VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme of Teaching and Examinations2021
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021 - 22)

III SEMESTER

Sl. No	Course and Course Code	Course title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
				Theory Lecture	Tutorial	Practical/ Drawing	Self -Study	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	S					
1	BSC 21MAT31	Mathematics course (common to all)	TD- Maths PSB-Maths	2	2	0	0	03	50	50	100	3
2	IPCC 21BT32	Unit operations + lab	TD: BT PSB: BT	3	1	2	0	03	50	50	100	4
3	IPCC 21BT33	Biochemistry + lab	TD: BT PSB: BT	3	0	2	0	03	50	50	100	4
4	PCC 21BT34	Microbiology	TD: BT PSB: BT	2	2	0	0	03	50	50	100	3
5	PCC 21BTL35	Microbiology lab	TD: BT PSB: BT	0	0	2	0	03	50	50	100	1
6	UHV 21UH36	Social Connect and Responsibility	Any Department	0	0	2	0	01	50	50	100	1
7	HSMC 21KSK37/47	Samskrutika kannada	TD and PSB HSMC	1	0	0	0	01	50	50	100	1
	HSMC 21KBK37/47	Balake kannada										
	OR											
	HSMC 21CIP37/47	Constitution of India and Professional Ethics										
8	AEC21BT38X	Ability Enhancement Course - III	TD: BT PSB: BT	If offered as Theory Course: 1	0	0	1	01	50	50	100	1
				If offered as lab. course: 0	0	2	0	02				
								Total	**400**	**400**	**800**	**18**

9	**Scheduled activities for III to VIII semesters**	NMDC 21NS83	National Service Scheme (NSS)	NSS	All students have to register for any one of the course namely National Service Scheme, Physical Education (PE)(Sports and Athletics) and Yoga with the concerned coordinator of the course during the first week of III semester. The activities shall be carried out between III semester to VIII semester (for 5 semesters). SEE in the above courses shall be conducted during VIII semester examinations and the accumulated CIE marks shall be added to the SEE marks. Successful completion of the registered course is mandatory for the award of the degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS, PE and Yoga activities.
		NMDC 21PE83	Physical Education (PE)(Sports and Athletics)	PE	
		NMDC 21YO83	Yoga	YOGA	

Course prescribed to lateral entry Diploma holders admitted to III semester B.E./B.Tech programs

1	NCMC 21MATDIP31	Additional Mathematics - I	Maths	02	02	--	--	---	100	---	100	0

Note: BSC: Basic Science Course, **IPCC:** Integrated Professional Core Course, **PCC:** Professional Core Course, **INT** –Internship, **HSMC:** Humanity and Social Science & Management Courses, **AEC**–Ability Enhancement Courses. **UHV:** Universal Human Value Course.
L –Lecture, **T –** Tutorial, P- Practical/ Drawing, **S –** Self Study Component, **CIE:** Continuous Internal Evaluation, **SEE:** Semester End Examination.**TD-**Teaching Department, **PSB**: Paper Setting department

21KSK37/47 Samskrutika Kannada is for students who speak, read and write Kannada and **21KBK37/47** Balake Kannada is for non-Kannada speaking, reading, and writing students.

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with practical of the same course. Credit for IPCC can be 04 and its Teaching–Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). 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. For more details, the regulation governing the Degree of Bachelor of Engineering /Technology (B.E./B.Tech.) 2021-22 may be referred.

21INT49Inter/Intra Institutional Internship: All the students admitted to engineering programs under the lateral entry category shall have to undergo a mandatory 21INT49 Inter/Intra Institutional Internship of 03 weeks during the intervening period of III and IV semesters. The internship shall be slated for CIE only and will not have SEE. The letter grade earned through CIE shall be included in the IV semester grade card.The internship shall be considered as a head of passing and shall be considered for vertical progression and for the award of degree. Those, who do not take up / complete the internship shall be declared fail and shall have to complete during subsequently after satisfying the internship requirements. The faculty coordinator or mentor shall monitor the students' internship progress and interact with them for the successful completion of the internship.

Non–credit mandatory courses (NCMC):

(A)Additional Mathematics I and II:

(1) These courses are prescribed for III and IV semesters respectively to lateral entry Diploma holders admitted to III semester of B.E./B.Tech., programs. They shall attend the classes during the respective semesters to complete all the formalities of the course and appear for the Continuous Internal Evaluation (CIE). In case, any student fails to register for the said course/fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have secured an F grade. In such a case, the student has to fulfill the course requirements during subsequent semester/s to earn the qualifying CIE marks. These courses are slated for CIE only and have no SEE.

