins. Gene therapy: Types and case studies of SCID and Cancer gene therapy

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Molecular Biology of the Cell, 4th edition, Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, Garland Science, 2002
2. Molecular Cell Biology, 4th edition, Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell, W. H. Freeman, 2000
3. Genomes, 3rd edition, Brown TA, Garland Science, 2006
4. Gene Cloning: An Introduction, Brown TA, Stanley Thornes Publishers Limited, 1995
5. Molecular Cloning: A Laboratory Manual, Vols 1- 3, J. Sambrook and D.W. Russel, CSHL, 2001

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102103074
2. https://www.youtube.com/watch?v=rEed9iU0WtM
3. https://nptel.ac.in/courses/102106065
4. http://www.digimat.in/nptel/courses/video/102103074/L13.html
5. https://www.youtube.com/watch?v=uZ6pCqCUIco
6. https://archive.nptel.ac.in/courses/104/108/104108056/

Skill Development Activities Suggested

1. Class Presentations and discussions of research articles from publications.
2. Online tools for surprise quizzes.
3. Collection of case studies via Newspapers/Journal articles, on topics covered.

Group discussions on recent advancements and case studies.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Appraise and distinguish the central dogma principles across eukaryotic and prokaryotic systems	L3, L4
CO2	Apply, comprehend, differentiate the principles of gene manipulation, expression and interaction of genes and proteins in various living systems	L3, L4
CO3	Analyse gene manipulation in the context of developing GM based products/processes of societal importance	L3, L4

Programme Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
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	PO3
7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**											
CO2	**3**											
CO3	**3**	**1**	**1**				**1**					

Semester- I

Bio-analytical Techniques (PCC)			
Course Code	**22BBC15**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

To gather knowledge of biophysical, spectroscopic, chromatographic techniques and their applications.

To be able to understand and select the specific analytical technique for required case study.

Module-1

ELECTROMAGNETIC SPECTRUM AND ABSORPTION OF RADIATIONS:

Electro-magnetic Spectrum, Theory of spectroscopy, Scattering, Emission and absorption by molecules, choice of solvent and solvent effects, modern instrumentation – design and working principle. Principles of vibrational spectroscopy, instrumentation, interpretation of sample spectra, applications in biology. FTIR - theory, instrumentation and applications in biology, interpretation of sample spectra.

Attenuated Total Reflectance (ATR) – theory and applications in biology, interpretation of sample spectra. Laser Raman Spectroscopy - theory, instrumentation, and applications to biology, interpretation of sample spectra. UV-Visible spectroscopy - Theory, Beer-Lambert's law, instrumentation and Applications in biology, interpretation of sample spectra. Fluorescence Spectroscopy.

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

Module-2

NMR, ESR / EPR and CD / ORD SPECTROSCOPY:

NMR: Theory and Instrumentation, solvents, chemical shift, and factors affecting chemical shift, spin-spin coupling, coupling constant, and factors influencing the value of coupling constant, spin-spin decoupling, proton exchange reactions, FT-NMR, 2D –NMR, Difference between Proton NMR and C13 NMR. Applications in biology and Pharmacy, interpretation of sample spectra. Magnetic resonance Imaging (MRI).

ESR: Theory and Instrumentation, interpretation of sample spectra, Hyperfine interactions and spectral splitting, Spin labelling techniques and their applications. Interpretation of sample spectra.

Circular Dichroism: basics of polarization, the origin of optical activity, Circular birefringence and optical rotation, Theory and Instrumentation, Circular dichroism and the study of biological molecules. Interpretation of sample spectra. ORD Principle, Plain curves, curves with cotton effect, octant rule and its applications, circular dichroism and its relation to ORD.

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-3	
MASS SPECTROSCOPY: Fragmentation processes and fragmentation pattern, Chemical ionization mass spectroscopy (CIMS), Field Ionization Mass Spectrometry (FIMS), Fast Atom Bombardment MS (FAB MS), Matrix Assisted laser desorption / ionization MS (MALDI-MS), Tandem MS techniques: GC-MS. LC-MS. MS-MS. Discussions with Case studies.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Module-4	
X-RAY SPECTROSCOPY: Generation of X-rays, X-ray diffraction, Bragg's law, X-ray powder diffraction, interpretation of diffraction patterns and applications. Single crystal diffractions of biomolecules. Fibre diffraction. Neutron diffraction. The basic physical process in XAS, characteristic excitation energies of various elements, X-ray absorption in condensed matter, XAS and valence state, XAS and local atomic structure, applications of X-ray Photoelectron Spectroscopy (XPS), photoelectric effect, binding energies, instrumentation, qualitative analysis. X-ray fluorescence spectroscopy and applications. Energy Dispersive X-ray Spectroscopy (EDS/EDX) and applications.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-5	
CHROMATOGRAPHIC TECHNIQUES: Classification of chromatographic methods based on mechanism of separation: paper chromatography, thin layer chromatography, column chromatography - ion exchange chromatography, affinity chromatography. Gel filtration chromatography – technical questions and applications. Single step purification by Ni-NTA column. Gas Chromatography: Theory and principle, column operation, instrumentation, derivatisation methods and applications. HPLC, HPTLC, GC-MS, LC-MS. Discussions with Case studies.	

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Fundamentals of Bioanalytical Techniques and Instrumentation, Sabari Goshal & A K Srivastava, PHI, 2009
2. Principles of Instrumental Analysis, 4th Edition, Donglas A. Skoog, James, J. Leary, Saunders College Publishing, Philadelphia, 1992
3. Practical Pharmaceutical Chemistry, 4thEdition, H. Beckett & J. Stenlake, Academic Press, 1988
4. Instrumental Methods of Chemical Analysis, B. K. Sharma, Goel Publishing House Meerut, 2000
5. Biochemical Methods of Analysis, Saroj Dua & Neera Garg, Alpha Science, 2010

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/104/106/104106122/
2. https://archive.nptel.ac.in/courses/104/108/104108097/
3. https://archive.nptel.ac.in/courses/115/105/115105122/
4. https://onlinecourses.nptel.ac.in/noc21_bt50/preview
5. https://archive.nptel.ac.in/courses/102/107/102107028/.

Skill Development Activities Suggested

1. Class Presentations and discussions of research articles from publications.
2. Online tools for surprise quizzes.
3. Collection of case studies via Newspapers/Journal articles, on topics covered.

Group discussions on recent advancements and case studies.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply the principles of Biology and Physics to understand the mechanisms/functions of different instruments used in bio-product / bio-molecular analysis	L1, L2, L3, L4
CO2	Solve problems using the most suited bioanalytical method	L1, L2, L3, L4
CO3	Analyze different bioanalytical methods in context of their relative merits and competencies for research and industrial problems.	L1, L2, L3, L4

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	**3**	**1**								
CO2	**3**	**1**								
CO3	**3**	**1**								

Semester- I

Research Methodology and IPR (PCC)			
Course Code	**22RMI16**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To define a research problem
- To carry out literature search, develop theoretical and conceptual frameworks and write reviews.
- To acquaint with research designs, sampling designs, measurement and scaling techniques and also different methods of data collection.
- To acquaint with parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports
- To acquaint with various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR

<table>
<tr><th colspan="2">Module-1</th></tr>
<tr><td colspan="2">RESEARCH METHODOLOGY:
Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration.</td></tr>
<tr><td>Teaching-Learning Process</td><td>✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching.
✓ Instructions with interactions in classroom lectures (physical/hybrid).
✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
✓ Flipped classroom sessions (~10% of the classes).
✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus.
✓ Students' participation through audio-video based content creation for the syllabus (as assignments).
✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
✓ Students' seminars (in solo or group) /oral presentations.</td></tr>
<tr><th colspan="2">Module-2</th></tr>
<tr><td colspan="2">REVIEWING THE LITERATURE:
Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed. Research Design: Meaning of Research Design, Need for Research Design and Features of a Good Design.</td></tr>
</table>

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments).
Module-3	
DESIGN OF SAMPLING: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs. Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Module-4	
TESTING OF HYPOTHESES: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. Chi- square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-5	
INTERPRETATION AND REPORT WRITING: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports. Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents	

Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

3. Three Unit Tests each of **20 Marks**
4. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International, 2018
2. Research Methodology a step- by-step guide for beginners(For the topic Reviewing the literature under module 2), RanjitKumar, SAGE, Publications, 2011.
3. Study Material (For the topic Intellectual Property under module 5), Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, 2013
4. Conducting Research Literature Reviews: From the Internet to Paper Fink A Sage Publications, 2009

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/121/106/121106007/
2. https://onlinecourses.nptel.ac.in/noc22_ge08/preview
3. https://archive.nptel.ac.in/courses/110/105/110105091/
4. https://archive.nptel.ac.in/courses/102/106/102106051/
5. https://www.youtube.com/watch?v=aKohB8lPueg
6. https://archive.nptel.ac.in/courses/110/105/110105091/

Skill Development Activities Suggested

1. Class Presentations and discussions of research articles from publications.
2. Online tools for surprise quizzes.
3. Collection of case studies via Newspapers/Journal articles, on topics covered.

Group discussions on recent advancements and case studies.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
1	Appraise and distinguish the central dogma principles across eukaryotic and prokaryotic systems	L1, L2, L3, L4
2	Apply, comprehend, differentiate the principles of gene manipulation, expression and interaction of genes and proteins in various living systems	L1, L2, L3, L4
3	Analyse gene manipulation in the context of developing GM based products/processes of societal importance	L1, L2, L3, L4

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
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	PO3
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.	PO4
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	PO5
6	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	PO10
7	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	PO11

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**											
CO2	**3**											
CO3	**3**	**1**	**1**				**1**					

Semester I

Molecular Biology and Genetic Engineering Lab (PCCL)			
Course Code	**22BBCL17**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0	SEE Marks	50
Credits	2	Exam Hours	3

Course objectives:

- To acquire the skill of screening of microbes for metabolit.es.
- To acquire the skill of isolating DNA plasmid and quantification of Nucleic acids.
- To acquire the skill of Performing bio assays like enzyme assay, antibiogram and kinetics of enzymes
- To acquire the skill of Analysing the products by shake flask culture

Sl.NO	Experiments
1	Preparations of common molecular biology lab buffers (TAE, TBE, TE, Tris-Hcl etc.)
2	Isolation of genomic DNA plant sources
3	Isolation of genomic DNA microbial or animal sources
4	Isolation of plasmid DNA from bacteria
5	Agarose gel electrophoresis and quantification of nucleic acids
6	Characterization of DNA by Spectrophotometric Assay and Melting Temperature (Tm)
7	Amplification of DNA by PCR.
8	Restriction Digestion of plasmid pUC18
9	Ligation of Gene of interest on the vector
10	Isolation of total RNA from bacteria/plant/animal samples
11	Culture and Preparation of Competent *E.Coli* Cells for bacterial transformation
12	Genetic transformation of *E.coli*

Course outcomes (Course Skill Set):

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

- Apply principles of molecular biology and genetic engineering and conduct experiments on nucleic acid solation, quantitation, digestion, amplification
- Interpret and discuss the outcome of the experiments formally through oral presentations and written reports.

Mapping of COS and POs												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			3								
CO2	1									3		

@# 03112023

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

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

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

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8^{th} week of the semester and the second test shall be conducted after the 14^{th} week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

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

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. https://onlinecourses.nptel.ac.in/noc22_bt59/preview
2. https://nptel.ac.in/courses/102106068
3. https://archive.nptel.ac.in/courses/102/104/102104056/

Semester- I

BOS recommended ONLINE courses (AUD/AEC)			
Course Code	**22AUD18/22AEC18**	CIE Marks	Evaluation procedures are as per the policy of the online course providers.
Teaching Hours/Week (L:P:SDA)	Classes are as per the policy of the online course providers.	SEE Marks	
Total Hours of Pedagogy		Total Marks	
Credits	pp	Exam Hours	

BOS RECOMMENDED ONLINE COURCES

1. Advanced Aquaculture Technology
2. Advanced Chemical Theory
3. Advanced Protein chemistry
4. Advanced Thermodynamics
5. An Introduction to Cardiovascular Fluid Mechanics
6. Animal Physiology
7. Applied Environmental Microbiology
8. Basic Principles and Calculations in Chemical Engineering
9. Bioenergetics of Life Processes
10. Bioenergy
11. Bioengineering : An Interface with Biology and Medicine
12. Biomedical nanotechnology
13. Biomicrofluidics

15.	Cell Culture Technologies
16.	Cellular biophysics: a framework for quantitative biology
17.	Computational Fluid Dynamics
18.	Computational Systems Biology
19.	Computer Aided Applied Single Objective Optimization
20.	Computer Aided Drug Design
21.	Conservation Geography
22.	Current regulatory requirements for conducting clinical trials in India for investigational new
23.	Dairy And Food Process And Products Technology
24.	Data Science for Engineers
25.	Descriptive Statistics with R Software
26.	Design Thinking - A Primer
27.	Design, Technology and Innovation
28.	Diary and food process and products technology
29.	Drug Delivery: Principles and Engineering
30.	drug/new drug (Version 2.0)
31.	Effective Engineering Teaching In Practice
32.	Electrochemical Technology in Pollution Control
33.	Electronic Waste Management - Issues And Challenges
34.	Employment Communication A Lab based course
35.	Energy Resources, Economics and Environment
36.	Entrepreneurship in Essentials