(2) Additional Mathematics I and II shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the courses shall be mandatory for the award of degree.

(3) Successful completion of the courses Additional Mathematics I and II shall be indicated as satisfactory in the grade card. Non-completion of the courses Additional Mathematics I and II shall be indicated as Unsatisfactory.

(B) National Service Scheme/Physical Education (Sport and Athletics)/ Yoga:

(1) Securing 40 % or more in CIE,35 % or more marks in SEE and 40 % or more in the sum total of CIE + SEE leads to successful completion of the registered course.

(2) In case, students fail to secure 35 % marks in SEE, they has to appear for SEE during the subsequent examinations conducted by the University.

(3) In case, any student fails to register for NSS, PE or Yoga/fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have not completed the requirements of the course. In such a case, the student has to fulfill the course requirements during subsequent semester/s to earn the qualifying CIE marks.

(4) Successful completion of the course shall be indicated as satisfactory in the grade card. Non-completion of the course shall be indicated as Unsatisfactory.

(5) These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the courses shall be mandatory for the award of degree.

ABILITY ENHANCEMENT COURSE – III

21BT381	Data presentation, Error Analysis and Inferences	21BT383	Biodiversity and Conservation Law
21BT382	Bio-Lab Management and Risk Assessment	21BT384	Linux programming for Biologists

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme of Teaching and Examinations2021
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021 - 22)

IV SEMESTER

Sl. No	Course and Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
				Theory Lecture	Tutorial	Practical/ Drawing	Self -Study	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	S					
1	BSC 21BT41	Biostatistics and Design of experiments	TD, PSB-Maths	3	0	0	0	03	50	50	100	3
2	IPCC 21BT42	Python programming + lab	TD: BT PSB: BT	3	0	2	0	03	50	50	100	4
3	IPCC 21BT43	Cell biology &Cell culture techniques + lab	TD: BT PSB: BT	3	0	2	0	03	50	50	100	4
4	PCC 21BT44	Molecular biology &Genetic engineering	TD: BT PSB: BT	2	2	0	0	03	50	50	100	3
5	AEC 21BE45	Biology for engineers	BT, CHE, PHY	1	2	0	0	02	50	50	100	2
6	PCC 21BTL46	Molecular biology &Genetic engineering lab	TD: BT PSB: BT	0	0	2	0	03	50	50	100	1
7	HSMC 21KSK37/47	Samskrutika Kannada	HSMC	1	0	0	0	01	50	50	100	1
	HSMC 21KBK37/47	Balake Kannada										
	OR											
	HSMC 21CIP37/47	Constitution of India & Professional Ethics										
8	AEC21BT48X	Ability Enhancement Course- IV	TD: BT PSB: BT	If offered as theory Course: 1	0	0	1	01	50	50	100	1
				If offered as lab. course: 0	0	2	0	02				
9	UHV21UH49	Universal Human Values	Any Department	1	0	0	0	01	50	50	100	1
10	INT21INT49	Inter/Intra Institutional Internship	Evaluation By the appropriate authorities	Completed during the intervening period of II and III semesters by students admitted to first year of BE./B.Tech and during the intervening period of III and IV semesters by Lateral entry students admitted to III semester.				3	100	--	100	2
								Total	**550**	**450**	**1000**	**22**

Course prescribed to lateral entry Diploma holders admitted to III semester of Engineering programs

1	NCMC 21MATDIP41	Additional Mathematics - II	Maths	02	02	--	--	--	100	--	100	0

Note: BSC: Basic Science Course, IPCC: Integrated Professional Core Course, PCC: Professional Core Course, AEC –Ability Enhancement Courses, HSMC: Humanity and Social Science and Management Courses, UHV- Universal Human Value Courses.
L –Lecture, T – Tutorial, P- Practical/ Drawing, S – Self Study Component, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

21KSK37/47 Samskrutika Kannada is for students who speak, read and write Kannada and 21KBK37/47 Balake Kannada is for non-Kannada speaking, reading, and writing students.

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with Practicals of the same course. Credit for IPCC can be 04 and its Teaching – Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). 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 practical part of IPCC shall be included in the SEE question paper. For more details the regulation governing the Degree of Bachelor of Engineering /Technology (BE/B.Tech.) 2021-22 may be referred.

Non – credit mandatory course (NCMC):
Additional Mathematics - II:
(1) Lateral entry Diploma holders admitted to III semester of B.E./B.Tech., shall attend the classes during the IV semester to complete all the formalities of the course and appear for the Continuous Internal Evaluation (CIE). In case, any student fails to register for the said course/fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have secured an F grade. In such a case, the student has to fulfill the course requirements during subsequent semester/s to earn the qualifying CIE marks. These courses are slated for CIE only and have no SEE.

(2) Additional Mathematics I and II shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the courses shall be mandatory for the award of degree.
(3) Successful completion of the course Additional Mathematics II shall be indicated as satisfactory in the grade card. Non-completion of the courses Additional Mathematics II shall be indicated as Unsatisfactory.

Ability Enhancement Course – IV			
21BT481	Hydroponics, Aquaponics and Aeroponics	21BT483	Biopesticides and Biofertilizers
21BT482	Quality Control and Quality Assurance	21BT484	R Programming for Biologists

Internship of 04 weeks during the intervening period of IV and V semesters; 21INT68Innovation/ Entrepreneurship/ Societal based Internship.
(1) All the students shall have to undergo a mandatory internship of 04 weeks during the intervening period of IV and V semesters. The internship shall be slated for CIE only and will not have SEE. The letter grade earned through CIE shall be included in the VI semester grade card. The internship shall be considered as a head of passing and shall be considered for vertical progression and for the award of degree. Those, who do not take up / complete the internship shall be considered under F (fail) grade and shall have to complete during subsequently after satisfying the internship requirements.
(2) Innovation/ Entrepreneurship Internship shall be carried out at industry, State and Central Government /Non-government organizations (NGOs), micro, small and medium enterprise (MSME), Innovation centres or Incubation centres. Innovation need not be a single major breakthrough; it can also be a series of small or incremental changes. Innovation of any kind can also happen outside of the business world.
Entrepreneurship internships offers a chance to gain hands on experience in the world of entrepreneurship and helps to learn what it takes to run a small entrepreneurial business by performing intern duties with an established company. This experience can then be applied to future business endeavours. Start-ups and small companies are a preferred place to learn the business tactics for future entrepreneurs as learning how a small business operates will serve the intern well when he/she manages his/her own company. Entrepreneurship acts as a catalyst to open the minds to creativity and innovation. Entrepreneurship internship can be from several sectors, including technology, small and medium-sized, and the service sector.
(3) Societal or social internship.
Urbanization is increasing on a global scale; and yet, half the world's population still resides in rural areas and is devoid of many things that urban population enjoy. Rural internship is a work-based activity in which students will have a chance to solve/reduce the problems of the rural place for better living.
As proposed under the AICTE rural internship programme, activities under Societal or social internship, particularly in rural areas, shall be considered for 40 points under AICTE activity point programme.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme of Teaching and Examinations2021
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021 - 22)

V SEMESTER

Sl. No	Course and Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
				Theory Lecture	Tutorial	Practical / Drawing	Self -Study	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	S					
1	PCC21BT51	Biokinetics &Bioreaction engineering	TD: BT PSB: BT	2	2	0	0	03	50	50	100	3
2	IPCC21BT52	Immunotechnology+lab	TD: BT PSB: BT	3	0	2	0	03	50	50	100	4
3	PCC21BT53	Structural biology &Analytical techniques	TD: BT PSB: BT	2	2	0	0	03	50	50	100	3
4	PCC21BT54	Genomics, Proteomics &Bioinformatics	TD: BT PSB: BT	3	0	0	0	03	50	50	100	3
5	PCC21BTL55	Bioinformatics lab	TD: BT PSB: BT	0	0	2	0	03	50	50	100	1
6	AEC21BT56	Research methodology & Intellectual property rights	TD: Any Department PSB: As identified by University	2	0	0	0	02	50	50	100	2
7	HSMC21CIV57	Environmental Studies	TD: Civil/ Environmental /Chemistry/ Biotech. PSB: Civil Engg	1	0	0	0	1	50	50	100	1
8	AEC21BT58X	Ability Enhancement Course-V	TD: BT PSB: BT	If offered as Theory courses 1	0	0	1	01	50	50	100	1
				If offered as lab. courses 0	0	2	0	02				
								Total	**400**	**400**	**800**	**18**

Ability Enhancement Course - V

21BT581	Bio-Innovation and Start-ups	21BT583	Modelling and Simulations in Biology
21BT582	Extraction Methods and Herbal products	21BT584	Good Manufacturing and Laboratory Practices

Note: BSC: Basic Science Course, PCC: Professional Core Course, IPCC: Integrated Professional Core Course, AEC –Ability Enhancement Course INT – Internship, HSMC: Humanity and Social Science & Management Courses.
L –Lecture, T – Tutorial, P- Practical/ Drawing, S – Self Study Component, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