37.	Environmental Biotechnology
38.	Environmental Quality Monitoring & Analysis
39.	Environmental Remediation of Contaminated Sites
40.	Equipment Design : Mechanical Aspects
41.	Essentials of Biomolecules : Nucleic Acids and Peptides
42.	Ethics in Engineering Practice
43.	Experimental Biotechnology
44.	Forest Biometry
45.	Forests and their management
46.	Functional Genomics
47.	Fundamentals Of Food Process Engineering
48.	Fundamentals Of Micro And Nanofabrication
49.	Fundamentals of Protein Chemistry
50.	Fundamentals of Spectroscopy
51.	Fuzzy Logic and Neural Networks
52.	General Microbiology
53.	Genetic Engineering: Theory and Application
54.	Genome Editing and Engineering
55.	Geographic Information System
56.	Health Research Fundamentals
57.	Human Behaviour

59.	Immunology
60.	Industrial Biotechnology
61.	Innovation by Design
62.	Instrumentation
63.	Intellectual Property
64.	Interactomics : Basics & Applications
65.	Introduction to Biomedical Imaging Systems
66.	Introduction to Biostatistics
67.	Introduction to Brain & Behaviour
68.	Introduction to Cell Biology
69.	Introduction to Cognitive Psychology
70.	Introduction to Developmental Biology
71.	Introduction to Dynamical Models in Biology
72.	Introduction to Environmental Economics
73.	Introduction to mechanobiology
74.	Introduction To Process Modelling In The Membrane Separation Process
75.	Introduction to Professional Scientific Communication
76.	Introduction to Proteogenomic
77.	Introduction To Proteomics
78.	Introductory Mathematical Methods for Biologists
79.	Manage TB
80.	Material and Energy Balances

81.	Matlab Programming for Numerical Computation
82.	Medical Biomaterials
83.	Medicinal Chemistry
84.	Membrane Technology
85.	Multiphase Flows
86.	Non-Conventional Energy Resources
87.	Offshore Structures Under Special Environmental Loads Including Fire Resistance
88.	Optical Spectroscopy and Microscopy : Fundamentals of optical measurements and
89.	Optimization in Chemical Engineering
90.	Organic farming for sustainable Agricultural production
91.	Patent Drafting for Beginners
92.	Patent Law for Engineers and Scientists
93.	Physics of Biological Systems
94.	Physics through Computational Thinking
95.	Plant Cell Bioprocessing
96.	Plastic Waste Management
97.	Post-Harvest Operations and Processing of Fruits, Vegetables, Spices and Plantation Crop Products
98.	Principles and Applications of NMR Spectroscopy
99.	Principles Of Downstream Techniques In Bioprocess
100.	Process Control - Design, Analysis and Assessment
101.	Product Design and Innovation

103.	Protein folding
104.	Qualitative Research Methods and Research Writing
105.	Quantitative Methods in Chemistry
106.	Regulatory requirements for medical devices including in vitro diagnostics in India (Version
107.	Roadmap for patent creation
108.	Soft Nano Technology
109.	Strategic Performance Management
110.	The Joy of Computing using Python
111.	Thermal Processing of Foods
112.	Thermodynamics for Biological Systems : Classical and Statistical Aspect
113.	Tissue Engineering
114.	Transport Phenomena in Biological Systems
115.	Advanced Chemical Thermodynamics and Kinetics
116.	Ultrafast laser spectroscopy
117.	Understanding Design
118.	Waste to Energy Conversion
	Classes and evaluation procedures are as per the policy of the online course providers.

Semester II

Bioprocess Engineering (PCC)			
Course Code	22BBC21	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Demonstrate strong basics in principles of fermentation technology
- Demonstrate strong basics numerical analysis
- Design and develop various fermentation processes

Module-1

HISTORY OF DEVELOPMENT OF FERMENTATION INDUSTRY:

The range of fermentation process, Microbial biomass, enzymes, metabolites, recombinant products, Transformation process, the component parts of Fermenter. Types of industrial bioprocesses; submerged, surface, solid state fermentations: aerobic, anaerobic and light based processes. The differences between laboratory, pilot, and manufacturing scale bioreactor experiments, Green biologics of fermentation technology, types of Reactor and reactor design, process economics. Discussions with case studies

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus.

	✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-2	
SCREENING OF IMPORTANT METABOLITES FROM MICROBIAL SOURCES: Primary and secondary screening of industrially important microbes, Screening methods, General Techniques in improvement of industrial strains, Isolation of auxotrophic mutants, resistant mutants, revertant mutants, Selection by induced mutants producing improved yields of secondary metabolites. Preservation and storage at reduced temperature; Agar slopes, liquid nitrogen, dehydrated form, dried culture and lyophilisation. Quality control of reservation of stock cultures	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-3	
INTRODUCTION TO CULTURE MEDIUM AND FORMULATION: Energy sources, Carbon & Nitrogen sources, Minerals, Growth factors, Buffers, Precursors and regulators, Oxygen and antifoam ingredients, Medium optimization. Substrates for solid state fermentation, Evaluation methods for complex Substrates differences based on product use.	

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

Module-4

STERILIZATION PROCESS AND INOCULUM DEVELOPMENT

Medium sterilization, Design for Batch sterilization process, Calculation of del factors and holding time. Design of continuous sterilization process, Sterilization of Fermenters, Feeds & liquid wastes, Filter sterilization of media. Discussions with case studies Development of Inoculum, criteria for transfer, development of inoculum in yeast, bacterial and mycelial processes, aseptic inoculation of plant fermenters. Inoculum development methods.

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

Module-5	
LABORATORY TO LARGE SCALE FERMENTATION PROCESSES: Batch, Continuous culture, Synchronous, nonsynchronous growth kinetics, Feedback systems, comparison of Batch and Continuous culture in industrial processes and investigative tools. Fed batch culture, Applications of Fed back cultures Techniques and trends in Fermentation technology for the production of recombinant vaccines, therapeutic proteins, antibiotics and diagnostics. Discussions with case studies. Treatment and disposal procedure for industrial effluents.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

2. Downstream Process Technology: A New Horizon In Biotechnology, Nooralabettu Krishna Prasad, PHI, 2012
3. Industrial Microbiology, Casida, Wiley, 1986
4. Biotechnology : A Text Book of Industrial Microbiology, T.D. Brock, Smaeur Associates, 1990
5. Comprehensive Biotechnology, Moo-Young, M., Bull, A. T., Dalton, H. Pergamon Press, 1987

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/102106022
- https://professional.mit.edu/course-catalog/downstream-processing
- https://www.biozeen.com/portfolio/training/biotechnology-training-for-students/downstream-processing-technology/
- https://educolifesciences.com/product/upstream-process-development-for-biopharmaceuticals-training-course/
- https://biolim.org/programmes/training/open/hands-on-experimental-training-on-upstream-and-downstreamprocessing-in-microbial-fermentation/
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate strong basics in principles of fermentation technology	L1, L2, L3,
CO2	Demonstrate strong basics numerical analysis	L1, L2, L3,
CO3	Design and develop various fermentation processes	L1, L2, L3,

Programm Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
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	PO3

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	**3**											
CO2		**3**										
CO3			**1**									

Semester - II

Bioprocess control and automation+ Lab (IPCC)			
Course Code	**22BBC22**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	4	Exam Hours	3

Course objectives:

- To understand the basics of process dynamics, principles and instrumentation.
- To Study various types of input functions and its response for lower and higher order system.
- To Study the different types of controllers and their design stability aspects.

MODULE-1

Instrumentation:

Principles, Introduction to flow, pressure, temperature and liquid level measurements criteria of selection of measuring instruments, Static characteristics of instruments, Flow injection analysis for measurement of substrates, products and other metabolites, Dynamics and control of bioreactors & sterilizers, On-line data analysis for state and parameter estimation techniques for biochemical processes

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes).

	✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

MODULE-2

FIRST ORDER SYSTEMS:

Process characteristics, Laplace transforms basics, Laplace transform of various forcing functions, first order systems –examples, mercury in glass thermometer, liquid level system, Mixing process, CSTR with first and second order reaction, linearization of first order system, response of first order system for Step, Impulse, Linear and Sinusoidal changes in input, conceptual numericals.

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

MODULE-3

SECOND ORDER SYSTEMS:

Dynamics of multicapcity systems (Interacting and Non-Interacting systems-Transfer functions for equal and unequal time constants), and their dynamic response to step and Impulse, inputs, Second order systems with transfer functions (spring -damper),

response of second order system to step and impulse for Over damped, underdamped and critically damped conditions, Various terms used to describe underdamped system, Transfer function for transport lag and first order system with transport lag.

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

MODULE-4

CONTROLLERS AND FINAL CONTROL ELEMENTS :

Actuators, Positioners, Valve body, Valve plugs characteristics and its types and operating condition (air to close and air to open) and transfer function of final control element (Pneumatic valve), controllers – two position control, proportional control, derivative control, integral control, P-I (proportional-integral) control, P-D (proportional- derivative) control, P-I-D (proportional integral-derivative) control, Transfer function for first order process controlled by PI controller, Modes of advance Control techniques (Feed forward, Feed back, Ratio and Adaptive control) conceptual numericals

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

MODULE 5

CONTROLLER DESIGN AND STABILITY :

Criteria for stability, Routh test; Root locus (basics), Introduction to frequency response, Qualitative discussion about Bode criteria and Nyquist criteria; Conceptual numericals

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

PRACTICAL COMPONENT OF IPCC

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks**

Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**

Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.

The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

.

SEE for IPCC

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

The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.

There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

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

The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.

SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

Books

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

Web links and Video Lectures (e-Resources):

- https://www.btec.ncsu.edu/industry/short_courses/fundamentals.php
- https://www.cytivalifesciences.com/en/us/solutions/bioprocessing/services/training-and-education
- https://educolifesciences.com/upstream-bioprocess-training/
- https://www.coursera.org/lecture/industrial-biotech/microbial-fermentation-processes-and-bioreactor-design-35cbb\VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Elaborate the basics of process principles, dynamics, and instrumentation.	L4, L5
CO2	Apply various types of input functions and study its response of lower and higher order system.	L4, L5
CO3	Perform studies on different types of controllers for their design and stability aspects	L4, L5

Program Outcome of this course

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
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	PO3
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.	PO4
5	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	PO9
6	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	PO12

Mapping of COS and POs

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

Semester II

Agricultural Biotechnology (PEC-1)			
Course Code	22BBC231	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To apply principles of basic biology to understand agriculture biotechnology.
- To evaluate current advancements and barriers in crop improvement in the context of biology and bioengineering

Module-1	
INTRODUCTION TO AGRICULTURAL BIOTECHNOLOGY: Introduction, history and scope of agriculture in India. Staple food, fiber, fuel and fruit crops of India and abroad, Agro-climatic zones and cropping pattern of India. Conventional crop improvement programs- Introduction, Selection and Hybridization, Mutation, Haploidy and Polyploidy Breeding. Modern agriculture biotechnology for food security and national economy. Green-revolution.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-2	
APPLICATIONS OF PLANT TRANSFORMATION TECHNOLOGY: Productivity and performance disease resistance, genes and gene constructs used for viral resistance by coat protein mediated production, bacterial resistance by lysozyme gene and fungal resistance by chitinase and beta glucanase genes. Agrobacterium mediated transformation. Crop improvement to resist adverse soil conditions. Salinity tolerance, drought resistance. Herbicide resistance in commercially important plants. Insecticide resistance through BT-gene. Integrated pest management. Current status of BT crops in the world. Effect of transgenic crops on environment	

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
INTRODUCTION TO PLANT CELL CULTURE: Explant selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L-2; Callus and cell suspension culture; plant regeneration: organogenesis. Somatic embryogenesis; somaclonal variation, its genetic basis and application in crop improvement. Role of tissue culture in rapid clonal propagation, production of pathogen - free plants and "synthetic seeds"; haploid production: advantages and methods. Protoplast technology	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Factorial- based calculations in context of media design ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

<table>
<tr><th colspan="2">Module-4</th></tr>
<tr><td colspan="2">ANTISENSE RNA TECHNOLOGY (ACC synthase gene and polygalacturonase):
Delay of softening and ripening of fleshy fruits by antisense RNA for ACC synthase gene in tomato, banana. Use of antisense RNA technology for extending shelf life of fruits and flowers Protection of cereals, millets and pulses following harvest using biotechnology. Biotechnology for fortification of agricultural products- Golden rice, transgenic sweet potatoes. Importance of biofertlilizers in agriculture. (Rhizobium azatobacter, Mycorrhiza, Frankia and Blue green algae) current practices and production of biofertilizers.</td></tr>
<tr><td>Teaching-Learning Process</td><td>✓ Include traditional teaching learning process such as Chalk and Talk using writing boards.
✓ Collaborate with students how tools are applied to solve biological problems.
✓ Integrate real time case studies in various scientific tools used.
✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data.
✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work.</td></tr>
<tr><th colspan="2">Module-5</th></tr>
<tr><td colspan="2">AN OVERVIEW OF LEGAL AND SOCIOECONOMICIMPACT OF BIOTECHNOLOGY:
Biotechnology & hunger. Ethical issues associated with labelling and consumption of GM foods. Public perception of GM technology. Biosafety management. Cartagena protocol on biosafety. Ethical implication of BT products, public education, Biosafety regulations, experimental protocol approvals, guidelines for research, environmental aspects of BT applications</td></tr>
<tr><td>Teaching-Learning Process</td><td>✓ Include traditional teaching learning process such as Chalk and Talk using writing boards.
✓ Collaborate with students how tools are applied to solve biological problems.
✓ Integrate real time case studies in various scientific tools used.
✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data.
✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work</td></tr>
</table>

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Genetic Engineering and Biotechnology: Concepts, Methods and Applications by Chopra VL & Nasim A. Oxford & IBH. 1990.
2. Elements of Biotechnology by Gupta PK, Rastogi Publ. 1997.
3. An Introduction to Recombinant DNA Technology: Basic Experiments in Gene Manipulation by Hackett PB, Fuchs JA & Messing JW2nd Ed. Benjamin Publ. Co., 1988.
4. Molecular Cloning, a Laboratory Manual by Sambrook J &Russel D.,3rd Ed. Cold Spring Harbor Lab. Press. 2001.
5. Biotechnology, Expanding Horizons by Singh BD. Kalyani, 2005.
6. Molecular Biology & Genetic Engineering by L M Narayanan, A. Mani, A.M Selvaraj, N Arumugam, Padmalatha Singh, Saras Publication. 2014

Web links and Video Lectures (e-Resources):

1. https://www.classcentral.com/course/food-production-agricultural-technology-plant-bio-14399
2. https://www.futurelearn.com/courses/food-production-agricultural-technology-plant-biotechnology
3. https://www.mooc-list.com/tags/plant-biotechnology
4. https://onlinecourses.nptel.ac.in/noc19_bt21/preview
5. VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply principles of biology in the context of agricultural science in order to solve problems pertaining to abiotic and biotic crop stress.	L4, L5
CO2	Apply principles of biology to agriculture in order to understand the basis of improving the nutritive properties of crop plants.	L4, L5
CO3	Utilize biotechnology for sustainable development of agricultural crops and practices	L4, L5

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	**PO1**
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	**PO2**
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	**PO3**
4	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	**PO5**
5	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	**PO6**
6	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	**PO7**

Mapping of COS and POs

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

Semester II

Animal Biotechnology (PEC-1)			
Course Code	22BBC232	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Understand principles and techniques in genetic engineering, gene transfer technologies for animals and animal cell lines
- To learn the present and future contribution of functional genomics in animal biotechnology.
- To learn the role of biotechnology in animal science for sustainable eco-system and human welfare.

Module-1

INTRODUCTION TO ANIMAL CELL CULTURE

History and development of animal tissue culture. Equipment and materials, Principles of sterile techniques. Sources & types of tissues,

serum and supplements, serum-free media, features and specifications of MEM, DMEM, RPMI and Ham's medium. Role of antibiotics in media. Measurement of cell viability and cytotoxicity. Dye exclusion and inclusion tests, colonigenic assay, macromolecular estimation, MTT based assay. Measuring parameters of growth – growth curves, PDT, Plating efficiency and factors influencing growth	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-2	
CELL LINES & ITS CULTURE Primary culture, Establishment of Primary Culture, Development of cell lines, characterization of cell lines, maintenance and preservation of cell lines. Contamination -causes, detection and control, cell transformation – normal v/s. transformed cells, growth characteristics of transformed cells. Viral and chemical-mediated methods of cell immortalization, Scale-up of suspension cultures - Batch reactor, continuous culture, perfusion systems. Scale-up of monolayer cultures – roller bottles, Nunc cell factory, micro-carrier cultures, organotypic culture, matrices, factors affecting culture and perspectives	

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

Module-3

INVITRO FERTILIZATION & CLONING

Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, in vitro fertilization, culture of embryos, embryo transfer, embryo-spliting, embryo sexing, transgenic manipulation of animal embryos, different applications of transgenic animal technology, animal viral vectors, animal cloning basic concept, cloning from- embryonic cells and adult cells, cloning of different animals, ethical, social and moral issues related to cloning, in situ and ex situ preservation of germplasm, in utero testing of foetus for genetic defects, anti-fertility animal vaccines, gene knock out technology and animal models for human genetic disorders.

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus.

	✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Module-4

MOLECULAR BREEDING

Introduction to different breeds of cattle, sheep, goats, pigs, canines and poultry, genetic characterization of livestock breeds, marker assisted breeding of livestock, introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD, genetic basis for disease resistance, Immunological and nucleic acid based methods for identification of animal species, detection of meat adulteration using DNA based methods, detection food/feed adulteration with animal protein.

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

Module-5

OTHER APPLICATIONS

Application of animal cell culture- Concepts of tissue engineering - skin, liver, kidney, Principles and species suitable for aquaculture (Indian major carps and prawns) Pearl culture - pearl producing mollusks, rearing of oysters, nucleation for pearl formation and

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Web links and Video Lectures (e-Resources):

1. https://www.digimat.in/nptel/courses/video/102104059/L01.html
2. https://onlinecourses.nptel.ac.in/noc20_me04/preview
3. https://nptel.ac.in/courses/102103013
4. https://onlinecourses.swayam2.ac.in/cec22_bt07/preview
5. https://www.digimat.in/nptel/courses/video/102104058/L01.html

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply principles and techniques of genetic engineering, gene transfer technologies to develop cell lines	L1, L2, L3,
CO2	To understand functional genomics and apply the same in Animal Biotechnology.	L1, L2, L3,
CO3	Apply the principles of biotechnology in animal sciece for sustainable development.	L1, L2, L3,

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
4	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**				**3**	**3**					
CO2	**3**	**3**				**3**	**3**					
CO3	**3**	**3**				**3**	**3**					

Semester II

Bioprocess Calculations (PEC-1)			
Course Code	22BBC233	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Comprehend fundamentals of chemical calculations and material and energy balance
- To discuss the material balance aspects involving chemical reactions and without chemical reactions.
- To highlight the energy balance and material balance for the development of bioprocess technology

Module-1

UNITS AND DIMENSIONS:

Fundamental and derived units, Conversion, Dimensional consistency of equations, Dimensionless groups and constants, conversions of equations. BASIC CHEMICAL CALCULATIONS: Concept of mole, mole fraction, Compositions of mixtures of solids, liquids and gases, Concept of Normality, Molarity, Molality, ppm, Ideal gas law calculations.

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

	✓ Students' seminars (in solo or group) /oral presentations.
Module-2	
MATERIAL BALANCES CALCULATION: In Distillation, Absorption, Extraction, Crystallization, Drying, Mixing and Evaporation Operations, Fuels – types of fuels, (solid, liquid and gaseous fuel), relevance to biofuels, characteristics of fuels, Ultimate and proximate analyses of fuels.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-3	
MATERIAL BALANCE INVOLVING CHEMICAL REACTIONS: Material balances calculation involving bypass, recycle and operations. Generalized material balance equations, Principles of stoichiometry, Definitions of limiting and excess reactants, fractions and percentage conversion, yield and percentage yield, Selectivity, unit process – neutralization, oxidation, nitration, hydrolysis, and problems relating to these unit processes.	
Teaching-	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions,

	and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-4	
ENERGY BALANCE: General steady state energy balance equation, Thermo-physics, Thermo-chemistry and laws, Heat capacity, Enthalpy, Heat of formation, Heat of reaction, Heat of combustion and Calorific values. Heat of solution, Heat of mixing, Heat of crystallization, determination of ΔHR at standard and elevated temperatures, Theoretical flame temperature and adiabatic flame temperature.	
Teaching- **Learning Process**	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Module-5	
BIOPROCESS PRINCIPLES & STOICHIOMETRY OF BIOPROCES: Historical development of bioprocess technology; Bioprocess principlesand operations, generalized process flow sheets. General material balance equation for steady state (for manufacture of penicillin and ethanol) - outline of a bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses. Stoichiometry of microbial growth and product formation	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

2. Bioprocess Engineering, Pauline Doran, Academic, 2013
3. Basic Principles and Calculations in Chemical Engineering, David Himmelblau, PHI, 2014
4. Bioprocess Engineering, Shule and Kargi, Prentice Hall, 1992
5. Chemical Process Calculations, R. Asokan, University Press, 2011

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/103/103/103103165/
2. https://www.digimat.in/nptel/courses/video/102106069/L14.html
3. https://archive.nptel.ac.in/courses/105/105/105105186/
4. https://onlinecourses.nptel.ac.in/noc21_ch50/preview
5. https://nptel.ac.in/courses/103105054

Skill Development Activities Suggested

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate strong fundamental knowledge in bioprocess principles.	L1, L2, L3,
CO2	Discuss the significance and solve problems related to material and energy balance to give solutions for bioprocess development	L1, L2, L3,
CO3	Develop the flow-sheet for general processes operating in bioprocess industry.	L1, L2, L3,
CO4	Apply the stoichiometry of microbial growth and product formation involved in bioprocess technology	L4

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3	**3**										
CO2	3	**3**										
CO3	2	**3**										
CO4	3	**3**										

Semester II

Genomics, Proteomics and Bioinformatics (PEC-1)			
Course Code	22BBC234	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

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

<table>
<tr><th colspan="2">Module-1</th></tr>
<tr><td colspan="2">INTRODUCTION:

Polymorphisms-types of polymorphism, genomes sequences and data base subscriptions. Early sequencing efforts. Extraction of DNA, Methods of preparing genomic DNA for sequencing, DNA sequence analysis methods Sanger Di-deoxy method, -Maxam &Gilbert Method, Fluorescence method, Shot-gun approach. NGS methods and their principles. Bioinformatics tools and automation in Genome Sequencing, analysis of raw genome sequence data, Transcriptome (RNA) sequencing: Differential gene expression analysis, Exome sequencing: Variant detection and disease prediction, ChIP-sequence, biological theories on ChIP-sequence analysis, Understanding the non-coding genome, Disease gene identification, DNA fragment evaluation, Peak identification, two condition comparison, Saturation analysis, Motif finding and related theories.</td></tr>
<tr><td>Teaching-
Learning Process</td><td>✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective
and questioning /inquiry based teaching.
✓ Instructions with interactions in classroom lectures (physical/hybrid).
✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
✓ Flipped classroom sessions (~10% of the classes).
✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus.
✓ Students' participation through audio-video based content creation for the syllabus (as assignments).
✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
✓ Students' seminars (in solo or group) /oral presentations.</td></tr>
<tr><th colspan="2">Module-2</th></tr>
</table>

GENOMICS:

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

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

Module-3

PROTEOMICS:

Two-dimensional PAGE for proteome analysis, Detection of proteins on SDS gels, Protein cleavage, Edman protein micro sequencing, Automation in proteomics, Protein- protein interaction assays - Two-hybrid methods, TAP/ GFP tags, Phage Display, Mass-spec based

Protein Arrays and "Protein Chip" - interactions and detection techniques. Phage antibodies as tools for proteomics. Proteome-wide interaction maps, Proteomics workflows; Proteomics and the study of diseases, Applications of proteome analysis to drug development and toxicology. Organellar proteomics. Protein Engineering.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-4	
DATABASES & SEQUENCE ANALYSIS: Bioinformatics resources: NCBI, EBI, ExPASy, RCSB. Significance of databases towards informatics projects. Databases and classifications. GenBank, DDBJ, EMBL, PIR, Uniprot-KB, SWISS-PROT, TrEMBL. Gene bank flat file. Protein Data Bank (PDB) flat file; FASTA Format, PIR Format; Structure file formats. the Modular Nature of proteins, Optional Alignment Methods, substitution matrices, Statistical significance of Alignments, BLAST and its different types,ProgressiveAlignmentMethods,MUSCLE,MotifsandPatterns,PROSITE, Hidden Markov Models (HMMs). Phylogenetic analysis: Alignment, Tree Building, and Tree Evaluation, Tree - Building Methods-Distance based and character-based methods, Evaluating Trees and Data- Bootstrapping (parametric and nonparametric), Phylogenetic softwares (CLUSTAL-omega, PHYLIP etc.) NGS Data retrieval: SRA Databases, ENA Data bases, DRA Search, Sequence Quality control, trimming, error correction	

and pre-processing of data, Quality control tools: FastQC, PRINSEQ, FastX toolkit, MultiQC. Adaptor removal: Cutadapt, ShortRead, Trimmomatic.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-5	
INSILICO APPLICATIONS: Detecting Functional Sites in the Prokaryotic and Eukaryotic Genomes (promoters, transcription factor binding sites, translation initiation sites), Integrated Gene Parsing, finding RNA Genes, Web based tools (GENSCAN, GRAIL, GENEFINDER). Protein Identity based on composition, Physical properties Based on sequence, secondary structure and folding classes, tertiary structure. protein fold prediction tools,Relatedweb-basedsoftware(JPRED,NNPREDICT,SOPMA,DSSP,STRIDE).Restriction mapping, Utilities, DNA strider, MacVector and OMIGA, Web based tools (MAP, REBASE); Primer design–need for tools, Primer design programs and software(PRIME3).3D Structure Modelling in drug discovery, molecular docking, quantitative structure activity relationship(QSAR), deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Ligand-Receptor Interactions: Docking software (AUTODOCK,HEX), Energy Calculations (no derivation).	