Integrated Professional Core Course (IPCC): refers to Professional Theory Core Course Integrated with Practical of the same course. Credit for IPCC can be 04 and its Teaching – Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). Theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by CIE only and there shall be no SEE. For more details the regulation governing the Degree of Bachelor of Engineering /Technology (BE/B.Tech.) 2021-22 may be referred.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme of Teaching and Examinations2021
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021 - 22)

VI SEMESTER

Sl. No	Course and Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
				Theory Lecture	Tutorial	Practical/ Drawing	Self -Study	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	S					
1	HSMC21BT61	Biobusiness Management and Entrepreneurship	Any Department	3	0	0	1	03	50	50	100	3
2	IPCC21BT62	Bioprocess Principles, Control &Automation + Lab	TD: BT PSB: BT	3	0	2	0	03	50	50	100	4
3	PCC21BT63	Enzyme Technology	TD: BT PSB: BT	3	0	0	0	03	50	50	100	3
4	PEC21BT64x	Professional elective course-I	TD: BT PSB: BT	3	0	0	1	03	50	50	100	3
5	OEC21BT65x	Open elective course-I	TD: BT PSB: BT	3	0	0	1	03	50	50	100	3
6	PCC21BTL66	Enzyme Technology lab	TD: BT PSB: BT	0	0	2	0	03	50	50	100	1
7	MP21BTMP67	Mini project	BT	Two contact hours /week for interaction between the faculty and students.				--	100	--	100	2
8	INT21INT68	Innovation/Entrepreneurship /Societal Internship	Completed during the intervening period of IV and V semesters.					--	100	--	100	3
								Total	**500**	**300**	**800**	**22**

Professional Elective Course - I

21BT641	Human Anatomy and Physiology	21BT643	Biological Data Management and Analysis
21BT642	Biochemical Thermodynamics and Bioenergetics	21BT644	Stem Cell Technology

Open Elective course – I

21BT651	Ecology and Ecosystem	21BT653	Forensic Science
21BT652	Food, Nutrition and Health	21BT654	Robotics in Healthcare and Agri Tech

Note: HSMC: Humanity and Social Science & Management Courses, **IPCC:** Integrated Professional Core Course, **PCC:** Professional Core Course, **PEC:** Professional Elective Courses, O**EC**–Open Elective Course, **MP** –Mini Project, INT –Internship.
L –Lecture, **T** – Tutorial, **P** - Practical / Drawing, **S** – Self Study Component, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Examination.

Integrated Professional Core Course (IPCC): Refers to Professional Theory Core Course Integrated with Practical of the same course. Credit for IPCC can be 04 and its Teaching – Learning hours (L : T : P) can be considered as (3 : 0 : 2) or (2 : 2 : 2). The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by CIE only and there shall be no SEE. For more details, the regulation governing the Degree of Bachelor of Engineering /Technology (BE/B.Tech) 2021-22 may be referred.

Professional Elective Courses(PEC):
A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses that are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course out of five courses. The minimum students' strength for offering professional electives is 10. However, this conditional shall not be applicable to cases where the admission to the programme is less than 10.

Open Elective Courses:
Students belonging to a particular stream of Engineering and Technology are not entitled for the open electives offered by their parent Department. However, they can opt an elective offered by other Departments, provided they satisfy the prerequisite condition if any. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor.
Selection of an open elective shall **not be allowed** if,

(i) The candidate has studied the same course during the previous semesters of the program.
(ii) The syllabus content of open electives is similar to that of the Departmental core courses or professional electives.
(iii) A similar course, under any category, is prescribed in the higher semesters of the program.

In case, any college is desirous of offering a course (not included in the Open Elective List of the University) from streams such as Law, Business (MBA), Medicine, Arts, Commerce, etc., can seek permission, at least one month before the commencement of the semester, from the University by submitting a copy of the syllabus along with the details of expertise available to teach the same in the college.

The minimum students' strength for offering open electives is 10. However, this conditional shall not be applicable to cases where the admission to the programme is less than 10.

Mini-project work: Mini Project is a laboratory-oriented course which will provide a platform to students to enhance their practical knowledge and skills by the development of small systems/applications.

Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini- project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini-project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two faculty members of the Department, one of them being the Guide. The CIE marks awarded for the Mini-project work shall be based on the evaluation of project report, project presentation skill, and question and answer session in the ratio of 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all the guides of the project.

The CIE marks awarded for the Mini-project, shall be based on the evaluation of project report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

No SEE component for Mini-Project.

Internship of 04 weeks during the intervening period of IV and V semesters; 21INT68Innovation/ Entrepreneurship/ Societalbased Internship.

(1) All the students shall have to undergo a mandatory internship of 04 weeks during the intervening period of IV and V semesters. The internship shall be slated for CIE only and will not have SEE. The letter grade earned through CIE shall be included in the VI semester grade card.The internship shall be considered as a head of passing and shall be considered for vertical progression and for the award of degree. Those, who do not take up / complete the internship shall be considered under F (fail) grade and shall have to complete during subsequently after satisfying the internship requirements.

(2) Innovation/ Entrepreneurship Internship shall be carried out at industry, State and Central Government /Non-government organizations (NGOs), micro, small and medium enterprise (MSME), Innovation centres or Incubation centres. Innovation need not be a single major breakthrough; it can also be a series of small or incremental changes. Innovation of any kind can also happen outside of the business world.

Entrepreneurship internships offers a chance to gain hands on experience in the world of entrepreneurship and helps to learn what it takes to run a small entrepreneurial business by performing intern duties with an established company. This experience can then be applied to future business endeavours. Start-ups and small companies are a preferred place to learn the business tack ticks for future entrepreneurs as learning how a small business operates will serve the intern well when he/she manages his/her own company. Entrepreneurship acts as a catalyst to open the minds to creativity and innovation. Entrepreneurship internship can be from several sectors, including technology, small and medium-sized, and the service sector.

(3) Societal or social internship.

Urbanization is increasing on a global scale; and yet, half the world's population still resides in rural areas and is devoid of many things that urban population enjoy. Rural internship is a work-based activity in which students will have a chance to solve/reduce the problems of the rural place for better living.

As proposed under the AICTE rural internship programme, activities under Societal or social internship, particularly in rural areas, shall be considered for 40 points under AICTE activity point programme.

VII semester Class work and Research Internship /Industry Internship (21INT82)

Swapping Facility

Institutions can swap VII and VIII Semester Scheme of Teaching and Examinations to accommodate research internship/ industry internship after the VI semester**.**

(2) Credits earned for the courses of VII and VIII Semester Scheme of Teaching and Examinations shall be counted against the corresponding semesters whether VII or VIII semester is completed during the beginning of IV year or later part of IV year of the program.

Elucidation:

At the beginning of IV year of the programme i.e., after VI semester, VII semester classwork and VIII semester Research Internship /Industrial Internship shall be permitted to be operated simultaneously by the University so that students have ample opportunity for internship. In other words, a good percentage of the class shall attend VII semester classwork and similar percentage of others shall attend to Research Internship or Industrial Internship.

Research/Industrial Internship shall be carried out at an Industry, NGO, MSME, Innovation centre, Incubation centre, Start-up, Centers of Excellence (CoE), Study Centre established in the parent institute and /or at reputed research organizations / institutes. The internship can also be rural internship.

The mandatory Research internship /Industry internship is for 24 weeks. The internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take up/complete the internship shall be declared fail and shall have to complete during the subsequent University examination after satisfying the internship requirements.

INT21INT82Research Internship/ Industry Internship/Rural Internship

Research internship: A research internship is intended to offer the flavour of current research going on in the research field. It helps students get familiarized with the field and imparts the skill required for carrying out research.

Industry internship: Is an extended period of work experience undertaken by students to supplement their degree for professional development. It also helps them learn to overcome unexpected obstacles and successfully navigate organizations, perspectives, and cultures. Dealing with contingencies helps students recognize, appreciate, and adapt to organizational realities by tempering their knowledge with practical constraints.

Rural Internship: A long-term goal, as proposed under the AICTE rural internship programme, shall be counted as rural internship activity.

The student can take up Interdisciplinary Research Internship or Industry Internship.

The faculty coordinator or mentor has to monitor the students' internship progress and interact with them to guide for the successful completion of the internship.

The students are permitted to carry out the internship anywhere in India or abroad. University shall not bear any expenses incurred in respect of internship.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme of Teaching and Examinations2021
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021 - 22)