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

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

Web links and Video Lectures (e-Resources):

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

Skill Development Activities Suggested

- NGS and Microarray data Analysis
- Proteomic data network analysis.
- AV presentation by students (on specific topics).
- Discussion of case studies based on research findings.
- Model making and Poster presentations

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply the basics of biology to understand Genomics, Proteomics and Bioinformatics	L3, L4, L5
CO2	Apply the concepts of Genomics, Proteomics and Bioinformatics in research.	L3, L4, L5
CO3	Apply Bioinformatics tools in Genomics and Proteomics study	L3, L4, L5

Programme Outcome

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	PO5
3	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	**3**					**3**				
CO2	**3**					**3**				
CO3	**3**				**3**	**3**				

Semester II

Environmental Biotechnology (PEC-1)			
Course Code	22BBC235	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To learn principles of environmental biotechnology for sustainable development and protection of our ecosystem.
- To lean the use the foundation principles and technologies to solve live problems in various spheres of environmental sciences

Module-1

INTRODUCTION TO ENVIRONMENT:

Concerns pertaining to Ecological damage, Environmental Pollution Types - Water, Soil, Air, Noise and Thermal pollutions, their sources and ecological effects of pollutants on living and non-living systems. Acid rain: sources and solutions. Significance of GHGs and carbon footprint; Biodegradation, of xenobiotic compounds, organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants and microbial treatment of oil pollution. Microbial desulfurization of coal. Environmental implications of Acid mine drainage and its remediation; Role of Biotechnology in providing solutions to environmental problems.

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.

	✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-2	
BOD, COD and TOC Estimation and correlation; Definition of Waste; Physical, Chemical and Biological characteristics of Industrial waste. Nitrification and Denitrification and their kinetics; Wastewater treatment systems. Waste Management in different industries (food processing, leather tanning, pharmaceutical, textile) Solid waste management: landfills, composting, earthworm treatment, recycling and processing of organic residues, Sources and dispersion of atmospheric pollutants and dispersion models. Control methods for air pollutants, noxious pollutants and odor control; Design of air pollution control equipments; Photochemical reactions.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Module-3	
WASTE TREATMENT METHODS: Types (Suspended and Attached growth processes), Aerobic and Anaerobic treatment of wastes; Other biological treatment process, Anaerobic digestion – Stoichiometry & Kinetic relationships, design consideration, Process modeling and control, Biological nutrient removal, Biological treatments with Case studies; Bioremediation types and biorestoration of contaminated lands. Handling of hazardous wastes from bioprocess industries and related case studies.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-4	
ENVIRONMENTAL SENSING TECHNIQUES: Characterization of water contaminants and their measurement Spectroscopic techniques, AAS, NAA, GCMS, HPLC, Electro analytical techniques, Environmental sensing techniques. Discussions with Case studies.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes)

	✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-5	
ENVIRONMENTAL POLICIES AND REGULATIONS: Waste minimization and its plan; Conservation of water and energy, Fugitive loss, Programs of municipal pollution control, Risk evaluation and decision analysis. Sustainable development, Environmental Management Systems, ISO and ISO 14000 series: Introduction, Areas covered in the series of standards, Necessity of ISO certification, Environmental Auditing; Other tools for environmental management, Environmental Impact assessment(EIA) and its future and scope. Objectives, Elements of EIA, Baseline studies Methodologies of EIA , Types of impacts, Prediction of impacts and its methodology, Uncertainties in EIA, Status of EIAs in India. EIA at various industries	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Textbook of Environmental Biotechnology, Pradipta Kumar Mohapatra, I K International, 2007.
2. Hazardous Waste Management, Buckingham and Evans, McGraw Hill International Edition, 2001
3. Biochemical Engineering Fundamentals, Bailey & Ollis, McGraw Hill International Edition, 1986.
4. Standard Methods for the Examination of Water and Waste Water, Laura Bridgewater, American Public Health Association, 2007.
5. Environmental Management, N K Uberoi, Excel Books publication, 2007.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/127105018
2. https://nptel.ac.in/courses/103107212
3. https://nptel.ac.in/courses/105107207
4. https://onlinecourses.nptel.ac.in/noc22_ch33/preview
5. https://nptel.ac.in/courses/129/106/129106002/
6. https://nptel.ac.in/courses/109107171
7. https://onlinecourses.swayam2.ac.in/cec20_ge12/preview

Skill Development Activities Suggested

5. NGS and Microarray data Analysis
6. Proteomic data network analysis.
7. AV presentation by students (on specific topics).
8. Discussion of case studies based on research findings.
9. Model making and Poster presentations

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate strong basics in principles of environmental biotechnology for sustainable development and protection of our ecosystem.	L1, L2, L3,
CO2	Apply the foundation principles and technologies to tackle live problems in various spheres of environmental sciences	L1, L2, L3,

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**					**3**					
CO2	**2**						**3**					

Semester II

Food Biotechnology (PEC-2)			
Course Code	22BBC241	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- apply knowledge of food engineering to design new process.
- Apply principles of biotechnology towards better food processing.
- Understand the importance of Food Safety & Quality Assurance in food industry

Module-1

BASIC CONSTITUTES OF FOOD:

Basic constituents of food, colloidal systems in food, molecular stability of colloidal systems, types of food starches, soluble fibers: pectin's, mucilage & gums, protein rich foods, oils in foods. Food Microbiology: Microbial growth pattern, types of microorganisms associated with food: mold, yeast and bacteria. Contaminants of food stuff, milk and meat during handling and processing. Mechanism of food spoilage. Biochemical changes caused by microorganism. Determination of various types of food products. Food borne intoxicants and mycotoxins.

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes)

	✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-2	
FOOD PRESERVATION TECHNOLOGY: Food preservation by high and ultrahigh temperatures- canning, drying. Food dehydration: Equipments for food dehydration: fixed tray dehydration, cabinet drying, tunnel drying. Freeze dehydration, controlled atmosphere, storage, Food preservation by irradiation treatment. Preservation by freezing and refrigeration. Frozen foods. Thermal properties of frozen foods. Food freezing equipments: Air blast freezers, plate freezers and immersion freezers. Preservation by Chemicals and Bacteriocins.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Module-3	
FOOD PROCESSING AND FERMENTED FOOD PRODUCTS Food Production Technology: Importance of food industry, specific objectives of food processing, impact of food processing on food constituents. Production of single cell protein, Tailoring of milk proteins and milk fats, Production of fermented food products: yoghurt, probiotic cheese, Wine, distilled liquors, Nutritional value, labelling of constituents: Soya foods, organic foods, dietary foods, nutritional food supplements, Use of plant cell culture for the production of food additives (Vanillin, Capsaicin),microbial transformations, regulatory and social aspects of BT. Food packaging, edible films, Marketing of food and promotional strategies.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-4	
BIOTECHNOLOGY FOR IMPROVED PROCESSING: Role of biotechnology in food industry, maintenance of nutritional quality, Enzymes in bakery and cereal products, utilization of hydrolases and lipases enzymes. Applications of immobilized enzymes in food industry, enzymes for enhanced flavor and aroma compounds, enzymes in fat and oil industries. Genetically modified plants for high nutritional food.	

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

Module-5

FOOD QUALITY ASSURANCE AND CONTROL:

Importance and functions of quality assurance and control. Methods of quality, concept of rheology, assessment of food materials- fruits, vegetables, cereals, dairy products, meat and processed food products. Microbiological safety of food products, chemical safety of food products, contaminants by heavy metal, fungal toxins and pesticide residue. Food regulations, grades and standards, USFDA/ ISO 9000 Series. Food adulterations and safety, sensors and instrumental analysis in quality control food laws and Standards.

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Food Biotechnology, James M, Jay, CBS Publishers, 2005
2. Food Biotechnology, Kalidas Shetty, CRC Press, ,2005
3. Applied dairy microbiology, H. Elmer, L James, Marath and Steele, CRC Press, 2005
4. Introduction to Food Engineering, R. Paul Singh, Academic Press, 2004
5. Food Processing Technology: Principles and Practice, P. Fellows, Woodhead Publishing Ltd., Cambridge, 2005

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/126/105/126105015/
2. https://onlinecourses.swayam2.ac.in/cec19_ag01/preview
3. https://nptel.ac.in/courses/102106080
4. https://nptel.ac.in/courses/126105015
5. https://onlinecourses.swayam2.ac.in/cec20_ag06/preview

Skill Development Activities Suggested

- NGS and Microarray data Analysis
- Proteomic data network analysis.
- AV presentation by students (on specific topics).
- Discussion of case studies based on research findings.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the basics of food science and nutrition and apply its concepts in Food Processing.	L3, L4
CO2	Apply the methods and techniques in Quality Control and Preservation	L3, L4
CO3	Understand various areas of Food Safety & Quality Assurance	L3, L4

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**					**3**	**3**					
CO2	**3**					**3**	**3**					
CO3	**3**					**3**	**3**					

Semester II

Pharmaceutical Biotechnology (PEC-2)			
Course Code	22BBC242	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To apply principles of Biotechnology for Pharmaceutical development
- To understand Molecular mechanisms of drug action and apply the same in lead identification.

Module-1

INTRODUCTION:

Introduction to pharmaceutical biotechnology, pharmacokinetic concepts, current research trends, new advances and approved biologicals for pharmaceutical use and manufacturing principles. Quality assurance and control;Concept of GMP, GLP.

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

Module-2

THERAPEUTICS BASED ON BIOTECHNOLOGY:

Hematopoietic growth factor and coagulation factors, interferons and cytokines; Preparation and standardization of hormones-thyroid, insulin and growth hormones; Enzymes-Enzymatic therapy and monographs; antibiotics and their derivatives-penicillin, streptomycin, tetracycline, cephalosporins, macrolides, peptide antibiotics (any two); vaccines BCG, DPT, Poliomyelitis, Typhus, toxoids-diptheria and tetanus; antitoxins diptheria and gas- gangrene(any two); others-whole human blood, dried human plasma, gamma globulins, clinical dextran and absorbable haemostats, uses, and storage

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

Module-3

BIOTRANSFORMATION:

Introduction, methods used in biotransformation, steroid transformation, contraceptives, L-Dopa, chemical reactions and mechanisms (hydroxylation, aromatization, synthetic routes, epoxidation and others), production and application of monoclonal antibodies.

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

NUTRACEUTICALS: Antioxidants, flavonoids, carotenoids, cholesterol lowering chemicals, nutritional importance and their functions, deficiency diseases, nutritional status evaluation. Drug delivery systems: Introduction to drug delivery systems and methods, overview of barriers, calculation of drug metabolism and, pharmacodynamics.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-5	
RECOMBINANT PROTEINS AND PROTEOMICS IN DRUG DEVELOPMENT: Role of proteomics in drug development Application of recombinant proteins in pharmaceutical industry, health care and future prospects.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Biopharmaceuticals: Biochemistry and Biotechnology, Walsh G John, Wiley & Sons Ltd, 2003
2. Pharmaceutical :Fundamentals and Applications, Crommelin, Daan J. A., Sindelar, Robert D., Meibohm, Springer, 2013
3. Wolff Burger's Medicinal Chemistry and Drug Discovery, Manfred E, Wiley & Sons Inc., 2000.

2 Drug delivery: principles and applications, Binghewang, Terunasiahaan, Richard Soltero, John Wiley & Sons, 2005.

3 Drug Metabolism: An Introduction, Michael D. Coleman, John Wiley & Sons, 2005

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102105058
2. https://archive.nptel.ac.in/courses/126/104/126104004/
3. https://dth.ac.in/medical/course-inner.php?id=278
4. https://onlinecourses.swayam2.ac.in/ugc19_hs33/preview
5. https://onlinecourses.nptel.ac.in/noc19_bt26/preview https://archive.nptel.ac.in/courses/102/106/102106070/

Skill Development Activities Suggested

- NGS and Microarray data Analysis
- Proteomic data network analysis.
- AV presentation by students (on specific topics).
- Discussion of case studies based on research findings.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply the basics of biology in drug discovery, manufacture of dosage forms, the infrastructural requirements and safety issues in line with the FDA requirements.	L1, L2, L3,
CO2	Analyse the Pharmacokinetics and Pharmacodynamics parameters, toxicology and mode of action of drugs.	L1, L2, L3,
CO3	Apply the principles of pharmacology to nutraceutical production	L1, L2, L3,

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
4	**Ethics: Apply** ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	PO8

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**					**3**	**3**	**3**				
CO2	**3**					**3**	**3**	**3**				
CO3	**3**					**3**	**3**	**3**				

Semester II

Bioprocess Optimisation, Modelling & Simulations (PEC-2)			
Course Code	22BBC243	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To apply the basics of biochemical engineering in optimization
- Understand the optimization processes in Unit operations and build up models and simulation.

Module-1

SCOPE AND HIERARCHY OF OPTIMIZATION:

Examples of applications of optimization, the essential features, procedure of optimization problems, obstacles to optimization.

Classification of models, fitting functions to empirical data, the method of least squares, factorial experimental designs, fitting a model

region, Necessary and sufficient conditions for an extremism of an unconstrained function one-dimensional search quadratic approximation.

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

Module-2

NUMERICAL METHODS:

Function of one variable, scanning and bracketing procedures, Newton's, Quasi- Newton's and Secant methods of uni-dimensional search, region elimination methods, polynomial approximation methods, multivariable optimization: Direct methods, random search, grid search, uni-variate search, simplex method, conjugate search directions, Powell's method, indirect methods- first order, gradient method, conjugate method, indirect method- second order: Newton's method forcing the Hessain matrix to be positive definite, movement in the search direction, termination, summary of Newton's method.