Swappable VII and VIII SEMESTER

VII SEMESTER

Sl. No	Course and Course Code	Course title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Teaching Hours /Week				Examination				Credits
				Theory Lecture	Tutorial	Practical/ Drawing	Self -Study	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	S					
1	PCC21BT71	Upstream &Downstream Bioprocess Technology	TD: BT PSB: BT	3	0	0	1	3	50	50	100	3
2	PCC21BT72	Bioethics and Biosafety	TD: BT PSB: BT	2	0	0	1	2	50	50	100	2
3	PEC21BT72X	Professional elective course-II	TD: BT PSB: BT	3	0	0	1	3	50	50	100	3
4	PEC21BT73X	Professional elective course-III	TD: BT PSB: BT	3	0	0	1	3	50	50	100	3
5	OEC21BT74X	Open elective course-II	TD: BT PSB: BT	3	0	0	1	3	50	50	100	3
6	Project21BTP75	Project work	BT	Two contact hours /week for interaction between the faculty and students.				3	100	100	200	10
								Total	**350**	**350**	**700**	**24**

VIII SEMESTER

Sl. No	Course and Course Code		Course Title	Teaching Department	Teaching Hours /Week				Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Self -Study	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	S					
1	Seminar21BT81		Technical seminar	BT	One contact hour /week for interaction between the faculty and students.				--	100	--	100	01
2	INT21INT82		Research internship/ industry internship	BT	Two contact hours /week for interaction between the faculty and students.				03 (Batch wise)	100	100	200	15
3	NCMC	21NS83	National Service Scheme (NSS)	NSS	Completed during the intervening period of III semester to VIII semester.				--	50	50	100	0
		21PE83	Physical Education (PE) (Sports and Athletics)	PE									
		21YO83	Yoga	Yoga									
									Total	**250**	**150**	**400**	**16**

Professional Elective Course - II

21BT721	Medicinal Chemistry and Chemoinformatics	21BT724	Metabolic Engineering and Functional Genomics
21BT722	Bioreactor Design and Scale up	21BT725	Nanobiotechnology
21BT723	Biomedical Imaging and Health Informatics		

Professional Elective Course - III

21BT731	Systems Biology & Rational Drug Design	21BT734	Agricultural Biotechnology and Crop Improvement
21BT732	Food Processing and Nutraceuticals	21BT735	Synthetic Biology and Tissue Engineering
21BT733	Pharmaceutical BT and Clinical Research		

Open Elective Course - II			
21BT741	Biomaterials and Medical Implants	21BT744	Biofuels and Bioenergy
21BT742	Biosensors and Applications	21BT745	Bioterrorism and National Security
21BT743	Bioremediation Techniques		

Note: PCC: Professional Core Course, **PEC:** Professional Elective Courses, **OEC**–Open Elective Course, **AEC** –Ability Enhancement Courses.
L –Lecture, T – Tutorial, P- Practical / Drawing, S – Self Study Component, CIE: Continuous Internal Evaluation, SEE: Semester End Examination.

Note: VII and VIII semesters of IV year of the programme

(1) Institutions can swap VII and VIII Semester Scheme of Teaching and Examinations to accommodate research internship/ industry internship after the VI semester**.**

(2) Credits earned for the courses of VII and VIII Semester Scheme of Teaching and Examinations shall be counted against the corresponding semesters whether VII or VIII semester is completed during the beginning of IV year or later part of IV year of the programme.

VII semester Class work and Research Internship /Industry Internship (21INT82)

Elucidation:

At the beginning of IV year of the programme i.e., after VI semester, VII semester classwork and VIII semester Research Internship /Industrial Internship shall be permitted to be operated simultaneously by the University so that students have ample opportunity for internship. In other words, a good percentage of the class shall attend VII semester classwork and similar percentage of others shall attend to Research Internship or Industrial Internship.

Research/Industrial Internship shall be carried out at an Industry, NGO, MSME, Innovation centre, Incubation centre, Start-up, Centers of Excellence (CoE), Study Centre established in the parent institute and /or at reputed research organizations / institutes. The internship can also be rural internship.

The mandatory Research internship /Industry internship is for 24 weeks. The internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take up/complete the internship shall be declared fail and shall have to complete during the subsequent University examination after satisfying the internship requirements.

INT21INT82Research Internship/ Industry Internship/Rural Internship

Research internship: A research internship is intended to offer the flavour of current research going on in the research field. It helps students get familiarized with the field and imparts the skill required for carrying out research.

Industry internship: Is an extended period of work experience undertaken by students to supplement their degree for professional development. It also helps them learn to overcome unexpected obstacles and successfully navigate organizations, perspectives, and cultures. Dealing with contingencies helps students recognize, appreciate, and adapt to organizational realities by tempering their knowledge with practical constraints.

Rural Internship: A long-term goal, as proposed under the AICTE rural internship programme, shall be counted as rural internship activity.

The student can take up Interdisciplinary Research Internship or Industry Internship.

The faculty coordinator or mentor has to monitor the students' internship progress and interact with them to guide for the successful completion of the internship.

The students are permitted to carry out the internship anywhere in India or abroad. University shall not bear any expenses incurred in respect of internship.

PROJECT WORK (21BTP75): The objective of the Project work is

(i) To encourage independent learning and the innovative attitude of the students.
(ii) To develop interactive attitude, communication skills, organization, time management, and presentation skills.
(iii) To impart flexibility and adaptability.
(iv) To inspire team working.
(v) To expand intellectual capacity, credibility, judgment and intuition.
(vi) To adhere to punctuality, setting and meeting deadlines.
(vii) To install responsibilities to oneself and others.
(viii) To train students to present the topic of project work in a seminar without any fear, face the audience confidently, enhance communication skills, involve in group discussion to present and exchange ideas.

CIE procedure for Project Work:

(1) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the project work, shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

(2) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the project work, shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

SEE procedure for Project Work: SEE for project work will be conducted by the two examiners appointed by the University. The SEE marks awarded for the project work shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the ratio 50:25:25.

TECHNICAL SEMINAR (21BTS81): The objective of the seminar is to inculcate self-learning, present the seminar topic confidently, enhance communication skill, involve in group discussion for exchange of ideas. Each student, under the guidance of a Faculty, shall choose, preferably, a recent topic of his/her interest relevant to the programme of Specialization.

(i) Carry out literature survey, systematically organize the content.
(ii) Prepare the report with own sentences, avoiding a cut and paste act.
(iii) Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
(iv) Present the seminar topic orally and/or through PowerPoint slides.
(v) Answer the queries and involve in debate/discussion.
(**vi)** Submit a typed report with a list of references.

The participants shall take part in the discussion to foster a friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

Evaluation Procedure:

The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill, participation in the question-and-answer session, and quality of report) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three teachers from the department with the senior-most acting as the Chairman.

Marks distribution for CIE of the course:

Seminar Report:50 marks
Presentation skill:25 marks
Question and Answer: 25 marks. No SEE component for Technical Seminar

Non – credit mandatory courses (NCMC):

National Service Scheme/Physical Education (Sport and Athletics)/ Yoga:

(1) Securing 40 % or more in CIE,35 % or more marks in SEE and 40 % or more in the sum total of CIE + SEE leads to successful completion of the registered course.
(2) In case, students fail to secure 35 % marks in SEE, they has to appear for SEE during the subsequent examinations conducted by the University.
(3) In case, any student fails to register for NSS, PE or Yoga/fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have not completed the requirements of the course. In such a case, the student has to fulfill the course requirements during subsequently to earn the qualifying CIE marks subject to the maximum programme period.
(4) Successful completion of the course shall be indicated as satisfactory in the grade card. Non-completion of the course shall be indicated as Unsatisfactory.
(5) These courses shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the courses shall be mandatory for the award of degree.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme and Syllabus of Teaching and Examinations 2021
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
III SEMESTER

TRANSFORM CALCULUS, FOURIER SERIES AND NUMERICAL TECHNIQUES (Common to all branches)			
Course Code	21MAT 31	CIE Marks	50
Teaching Hours/Week (L:T:P:S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To have an insight into solving ordinary differential equations by using Laplace transform techniques
- Learn to use the Fourier series to represent periodical physical phenomena in engineering analysis.
- To enable the students to study Fourier Transforms and concepts of infinite Fourier Sine and Cosine transforms and to learn the method of solving difference equations by the z-transform method.
- To develop proficiency in solving ordinary and partial differential equations arising in engineering applications, using numerical methods

Teaching-Learning Process (General Instructions):

ThesearesampleStrategies,whichteacherscanusetoacceleratetheattainmentofthevariouscourse outcomes.

- ✓ Inadditiontothetraditionallecturemethod,differenttypesofinnovativeteachingmethodsmay be adopted so that the delivered lessons shall develop students' theoretical and applied mathematicalskills.
- ✓ StatetheneedforMathematicswithEngineeringStudiesandProvidereal-lifeexamples.
- ✓ Supportandguidethestudentsforself–study.
- ✓ Youwillalsoberesponsibleforassigninghomework,gradingassignmentsandquizzes,and documenting students'progress.
- ✓ Encouragethestudentsforgrouplearningtoimprovetheircreativeandanalyticalskills.
- ✓ Showshortrelatedvideolecturesinthefollowingways:
  - a. Asanintroductiontonewtopics(pre-lectureactivity).
  - b. As a revision of topics (post-lectureactivity).
  - c. As additional examples (post-lectureactivity).
  - d. Asanadditionalmaterialofchallengingtopics(pre-andpost-lectureactivity).
  - e. Asamodelsolutionforsomeexercises(post-lectureactivity).