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

Module-3

OPTIMIZATION OF UNIT OPERATIONS:

Recovery of waste heat, STHE and DPHE (Pinch technology), optimal design of stages in distillation column. Optimal pipe diameter, optimal residence time for maximum yield in an ideal isothermal batch reactor, chemostat, optimization of thermal cracker using liner programming, Optimization of components in bioreactor- media, oxygen requirement, pH, temperature. L/D ratio, Flow rate optimization of fluids. Optimal speed of agitator, paddles.

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

Module-4	
SOLUTION OF GENERAL FORM OF DYNAMIC MODELS, DIMENSIONLESS MODELS. General form of linear systems of equations, nonlinear function. General state-space form. Solving homogeneous, linear ODEs with distinct and repeated Eigenvalues. Solving non- homogeneous equation, equation with time varying parameters. Introduction to systems and modelling – discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation. Discrete event simulation. Random number generation and their techniques - tests for random numbers Random variable generation.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-5	
ANALYSIS OF SIMULATION DATA Input modelling – verification and validation of simulation models – output analysis for a single model. Related to li near regression and generalization of linear regression technique. Stirred tank heaters: model equations, Isothermal continuous stirred tank chemical reactors, Biochemical reactors: model equations, linearization. Case studies	

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Optimization of chemical processes, T.F. Edgar and Himmelblau DM, Mc-Graw. Hill, 2001
2. Process system analysis and control, Coughanowr and Koppel, McGraw-Hill publishing company, 2009
3. Optimization for Engineering Design, Kalyan Moy Deb, PHI, 2000.
4. Applied mathematics in chemical engineering, Mickley, Sherwood and Reed, McGraw-Hill publishing company, 2006.
5. Chemical process control: an introduction to theory and practice, George Stephanopoulos, Prentice-Hall of India Private Ltd., 1994

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112107214
2. https://nptel.ac.in/courses/103105139
3. https://nptel.ac.in/courses/103106074
4. https://www.digimat.in/nptel/courses/video/103105139/L46.html
5. https://nptel.ac.in/courses/111107113
   https://archive.nptel.ac.in/courses/103/106/103106119/

Skill Development Activities Suggested

- NGS and Microarray data Analysis
- Proteomic data network analysis.
- AV presentation by students (on specific topics).
- Discussion of case studies based on research findings.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply the basics of chemical Engineering in optimization processes	L4, L5
CO2	Analyse and interpret simulation data	L4, L5

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	1
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.	2
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.	3
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.	4
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	5
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	6

Mapping of COS and POs												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**			**3**							**1**
CO2	**3**	**3**			**2**							**1**

Semester II

Metabolic Engineering (PEC-2)			
Course Code	22BBC244	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- apply basics of biology & bioengineering to evolve approaches in metabolic engineering relevant for bioprocess industry.
- To apply the knowledge of different metabolic pathways to understand the cell regulatory events in order to facilitate alterations wherever required.
- To evaluate different metabolic approaches towards synthesis of a particular product

Module-1

INTRODUCTION AND METABOLIC REGULATION:

Introduction: Importance of metabolic engineering and its multidisciplinary nature. An overview of Cellular Metabolism, Transport Processes, Passive Transport, Facilitated Diffusion, Active Transport, Fueling Reactions, Fermentative Pathways, Glycolysis, TCA Cycle and Oxidative Phosphorylation, Anaplerotic Pathways, Catabolism of Fats, Organic Acids, and Amino Acids, Biosynthetic Reaction, Biosynthesis of Amino Acids Biosynthesis of Nucleic Acids, Fatty Acids.

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-2

METABOLIC FLUX AND APPLICATIONS OF METABOLIC FLUX ANALYSIS:

Metabolic flux analysis and its application, Methods for experimental determination of metabolic flux by isotope dilution method. Production of Glutamic Acid and regulation by Bacteria, Calculation of Theoretical Yields, Metabolic Flux Analysis of Lysine Biosynthetic Network in C. glutamicum, Metabolic Flux Analysis of Specific Deletion Mutants of C. glutamicum, Metabolic Fluxes in Mammalian Cell Cultures, Determination of Intracellular Fluxes, Application of Flux Analysis to the Design of Cell Culture Media.

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-3

REGULATION OF METABOLIC PATHWAYS:

Regulation of Enzymatic Activity, Overview of Enzyme Kinetics, Simple Reversible Inhibition Systems, Irreversible Inhibition, Allosteric Enzymes: Cooperativity, Regulation of Enzyme Concentration, Control of Transcription Initiation, Control of Translation,

Global Control: Regulation at the Whole Cell Level, Regulation of Metabolic Networks, Branch Point Classification, Coupled Reactions and the Role of Global Currency Metabolites.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-4	
METABOLIC ENGINEERING IN PRACTICE: Enhancement of Product Yield and Productivity, Ethanol, Amino Acids, Solvents, Extension of Substrate Range, Metabolic Engineering of Pentose Metabolism for Ethanol Production, Cellulose-Hemicellulose Depolymerization, Lactose and Whey Utilization, Sucrose Utilization, Starch Degrading Microorganisms, Extension of Product Spectrum and Novel Products, Antibiotics, Polyketides, Vitamins, Biopolymers, Biological Pigments, Hydrogen, Pentoses: Xylitol, Improvement of Cellular Properties, Prevention of Overflow Metabolism, Alteration of Substrate Uptake, Maintenance of Genetic Stability.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-5	
BIOSYNTHESIS OF METABOLITES AND BIOCONVERSIONS: Primary metabolites: Alteration of feedback regulation, limiting of accumulation of end products, resistant mutants. Secondary metabolites: Precursor effects, prophage, idiophase relationship, enzyme induction, feedback repression, catabolic repression, important groups of secondary metabolic enzymes, phosphotransferase, ligases oxidoreductases, oxygenases, carboxylases. Advantages of bioconversions, specificity, yields. Factors important to bioconversions, regulation of enzyme synthesis, permeability co metabolism, conversion of insoluble substrates.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Metabolic Engineering Principles and Methodologies, Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens
2. Nielsen, Academic Press, 1998
3. Control of metabolic process A.C. Bowdenand, M.L. Cardens, Plenum Publisher, 1991
4. Bioprocess engineering basic concepts, M.L. Shuler and Kargi, Pearson Hall, 1992
5. Fermentation and enzyme Technology, Wang D I C Cooney C I Demain, A L John Willey, 1992
6. Scale-up Methods in Chemical Engineering, Johnson and Thring, Johnson and Thring, 2006

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/102105086
2. https://www.digimat.in/nptel/courses/video/102105086/L01.html https://nptel.ac.in/courses/102105086
3. https://onlinecourses.nptel.ac.in/noc22_bt29/preview
4. https://nptel.ac.in/courses/104103121
5. https://www.youtube.com/watch?v=6UENBbP-1OA

Skill Development Activities Suggested

- NGS and Microarray data Analysis
- Proteomic data network analysis.
- AV presentation by students (on specific topics).
- Discussion of case studies based on research findings.

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	To apply basics of biology & bioengineering to evolve approaches in metabolic engineering relevant for bioprocess industry.	L3, L4
CO2	To apply the knowledge of different metabolic pathways to understand the cell regulatory events in order to facilitate alterations wherever required.	L3, L4
CO3	Evaluate different metabolic approaches towards synthesis of a particular product	L5

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
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.	PO4
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of	PO5

6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

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

Semester II

Waste management (PEC-2)			
Course Code	22BBC245	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To learn broader understandings on various aspects of solid waste management practiced in industries.
- To learn recovery of products from solid waste to compost and biogas, incineration and energy recovery, hazardous waste management and treatment, and integrated waste management.

Module-1

INTRODUCTION TO SOLID WASTE MANAGEMENT:

Classification of solid wastes (source and type based), solid waste management (SWM), elements of SWM, ESSWM (environmentally sound solid waste management) and EST (environmentally sound technologies), factors affecting SWM, Indian scenario, progress in MSW (municipal solid waste) management in India.

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

<table>
<tr><th colspan="2">Module-2</th></tr>
<tr><td colspan="2">WASTE GENERATION ASPECTS:
Waste stream assessment (WSA), waste generation and composition, waste characteristics (physical and chemical), health and environmental effects (public health and environmental), comparative assessment of waste generation and composition of developing and developed nations, a case study results from an Indian city, handouts on solid waste compositions.</td></tr>
<tr><td>Teaching-Learning Process</td><td>✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective
and questioning /inquiry based teaching.
✓ Instructions with interactions in classroom lectures (physical/hybrid).
✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
✓ Flipped classroom sessions (~10% of the classes).
✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus.
✓ Students' participation through audio-video based content creation for the syllabus (as assignments).
✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
✓ Students' seminars (in solo or group) /oral presentations.</td></tr>
<tr><th colspan="2">Module-3</th></tr>
<tr><td colspan="2">COLLECTION, STORAGE, TRANSPORT AND DISPOSAL OF WASTES:
Waste Collection, Storage and Transport: Collection components, storage-containers/collection vehicles, collection operation, transfer station, waste collection system design, record keeping, control, inventory and monitoring, implementing collection and transfer system, a case study. Waste Disposal: key issues in waste disposal, disposal options and selection criteria, sanitary landfill, landfill gas emission, leachate formation, environmental effects of landfill, landfill operation issues, a case study..</td></tr>
</table>

Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.
Module-4	
Waste Processing Techniques & Source Reduction, Product Recovery & Recycling: Purpose of processing, mechanical volume and size reduction, component separation, drying and dewatering. Source Reduction, Product Recovery and Recycling: basics, purpose, implementation monitoring and evaluation of source reduction, significance of recycling, planning of a recycling programme, recycling programme elements, commonly recycled materials and processes, a case study.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.

Module-5	
HAZARDOUS WASTE MANAGEMENT AND TREATMENT: Identification and classification of hazardous waste, hazardous waste treatment, pollution prevention and waste minimization, hazardous wastes management in India.	
Teaching-Learning Process	✓ Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching. ✓ Instructions with interactions in classroom lectures (physical/hybrid). ✓ Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools. ✓ Flipped classroom sessions (~10% of the classes). ✓ Industrial visits, Guests talks and competitions for learning beyond the syllabus. ✓ Students' participation through audio-video based content creation for the syllabus (as assignments). ✓ Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes. ✓ Students' seminars (in solo or group) /oral presentations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. George Tchobanoglous et.al., “Integrated Solid Waste Management”, McGraw-Hill Publishers, 1993.
2. B. Bilitewski, G. Hard He, K. Marek, A. Weissbach, and H. Boeddicker, “Waste Management”, Springer, 1994.
3. Solid Wastes-Engineering Principles and Management Issues, Tchobanoglous, G., Theisen, H., and Eliassan, R. McGraw-Hill Series, Kogakusha, Ltd. 1977
4. Integrated Solid Waste Management, McGraw-Hill, Inc., New Delhi. Tchobaanoglous, G., Theisen, H., and Samuel A Vigil, 1993.
6. Integrated solid waste management: a life cycle inventory. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. John Wiley & Sons. 2001
7. Handbook of solid waste management and waste minimization technologies, Nicholas, P., & Cheremisinoff, P. D., Imprint of Elsevier Science. 2005

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/105103205

https://www.youtube.com/watch?v=k0ktJRoRcOA

https://nptel.ac.in/courses/103/107/103107125/

https://onlinecourses.nptel.ac.in/noc22_ce76/preview

https://onlinecourses.swayam2.ac.in/cec20_ge13/preview

Skill Development Activities Suggested

- Solid waste Management projects.
- AV presentation by students (on specific topics).
- Discussion of case studies based on research findings.
- Model making and Poster presentations

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply the basics of solid waste management towards sustainable development	L1, L2, L3,
CO2	Apply technologies to process waste and dispose the same.	L1, L2, L3,
CO3	Design working models to convert waste to energy	L1, L2, L3,

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**						**3**					
CO2	**3**						**3**					
CO3		**2**					**3**					

Semester II

Bioprocess Engineering Lab			
Course Code	22BBCL26	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0	SEE Marks	50
Credits	2	Exam Hours	3

Course objectives:

- Apply the basics of biology in Product Formation
- Apply biochemical principles in Downstream Processing

Sl.NO	Experiments
1	Development of inoculum and biomass estimation (dry weight basis) in Shake flask studies
2	Preparation of the fermenter
3	Production and estimation of citric acid in both SSF and submerged fermentation
4	Production of ethanol/enzymes in fermenter- Study of product formation kinetics and substrate utilization

5	Production ethanol/enzyme by immobilized microbes
6	Purification of intracellular products through cell disruption techniques (homogenization /sonication)
7	Separation of biomass/product through tangential flow filtration (TFF)
8	Product enrichment operation through two phase aqueous extraction
9	Analysis of biomolecules through TLC/HPLC
10	Separation of Enzymes through gel and ion exchangechromatography
11	Molecular weight determination of protein by bothnative and SDS PAGE
12	Characterisation protein by western blotting

Course outcomes (Course Skill Set):

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

CO1- Understand the basic principles of fermenter and its operations

CO2- Optimize the parameters for production of ethanol and organic acids

CO3- Appreciate various downstream processing techniques, purification steps and operations of associated instruments

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

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

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

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8^{th} week of the semester and the second test shall be conducted after the 14^{th} week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

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

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. Downstream Process Technology: A New Horizon In Biotechnology, Nooralabettu Krishna Prasad, PHI, 2012
2. Industrial Microbiology, Casida, Wiley, 1986
3. Biotechnology : A Text Book of Industrial Microbiology, T.D. Brock, Smaeur Associates, 1990
4. Comprehensive Biotechnology, Moo-Young, M., Bull, A. T., Dalton, H. Pergamon Press, 1987

Semester III

Biosafety, Bioethics and Regulatory affairs			
Course Code	22BBC31	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Apply Biosafety principles in experimentation
- Understand Bioethics and Regulatory affairs

Module-1

BIOTECHNOLOGY AND SOCIETY Introduction to science, technology and society, issues of access-Case studies/experiences from developing and developed countries. Ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs. private funding, biotechnology in international relations, globalization and development divide. Public acceptance issues for biotechnology: Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries.

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-2	
LEGAL ISSUES & BIOETHICS The legal, institutional and socioeconomic impacts of biotechnology; biotechnology and social responsibility, Public education to increase the awareness of bioethics with regard to generating new forms of life for informed decision making – with case studies. Principles of bioethics: Legality, morality and ethics, autonomy, human rights, beneficence, privacy, justice, equity etc. The expanding scope of ethics from biomedical practice to biotechnology, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and other global biotech issues.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
BIOSAFETY CONCEPTS Ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, Biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management. Ethical implications of biotechnological products and techniques Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution. Experimental protocol approvals, levels of containment.	
Teaching-Learning	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems.

	✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-4	
REGULATIONS Biosafety assessment procedures in India and abroad. International dimensions in biosafety, bioterrorism and convention on biological weapons. Social and ethical implications of biological weapons. Biosafety regulations and national and international guidelines with regard to recombinant DNA technology. Guidelines for research in transgenic plants. Good manufacturing practice and Good lab practices (GMP and GLP). National and international regulations for food and pharma products.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-5	
OTHER SECTORS: The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance. Key to the environmentally responsible use of biotechnology. Environmental aspects of biotech applications. Use of genetically modified organisms and their release in environment. Discussions on recombinant organisms and transgenic crops, with case studies of relevance. Plant breeder's rights. Legal implications, Biodiversity and farmers rights. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc. Biosafety issues in Clinical Trials.	

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

Biotechnology and Safety Assessment by Thomas, J.A., Fuch, R.L, Academic Press.

(2)Biological safety Principles and practices by Fleming, D.A., Hunt, D.L, ASM Press.

Reference Books

(1) Bioethics &Biosafteyby SATEESH MK, IK Publishers

(2) Biotechnologies and development by Sassaon A, UNESCO Publications

(3)Biotechnologies in developing countries by Sasson A, UNESCO Publishers

Web links and Video Lectures (e-Resources):

Web links and Video Lectures (e-Resources): •

https://www.futurelearn.com/courses/biosecurity

• https://www.mooc-list.com/tags/biosafety • https://www.coursera.org/learn/synbioethics •

https://www.coursera.org/lecture/synbioethics/ethical-issues-raised-by-gof-research-iNrh5 •

https://www.coursera.org/courses?query=safety

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

- Activity Based Learning (Suggested Activities in Class)/ Practical Based learning
- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies based on research findings
- Model making and Poster presentations on specific case studies

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Describe the rules governing manufacture, use/import/export and storage of hazardous microorganisms/genetically engineered organisms or cells	L3, L4
CO2	Describe the ethical issues related to biotechnology research	L3, L4
CO3	Explain the various forms of IPR, methods of application of Patents, Protection of Plant varieties and farmer rights and Regulatory affairs	L5

Program Outcomes

Sl. No.	Description	POs
1	**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.	PO4
2	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
4	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the	PO8

Mapping of COS and POs

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

Biosensors Technologies (PEC3)			
Course Code	22BBC321	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

Identify different classes of biosensors and describe their functioning principles

Extend engineering principles to biosensor development

Understanding the technical and societal factors involved in point-of-care diagnostics and wearable sensors

Module-1

BIOSENSOR CHARACTERISTICS Definition and components of biosensor, Basic measurement system, Measurement, Measurand, Errors in Measurements, Signal and Noise, Calibration, Method validation, Surface chemistry, Mass transport, Static characteristics-

accuracy, precision, linearity, hysteresis, threshold; dynamic range, Dynamic Characteristics – response time, damping, calibration, standards and AC/DC bridges, Biocompatibility and surface fouling, sensor integration and systems fabrication	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-2	
TRANSDUCERS Various types of transducers; principles and applications - Calorimetric, Optical, Potentiometric / Amperometric, Conductometric / Resistometric, Piezoelectric, Semiconductor, Impedimetric, Chemiluminescence - based Biosensors, Quantum dots, Fluorescence, Raman Spectroscopy and Fluorescence Enhancement and DNA microarrays	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
BIOCHEMICAL RECOGNITION Chemical reactions: history of gravimetric and colorimetric reactions. Problems of specificity. Enzymes: biological catalysts, specificity, activity, storage/shelf life. Enzyme kinetics in solution and on a surface. Chemical equilibria-	

and transformed 'bio reporter' organisms. Antibodies: Immunochemistry, binding affinity and kinetics; hapten synthesis. Nucleic Acids (RNA and DNA): Basic biochemistry, hybridization; Amplification/self-replication; Secondary Structure and folding Aptamer (oligonucleotide) based recognition and molecularly imprinted polymers. Common assaying formats, Labels: Radioisotopes, fluorophores, dyes, enzymes/substrates, liposomes, electroactive compounds. ELISAs and nucleotide capture assays	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-4	
MODERN INTEGRATED BIOSENSORS Bioelectronic sensors (Fundamentals of microelectronics and CMOS based sensors) Biophotonic sensors (Fundamentals of photonic sensors, Resonant optical sensors, Plasmonic sensors) Biomechanical sensors (Principles of micro-electromechanical (MEM) resonators and sensors) Microfluidic devices for Lab-on-a-chip (Fabrication, Devices and techniques) Application of nanotechnology in biosensing (Nanoparticles, Active nanochannels, Nanoelectronic, Nanophotonic and Nanomechanical sensors) Potential advantages & Developments towards a biomolecular computer, development of molecular arrays as memory stores; molecular wires and switches; mechanisms of unit assembly, Assembly of photonic biomolecular memory store; Information processing; commercial prospects for biomolecular computing systems Chemometrics, Biosensor arrays; Electronic nose and electronic tongue	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data.

Module-5	
APPLICATIONS Biosensor applications in clinical chemistry, medicine and health care, biosensors for veterinary, agriculture and food, Low cost - biosensor for industrial processes for online monitoring; biosensors for environmental monitoring. Application of enzymes in analysis; design of enzyme electrodes and their application as biosensors in industry, healthcare, food and environment, Mobile/Point of Care biosensors	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Books:

1. Chemical Sensors and Biosensors: Fundamentals and Applications", F.-G. Bănică, Wiley, 2012

2. Advances in Biosensors by B.D. Malhotra, A.P.F.Turner, Elsevier JAI, 2003

Reference Books

3. Electronic Measurements and Instrumentation, P.Sharma, Umesh Publications, 2006

4. Bioelectronics: From Theory to Applications, I.Willner, E.Katz, Wiley-VCH Verlag GmbH & C0, KGaA, ISBN: 3527306900, 2005

5. Biosensors for environmental monitoring, Bilitewski, U.Turner, A.P.F. Harwood, Amsterdam. 2000

Web Learning

Web links and Video Lectures (e-Resources):

- https://www.edx.org/course/principles-of-electronic-biosensors
- https://www.mooc-list.com/tags/biosensors
- https://www.futurelearn.com/info/courses/music-moves/0/steps/12721
- https://onlinecourses.nptel.ac.in/noc22_ph01/preview
- https://archive.nptel.ac.in/courses/127/105/127105225/
- https://www.biologydiscussion.com/enzymes/biosensors/biosensors-features-principle-and-types-withdiagram/10240

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Elaborate the principles and concepts of biology, electrochemistry, electronics and engineering involved in the design of biosensors	L3, L4
CO2	Recognize different types of transducers, and their application in biosensor design	L3, L4
CO3	Apply principles and concepts of sensing and engineering in the design and evaluation of biosensors for detection of markers in biofluids and point-of-care point-of-care diagnostic devices.	L5

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems**.**	PO1
2	**Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
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	PO3
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	PO4

5	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
6	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**1**	**2**	**1**									
CO2	**1**	**1**	**1**	**1**								
CO3	**1**	**1**	**1**	**2**		**1**	**1**					

Protein Engineering & Insilico drug Design (PEC3)			
Course Code	22BBC322	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

Understand Protein Structure

Apply tools of bioinformatics in drug design

Module-1

Introduction to Protein Structure: The Building Blocks, Motifs of Protein Structure, Protein folding Molecular Recognition: Protein-protein interactions, Protein-DNA interactions, The Thermodynamics of Binding like thermal stability and specificity of Macromolecular Recognition, Transcription, translation, and post-translational modifications of proteins

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-2	
CHARACTERIZATION & APPLICATIONS OF PROTEIN ENGINEERING: NMR spectroscopy, crystallography, spectroscopic and calorimetric methods. Design of polymeric biomaterials, nicotinic acetylcholine receptors as a model for a super family of ligand - gated ion channel proteins	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
Protein design principles, Student design proposals, Protein engineering by directed evolution and rational design, Directed Evolution Strategy- Phage Display Systems, Cell Surface Display Systems, Cell Free Display System, Alternative Scaffolds, Combinatorial Enzyme Engineering, Protein Engineering using noncanonical amino acids	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-4	
MOLECULAR MODELING: Constructing an Initial Model, Refining the Model, Manipulating the Model, Visualization. Structure Generation or Retrieval, Structure Visualization, Conformation Generation, Deriving Bioactive Conformations, Molecule Superposition and Alignment, Deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Calculation of Molecular Properties, Examples of Small Molecular Modeling Work, Nicotinic Ligands. INSILICO DRUG DESIGN: Generation of Rational Approaches in Drug Design, Molecular Modeling: The Second Generation, Conceptual Frame and Methodology of Molecular Modeling, The Field Currently Covered, Importance of the "Bioactive Conformation", Molecular Mimicry, Structural Similarities and Superimposition Techniques, An Important Key and the Role of the Molecular Model, Limitations of Chemical Intuition Major Milestones and Future Perspectives.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-5	
DOCKING METHODS: Program GREEN Grid: Three – Dimensional Description of Binding Site Environment and Energy Calculation, Automatic Docking Method, Three-Dimensional Database Search Approaches, Automated Structure Construction Methods, Structure Construction Methods with known Three-Dimensional Structure of the Receptor, Structure Construction in the case of Unknown Receptor Structure. Points for Consideration in Structure Construction Methods, Handling of X-Ray Structures of Proteins, Future Perspectives. Other web based programs available for molecular modeling, molecular docking and energy minimization techniques – Scope and	

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Strategies for the Design of Novel Proteins Computer Methods in Protein Modeling: An Overview Jiri Novotny

Protein Engineering and Design, 1st Edition, Sheldon J. Park, Jennifer R. Cochran, CRC Press ,Published September 25, 2009,

Reference

B/W Illustrations ,ISBN 9781420076585 - CAT# 76582

Web links and Video Lectures (e-Resources):

Web links and Video Lectures (e-Resources): •

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

- https://in.coursera.org/learn/drug-discovery

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyze the various types of protein structures and modifications	L3, L4
CO2	Apply the knowledge of Protein engineering technology to produce novel proteins with pharmaceutical and industrial significance	L3, L4
CO3	Apply insilico tools to design and analyse molecules of therapeutic use	L5

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**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.	PO4
3	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations	PO5
4	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6

Mapping of COS and POs

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

Nanobiotechnology (PEC 3)			
Course Code	22BBC323	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

: ➢ To understand the field of nano-biotechnology,

➢ To learn the principles behind nanobiotechnology

➢ To comprehend the current applications of nanobiotechnology and its scope

Module-1

INTRODUCTION TO NANOMATERIALS AND NANOBIOMATERIALS: History of Nanotechnology and Nanobiotechnology, scope and Applications. Structures and properties of Carbon based, metal based andbionanomaterails: Fullerenes, Bucky Ball, Nanotubes, Quantum Dots, Magnetic, Nano Shells,Dendrimers, Nanocarriers, Nanocrystals, Nanowires, Nanomembranes, hybrid biological/inorganic, protein & DNA based nanostructures. Introduction & overview of 1st, 2 nd and 3rd generation biomaterials

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-2	
CHARACTERIZATION OF NANOSTRUCTURES: UV-Visible spectroscopy, Electron Microscopy-Scanning electron microscopy (SEM), Atomic Force microscopy (AFM), Transmission electron microscopy (TEM), Scanning Probe microscopy (SPM), Scanning tunnel microscopy (STM); Fourier Transform infrared spectroscopy (FTIR); X-ray spectroscopy	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
NANO SYNTHESIS AND FABRICATION: Introduction & overview of Nanofabrication: Bottom up-selfassembly and Top down approaches using processes like Ball milling, Sol-gel Process, Chemical Vapor deposition (CVD). Plasma or flame spraying synthesis, Ion-Bean sculpting electrodeposition and various lithography techniques. Nanolithography and Soft lithography. Biosensors: types, applications and developments. Biosensor in modern medicine.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-4	
APPLICATION OF NANOBIOTECHNOLOGY: Medical Nanobiotechnology: Diagnostics: Imaging: Benefits and Applications. Nanotherpeutics: cancer treatment – Nanotechnology based chemotherapy (Smart Bomb), Pebbles, wound care products, Implantable materials for vascular interventions, Implantables materials for orthopaedics and dentistry. Active implantable devices and biomics. Nanosurgery. Pharmaceutical Nanobiotechnology: Drug delivery – Nanoparticles used as drug delivery systems, types of drug loading, drug release (sustained and targeted release mechanism), Biodegradable polymers. Application in the field of Nano Surgery and Tissue Engineering. Nano Safety Issues: Nanotoxicology: Toxicology health effects caused by Nanoparticles, EthicsChallenges and Future.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-5	
ETHICS, SAFETY AND REGULATORY ASPECTS : Introduction, ethical, legal and social implications of Nano medicine, and nano-bio-products, Safety concerns- Health Risks, and Challenges. Assessment of the toxic effects of nanoparticles based on in-vitro & In-Vivo experiments. Case studies. Environmental effects, public perceptions, Guidelines and regulatory aspects and evaluation of Nano pharmaceuticals in India, Europe and USA, challenges and risks associated with Markets for Nano medicine. Trends in Research and education	
Teaching-Learning	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems.

	✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

• Nanoparticle technology handbook, Masuo Hosokawa, Elsvier, 2012

• Nanotechnology in biology and medicine, Tuvan ho Dhin, CRC press, 2006

• The handbook of nanomedicine, Kewal K. Jain, Humana press, 2008

• Essential of nanotechnology, Jereme Ramsden, Ventus publishing, 2006

. • NanoBiotechnology Protocols, Sandra J. Rosenthal and David W. Wright, Humana press, 2005

• Nanobiotechnology Human Health and the Environment, by Alok Dhawan, Sanjay Singh, Ashutosh Kumar Rishi Shanker, CRC Oress, 2018

• The nanobiotechnology handbook, Yubing Xie, CRC press, 2013

Web links and Video Lectures (e-Resources):

Web links and Video Lectures (e-Resources):

• https://www.udemy.com/course/nanotechnology

• https://www.coursera.org/courses?query=nanotechnology

• https://stores.biotecnika.org/products/nanobiotechnology-certification-course

• https://www.edx.org/learn/nanotechnology

• https://www.classcentral.com/subject/nanotechnology

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Appreciate nano-biotechnology as an emerging field .	L3, L4
CO2	Apply the principles and methods to various fields of biotechnology	L3, L4
CO3	Apply ethical principles to the use of Nano biotechnology	L5

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**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.	PO4
4	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering	PO6

4	**Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice**	PO8

Mapping of COS and POs

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

Bioenergy Management (PEC3)			
Course Code	22BBC324	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- Integration of the biological and engineering principles of resource use and productivity in a quantitative manner in order to assess the effectiveness of agricultural and agroforestry biomass production systems
- Location of relevant information sources on biomass energy and to critically assess the quality of the data and the information source
- Production of clear and concise analyses of benefits and problems relating to the production and use of different forms of

Module-1	
BIOENERGY CONCEPTS- INTRODUCTION Biopower, bioheat, Biofuels, advanced liquid fuels, drop-in fuels, Biobased products, Sustainability & Resilience, Bioenergy & Environment, Carbon Footprint, Emissions of biomass to power generation applications, Emissions from biofuels,.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-2	
BIOMASS Properties and types, proximate and ultimate analysis, calorific value, density, moisture content, energy content in biomass, chemical composition of biomass, Biomass logistics, Harvesting or collection, Densification, Transport, Storage.	

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
BIOMASS FEEDSTOCKS Harvested Feedstocks: Feedstocks for first generation biofuels – Sugar crops, grains, oil seeds considered in terms of their potential for production; land use; competition with food and other industrial crops; energy inputs in production; and transport logistics Feedstocks for second generation Biofuels - Dedicated plantation, Forestry and agricultural residues, secondary biomass feedstocks (agricultural, industrial, commercial, and municipal organic wastes) considered in terms of their production, composition, purity, conversion potential and environmental impacts. Feedstocks for third generation feedstocks - Micro and macro algae considered in terms of development of new biomass feedstocks and technical constrains. Biofuels from biomass conversion processes (solid: biochar; liquids: bioethanol and biodiesel; gaseous: biogas and syngas). Residue Feedstocks: Agricultural waste, Forestry waste, Farm waste, Organic components of residential, commercial, institutional and industrial waste	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-4	
BIOMASS CONVERSION TECHNOLOGIES Pre treatment of biomass (pelleting; chipping; bio drying etc.), Bio refineries& end products Biochemical Conversion: Hydrolysis, enzyme & acid hydrolysis, Fermentation for bioethanol and bio butanol production, Anaerobic digestion for biogas/bio methane production, Trans-esterification for biodiesel production Thermochemical Conversion: Combustion, Gasification, Pyrolysis Types of reactors, chemical equilibrium and reaction kinetics. Management of solids / liquids / gaseous biomass process waste. Heat generation from biomass boilers and stoves (operation, sizing criteria). Power generation from biofuels: engines (ICE), turbines (steam, ORC, gas) and fuel cells.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-5	
LIFE CYCLE ANALYSIS Cradle-to-grave, field to wheels concepts; Goal and scope determination, defining LCA boundaries; Life Cycle Inventory, Life Cycle Assessment; Advanced low-carbon fuels from waste; Bioelectrochemical systems (e.g. microbial fuel cell) for bioenergy and chemical production.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Biorenewable Resources: Engineering New Products from Agriculture. Robert C. Brown. Wiley-Blackwell Publishing (2003)

Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. Samir K. Khanal. WileyBlackwell Publishing (2008)

Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. Samir K. Khanal. WileyBlackwell Publishing (2006)

Introduction to Bioenergy. Vaughn C. Nelson and Kenneth L. Starcher.

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc19_bt16/preview

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply the basics of bioengineering to biomass production	L3, L4
CO2	Analyse the outcomes of bioenergy production	L3, L4

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**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.	PO4
4	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**		**1**		**2**	**2**					
CO2	**3**	**2**		**1**		**2**	**2**					

Biomaterials & Artificial Organs (PEC 3)			
Course Code	22BBC325	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

To study the various biomaterials and their applications

Module-1

STRUCTURE OF BIO-MATERIALS AND BIO-COMPATIBILITY Definition and classification of bio-materials, mechanical properties, composite materials, Nanomaterials and nanocomposites, Tissue-biomaterial interactions, biomaterial characterization, medical devices, Testing of biomaterials: In-vitro, in-vivo pre-clinical tests, safety and biocompatibility evaluation

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-2	
METALS AND CERAMICS Metallic implant materials, stainless steels, Co-based alloys, Ti-based alloys, ceramic implant materials, aluminum oxides, hydro-apatite, glass ceramics, carbons	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
SYNTHETIC AND BIOPOLYMERS Polymerization, poly amides, Acrylic polymers, rubbers, high strength thermoplastics, Bio polymers: Collagen, Hyaluronic acid, chitosan and Elastin.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data.

	✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-4	
ARTIFICIAL ORGANS Artificial Heart, Prosthetic Cardiac Valves, Limb prosthesis, Externally powered limb prosthesis, Dental Implants, Artificial cornea, Artificial liver and pancreas, artificial skin	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-5	
APPLICATIONS Medical applications of biomaterials, Drug delivery, Bioinspired Materials and Biomimetics, Tissue engineering, Regenerative medicine, Stem cell biology, modern scaffold structures, advanced fabrication technologies including computer-aided tissue engineering and organ printing, global regulatory requirements, technology transfer and ethical issues	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

- An Introduction to Biomaterials, J. B. Park and R. S. Lakes, Springer, 2007
- Biological Performance of materials, J. Black, Taylor & Francis, 2005
- Biomaterials Science: An Introduction to Materials in Medicine. Buddy D. Ratner et al. Elsevier, 2004.
- Essential Biomaterials: Cambridge Texts in Biomedical Engineering. David Williams 2014, 1st edition.
- Polymeric Biomaterials, Piskin and A S Hoffmann, MartinusNijhoff Springer, 1986

Web links and Video Lectures (e-Resources):

- https://www.udemy.com/course/draft/3729862/
- https://www.edx.org/learn/biomaterials
- https://onlinecourses.nptel.ac.in/noc20_bt12/preview
- https://www.mooc-list.com/tags/biomaterials
- https://www.coursera.org/lecture/industrial-biotech/biomaterials-engineering-cell-niches-hydrogels-p5lVD
- https://onlinecourses.nptel.ac.in/noc20_bt12/preview

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Express a range of potential biomaterial and implants as specific treatments options.	L3, L4
CO2	Outline all parameters needed to optimize the design of implants and devices.	L3, L4
CO3	Identify the advantages and disadvantages of materials in terms of its compatibilities, biological responses, and degradation.	L5

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**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.	PO4

4	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

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

Ecology and Ecosystem (PEC 4)			
Course Code	22BBC331	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course objectives:

➢ To Distinguish among allied scientific disciplines (environmental science, conservation biology, restoration ecology, and environmental engineering) and compare their purposes with that of ecology.

➢ To Describe the ecosystem services important to human ecology.

Module-1

Introduction to Ecology: Terrestrial Environments, Aquatic Environments, Energy and Nutrient Acquisition; Realized and Fundamental Niche, Stream ecology, Lake ecology and Ocean ecology, Forest , Grassland and Dessert ecosystem, Species Interactions and Community Ecology, : Lamarckism; Darwinism; Modern Synthesis

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-2	
Ecosystem: Species diversity, Competition, Mutualism, Commensalism, Predation, Cybernetic nature of ecosystems. Factors affecting ecosystem: biotic and abiotic factors and their influence to organisms in various ecosystems; Concept of limiting factors; Liebig's law of the minimum; Shelford law of tolerance.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
Trophic Levels: Energy flow in ecosystems; Food Chain Ecological Pyramids, Biogeochemical cycles and the food web, Ecological Succession Concept of trophic dynamics and trophic cascade; Food chains, food webs and trophic levels; Ecological pyramids; Energy transfer; Ecological efficiencies;	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-4	
Environmental Pollutlon and their effects. Water pollution, Land pollution. Noise pollution, Public Health aspects, Air Pollution, solid waste management, e-waste management Current Environmental Issues of Importance: Population Growth, Climate Change and Global warming- Effects, Urbanisation, Automobile pollution. Acid Rain Ozone Layer depletion	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-5	
PRODUCTIVITY: Primary productivity; concept, methods of estimation, world patterns of primary productivity and Man's exploitation of primary productivity; Secondary productivity; concept, methods of estimation, world patterns of secondary productivity, and man's exploitation of secondary productivity. Evolutionary Ecology: Natural Selection and its ecological significance, modern concept of species, adaptation; Significance of mutation, isolating mechanism and ecological role and other evolutionary processes in ecology.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

• The Science of Ecology.R Brewer; Saunders College Pub., 1994.

• Environmental Science (9th edn.). Dash, M.C.and Dash, S.P. Jones and Barlett Learning. 2009.

• Fundamentals of Ecology (3rd edn.). Kormondy, E. J., Tata McGraw-Hill Publishing Co., New Delhi. 1996.

• Concepts of Ecology (4th edn.). Krebs, C. J. , Prentice-Hall of India Pvt. Ltd. 1985.

• Ecology: The Experimental Analysis of Distribution and Abundance. Charles J. Krebs, Pearson Publications, 2014.

• Introduction to Environmental Health. Bridgman, H., Springer Publishing Co. Ltd. New York. 1990.

Web links and Video Lectures (e-Resources):

Web links and Video Lectures (e-Resources):

• https://www.edx.org/learn/ecosystems

• https://www.coursera.org/courses?query=ecology

• https://www.futurelearn.com/subjects/nature-and-environment-courses/ecology

• https://www.classcentral.com/subject/ecology

• https://www.open.edu/openlearn/nature-environment/the-environment/environmental-studies/introducing-theenvironment-ecology-and-ecosystems/content-section

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the importance of the ecosystem, different types and their impact on the environment	L3, L4
CO2	Correlate the ecological energy flow in ecosystems to maintain ecological balance	L3, L4
CO3	Analyse the impact of Pollution on the Ecosystem	L5
CO4	Appreciate the ethical context of environmental issues and the links between human and natural systems	L4, L5

Program Outcomes

Sl. No.	Description	POs
1	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
2	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
3	**Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice**	PO8

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						**1**	**3**	**3**				
CO2						**1**	**3**	**3**				
CO3						**1**	**3**	**3**				

Nutrition and Human Health (PEC 4)			
Course Code	22BBC332	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

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

Module-1	
Public Health Nutrition and Health Care Systems: Aim, scope and content of Public Health Nutrition, Role of Public Health Nutritionist in national development Health – definition, dimensions, determinants and indicators Health care of the community Health care systems, ICDS, Rural Development (National Rural Livelihood Mission, Panchayat Raj Institutions) Public Sector programmes for improving of food and nutrition security and POSHAN Abhiyaan	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-2	
Introduction to Food and Nutrition : Historical perspective,, Macro nutrients and micro nutrients: Water, Carbohydrates, Proteins, Fats, Vitamins, Minerals and enzymes. national and international nutrient allowances; factors affecting the requirements. Protein quality and its assessment, BMR/BMI, Food Pyramid, FDA and ICMR guidelines to Nutrition.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-3	
Nutrition and Life cycle: Nutrition for infants, adolescents, adults, Geraitric nutrition. Special needs for Pregnant women, Lactation and Pre and Post menopause.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-4	
Nutrition in Special Conditions: Extreme temperatures - low and high High altitude Space nutrition and food systems Introduction to sports nutrition, Nutrigenomics, Functional foods and bioactive compounds, Nutraceuticals, Genetically modified foods and advances in biotechnology	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-5	
Nutrition Therapy in metabolic diseases Diabetes Mellitus – Type 1, Type 2 and Gestational diabetes Endocrine disorders – Polycystic ovary disease, thyroid Coronary Heart Diseases Hypertension, dyslipidemia, Congestive heart failure Gastrointestinal Tract Disorders	

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

The question paper will have ten full questions carrying equal marks.

Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

Each full question will have a sub-question covering all the topics under a module.

. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

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

Web links and Video Lectures (e-Resources):

- https://www.mhbacademy.com/
- https://www.udemy.com/topic/nutrition/
- https://www.coursera.org/browse/health/nutrition
- https://www.edx.org/learn/nutrition
- https://www.oxfordhomestudy.com/courses/nutrition-certificate-programs-online/free-online-nutrition-courses
- https://onlinecourses.swayam2.ac.in/cec19_ag02/preview
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource OLRs:

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Describe the basics of food and nutrients and their relationship with health. .	L3, L4
CO2	Develop balanced diet for various age groups	L3, L4
CO3	Correlate causes and prevention for nutritional diseases.	L5

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**					**1**	**1**					
CO2	**3**					**1**	**1**					
CO3	**3**					**1**	**1**					

Systems Biology and Medical Informatics (PEC4)			
Course Code	22BBC333	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- To understand the basic concepts of biological networks, their models, tools and statistical measures to characterize their properties.
- To introduce problems, challenges and research practices that health informatics addresses
- To learn ethical and diversity issues in health informatics.

Module-1	
Introduction to Systems Biology: Scope, Applications. Systems Biology in Practice Concepts Implementation and Applications. Mathematics in a Nutshell. Experimental Techniques in a Nutshell. **Modeling Tools:** SBML, MathML, CellML, Petri Nets and Bioinformatics. Data Integration - bicluster, mutual information, data warehouse. Databases related to systems biology.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-2	
Standard Models and Approaches in Systems Biology Metabolic control analysis, metabolic network, Michaelis-Menten kinetics. Signal Transduction - phosphorylation, Jak-Stat pathway, MAP kinase. Biological Processes – mitochondria. Modelling of Gene Expression - lactose, lac operon, tRNA. Analysis of Gene Expression Data - support vector machines, cDNA, microarray. Evolution and Self organization - hypercycle, quasispecies model, self-replication.	

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
Applications of Systems Biology: Standards Platforms and Applications - metabolic control analysis, glycolysis, flux balance analysis. Biological Foundations of Signal transduction and the Systems - phosphorylation, microRNAs, protein kinase. Reconstruction of Metabolic Network from Genome Information and Integrated Regulatory and Metabolic Models - phosphorylation, gene expression, metabolites. Integrated Regulatory and Metabolic Models - phosphorylation, gene expression, metabolites. Estimation Modeling and Simulation - circadian rhythms, Petri net, mRNA. Deterministic - circadian rhythms, mRNA, circadian oscillations. MultiScale Representations of Cells and Emerging Phenotypes - Gene Regulatory Networks.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-4	

Medical Informatics:

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

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-5

Knowledge Based Expert Systems:

AI/ML, expert systems, materials and methods, applications of ES, Introduction to computer based patient record, development tools, CPR in radiology, legal security and private issues, application service providers. Critical medical issues: security, confidentiality, privacy, accuracy and access.

Data Management for Clinical Research, Data Visualization and Analytics, EHRs and Clinical Decision Support Systems, Clinical Decision Making. Role of a CHIO, Enterprise Data Strategy

Health Information Exchange, Data Standards, Geospatial Analysis and Social Determinants, Human Factors in User Interface Design, SMART on FHIR, Public Health Informatics.

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

. The question paper will have ten full questions carrying equal marks.

. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

. Each full question will have a sub-question covering all the topics under a module.

. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

- A First Course in Systems Biology by Voit E ,Garland Science, 2012
- Systems biology byKlipp E, Wiley-VCH, 2009.
- Networks: an introduction. By Newman, Oxford Univ. Press. MEJ, 2011.
- An Introduction to Systems Biology: Design Principles of Biological Circuits. By Alon, Uri. Chapman&
- Hall /CRC, 2006.
- Radiological Imaging, The Theory of Image Formation, Detection, and Processing byHarrison Barrett and William Swindell, Academic Press,1996.
- Introduction to Biomedical Imaging by Andrew G. Webb, Wiley, 2017.
- Medical Imaging Systems by A. Macovski by R. Bracewell, Springer ebook, 2018.

Online Resources

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
  https://www.coursera.org/courses?query=system%20biology
- https://onlinecourses.nptel.ac.in/noc20_bt08/preview
- https://ocw.mit.edu/courses/8-591j-systems-biology-fall-2014/

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Gain knowledge about problems, challenges and research practices that health informatics addresses. 4. Analyze ethical and diversity issues in health informatics	L3, L4
CO2	. Demonstrate ability to identify genomic variants associated with a disease phenotype and Perform visualization and simple analysis for disease prognosis.	L3, L4
CO3	Explain the basic concepts, principles and methods of metabolic engineering networks and flux balance analysis.	L5
CO4	Apply the tools and techniques used in the process of drug development, from target identification to final drug registration	L5

Program Outcomes

Sl. No.	Description	POs
1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

4	**Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice**	PO8

Mapping of COS and POs												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**					**1**	**2**	**1**				
CO2	**3**					**1**	**2**	**1**				
CO3	**3**					**1**	**1**	**1**				
CO4	**3**				**2**	**1**	**1**	**1**				

Bio business and Entrepreneurship (PEC 4)			
Course Code	22BBC334	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course objectives:

- Demonstrate strong basics in entrepreneurship
- Demonstrate the ability to manage industrial projects and develop products

Module-1

BIO ENTERPREUNERSHIP: Introduction to bio-business, from the Indian context, SWOT analysis of bio-business Concept of Entrepreneurship - Evolution of Entrepreneurship, Development of Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Entrepreneurship in India; Entrepreneurship - its barriers. Small scale industries: Definition; Characteristics; Need and rationale; Objectives; Scope; Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. Global bio business and industry future trends.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-2	
BUSINESS OPPORTUNITY IN AGRI BIOTECHNOLOGY: Business opportunity, Essential requirement, marketing, strategies, schemes, challenges and scope-with case study on Plant cell and tissue culture technique, polyhouse culture. Herbal bulk drug production, Nutraceuticals, value added herbal products. Bioethanol production using Agri waste, Algal source. Integration of system biology for agricultural applications. Biosensor development in Agri management	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-3
Business opportunity, Essential requirement, marketing strategies, schemes, challenges and scope-with case study- Pollution monitoring and Bioremediation for Industrial pollutants, Pesticides, Herbicides etc. Integrated compost production- microbe enriched compost. Biopesticide/insecticide production. Fermented products-probiotic and prebiotics. Stem cell production, stem cell bank, contract research. Production of monoclonal/polyclonal antibodies, Single cell protein and secondary metabolite production. Contact research in microbial genomics.

Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-4

PROJECT MANAGEMENT, INTELLECTUAL PROPERTY, TECHNOLOGY MANAGEMENT AND STARTUP SCHEMES: Building Biotech business challenges in Indian context-biotech partners (BICEPS, BIRAC, DBT, Incubation centers. etc.), operational biotech parks in India. Indian Company act for Bio business-schemes and subsidies. Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; Formulation; Guidelines by Planning Commission for Project report; Network Analysis; Errors of Project Report; Project Appraisal. Identification of business opportunities: Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. Patent expiry and Entrepreneurship opportunity, Principles of Technology leasing, licensing and transfer, Start-ups schemes in Indian government, Business incubation support schemes, Successful startups-case study

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-5
REGULATORY AFFAIRS, BIOETHICS & BIO-SAFETY: Regulatory affairs in Bio business-regulatory bodies and their regulations (ex. FDA, EU, DSIR, AYUSH, FSSAI etc.,) Public education of the process of biotechnology involved in generating new forms of life for informed decision-making. Ethical concerns of biotechnology research and innovation Interference with nature, fear of unknown, unequal distribution of risks. Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards. biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management.

Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

. The question paper will have ten full questions carrying equal marks.

. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

. Each full question will have a sub-question covering all the topics under a module.

. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Text Books

- The 10 Commandments for Building a Growth Company Brandt, Steven C Macmillan Business Books 1977
- Bhide, Amar V The Origin and Evolution of New Business Oxford University Press 2000

Reference Books

- Patel, V.G The Seven Business Crises and How to Beat Them TMH 1995
- SIDBI Report on Small Scale Industries Sector [latest edition)
- Verma, J.C.., and Gurpal Singh Verma, J.C.., and Gurpal Singh Sage 2002

Web links and Video Lectures (e-Resources):

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Demonstrate strong basics in entrepreneurship	L3, L4
CO2	Demonstrate the ability to manage industrial projects and develop products	L3, L4

Program Outcomes

Sl. No.	Description	POs
1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	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.	PO3
3	**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.	PO4
4	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6

5	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**		**3**			**2**						
CO2	**3**		**3**	**1**		**2**						

Vaccine Technology (PEC 4)			
Course Code	22BBC335	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	3	Total Marks	100
Credits	3	Exam Hours	3

Course Learning objectives:

- ➢ To understand vaccine development for various diseases
- ➢ To distinguish between conventional and new technology vaccine development

Module-1	
Immunopathology: Tolerance and Autoimmunity, Hypersensitive reactions, Primary and Secondary Immunodeficiency, Active and passive immunization, General immunization practices, , AIDS, Immune response to Infectious disease, Basic principles of vaccine development. Vaccination of immune-compromised hosts, Vaccination of human immunodeficiency virus- infected persons. Vaccines and its historical perspective.	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-2	
Traditional and modern methods of vaccine production, Egg and cell based vaccine development, Current and future scenario of Vaccines, Edible Vaccines, Reverse vaccinology, Immunoinformatics approach to identify T and B cell epitopes, Bacterial and Viral vaccine. Passive immunization; antibody, transfusion of immune competent cells, cell based vaccines. Immunomodulators (cytokines) Innovative methods of delivery of immunogens through liposomes, microspheres, ISCOMS.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-3	
Vaccine Technology: Criteria for effective vaccine, Vaccines, Live, killed, attenuated, sub unit vaccines; Role and properties of adjuvants, recombinant DNA and protein based vaccines, Multivalent subunit vaccines, mini cell vaccines, conjugate vaccines plant-based vaccines, recombinant antigens as vaccines. Interferons, designing and screening for antivirals, mechanisms of action, antiviral libraries, antiretrovirals— mechanism of action and drug resistance. Comparative Genomics as a tool for vaccine design	
Teaching-Learning Process	✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Module-4	
Licensed vaccines, Viral Vaccine (Poliovirus vaccine-inactivated & Live, Rabies vaccines Hepatitis A & B vaccines), Bacterial Vaccine (Anthrax vaccines, Cholera vaccines, Diphtheria toxoid), Parasitic vaccine (Malaria Vaccine). Vaccines against Hepatitis A, Malaria, Typhoid (in clinical trials). Conventional vaccines, antiidiotype vaccine, naked DNA vaccine. Recombinant Vaccines - Definition, recombinant vector vaccines, DNA vaccines. Vaccine potency testing.	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work
Module-5	
The vaccine industry, Vaccine manufacturing, Vaccine additives and manufacturing residuals, Regulation and testing of vaccines, Vaccine safety and Legal issues. Regulatory issues- Environmental concerns with the use of recombinant vaccinesDisease security and biosecurity principles and OIE guidelines Method of manufacture- in process control, batch control, test on final products. large scale manufacturing—QA/QC issues	
Teaching-Learning Process	✓ ✓ Include traditional teaching learning process such as Chalk and Talk using writing boards. ✓ Collaborate with students how tools are applied to solve biological problems. ✓ Integrate real time case studies in various scientific tools used. ✓ Reflective approaches on analysing how and why the tools are used in self-reflected or published data. ✓ Incorporate Inquiry based approach using demonstration, field study, experiments and project work

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks**

Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.

. The question paper will have ten full questions carrying equal marks.

. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.

. Each full question will have a sub-question covering all the topics under a module.

. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

• Eweis JB, Ergas SJ, Chang DPY, and Schroeder ED, Bioremediation Principles, McGraw-Hill Companies, Inc.,

Text Books:

Vaccines Stanley A. Plotkin& year Walter Orenstein & Paul A. Offit Elsevier Publication 2013

Clinical Immunology Brostoff J, Seaddin JK, Male D, Roitt IM Gower Medical Publishing 2002

Reference Books

Essential Immunology Roitt, I Blackwell Scientific Publications 2001

New Vaccine Technologies Ronald W. Ellis Landes Bioscience 2001

Cheryl Barton Advances in Vaccine Technology and Delivery Espicom Business intelligence 2009

Web links and Video Lectures (e-Resources):

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

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyse the various types of vaccines	L3, L4
CO2	Apply the knowledge of vaccine technology to cure various health ailments and intricacies.	L3, L4
CO3	Evaluate the biosafety, ethical and quality issues of various vaccine technologies.	L3, L4

@# 03112023

Program Outcomes

Sl. No.	Description	POs
1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	PO1
2	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	PO6
3	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	PO7
4	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	PO8

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**					**3**	**3**	**2**				
CO2	**3**					**3**	**3**	**2**				
CO3	**3**					**3**	**3**	**2**				