Module-1: Laplace Transform(8 Hours)

Definition and Laplace transforms of elementary functions (statements only). Problems on Laplace's Transform of $e^{at}f(t)$, $t^n f(t)$, $\frac{f(t)}{t}$. Laplace transforms of Periodic functions (statement only) and unit-step function – problems.
Inverse Laplace transforms definition and problems, Convolution theorem to find the inverse Laplace transforms (without Proof) problems. Laplace transforms of derivatives, solution of differential equations.
Self-study: Solution of simultaneous first-order differential equations.
(RBT Levels: L1, L2 and L3)

Module-2: Fourier Series (8 Hours)

Introduction to infinite series, convergence and divergence. Periodic functions, Dirichlet's condition. Fourier series of periodic functions with period 2π and arbitrary period. Half range Fourier series. Practical harmonic analysis.
Self-study: Convergence of series by D'Alembert's Ratio test and, Cauchy'sroot test.
(RBT Levels: L1, L2 and L3)

Module-3: Infinite Fourier Transforms and Z-Transforms (8 Hours)

Infinite Fourier transforms definition, Fourier sine and cosine transforms. Inverse Fourier transforms, Inverse Fourier cosine and sine transforms. Problems.
Difference equations, z-transform-definition, Standard z-transforms, Damping and shifting rules, Problems. Inverse z-transform and applications to solve difference equations.
Self-Study: Initial value and final value theorems, problems.
(RBT Levels: L1, L2 and L3)

Module-4: Numerical Solution of Partial Differential Equations(8 Hours)

Classifications of second-order partial differential equations, finite difference approximations to derivatives, Solution of Laplace's equation using standard five-point formula. Solution of heat equation by Schmidt explicit formula and Crank-Nicholson method, Solution of the Wave equation. Problems.

Self-Study: Solution of Poisson equations using standard five-point formula.

(RBT Levels: L1, L2 and L3)

Module-5: Numerical Solution of Second-Order ODEs and Calculus of Variations (8 Hours)

Second-order differential equations - Runge-Kutta method and Milne's predictor and corrector method. (No derivations of formulae).

Calculus of Variations: Functionals, Euler's equation, Problems on extremals of functional. Geodesics on a plane, Variational problems.

Self-Study: Hanging chain problem

(RBT Levels: L1, L2 and L3)

Course outcomes (Course Skill Set)

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

- To solve ordinary differential equations using Laplace transform.
- Demonstrate the Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
- To use Fourier transforms to analyze problems involving continuous-time signals and to apply Z-Transform techniques to solve difference equations
- To solve mathematical models represented by initial or boundary value problems involving partial differential equations
- Determine the extremals of functionals using calculus of variations and solve problems arising in dynamics of rigid bodies and vibrational analysis.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

First test at the end of 5th week of the semester

Second test at the end of the 10th week of the semester

Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(To have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be scaled down 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. Marks scored out of 100 marks are reduced proportionally to 50 marks

Suggested Learning Resources:

TEXT BOOKS:

- **B.S.Grewal**:"HigherEngineeringMathematics",Khanna publishers,44th Ed.2018
- **E.Kreyszig**:"AdvancedEngineeringMathematics",JohnWiley&Sons,10th Ed.(Reprint),2016.

REFERENCE BOOKS

- **V.Ramana:**"HigherEngineeringMathematics"McGraw-HillEducation,11th Ed.
- **SrimantaPal&SubodhC.Bhunia:**"EngineeringMathematics"OxfordUniversityPress,3rd Reprint, 2016.
- **N.P Bali and Manish Goyal**: "A textbook of Engineering Mathematics" Laxmi Publications, Latest edition.
- **C. Ray Wylie, Louis C. Barrett:** "Advanced Engineering Mathematics" McGraw – Hill Book Co.Newyork, Latested.
- **Gupta C.B, Sing S.R and Mukesh Kumar:** "Engineering Mathematic for Semester I and II", Mc- Graw Hill Education(India) Pvt. Ltd2015.
- **H.K.DassandEr.RajnishVerma:**"HigherEngineeringMathematics"S.ChandPublication(2014).
- **JamesStewart:"**Calculus"Cengagepublications,7thedition,4thReprint2019

Web links and Video Lectures (e-Resources):

- http://.ac.in/courses.php?disciplineID=111
- http://www.class-central.com/subject/math(MOOCs)
- http://academicearth.org/
- http://www.bookstreet.in.
- VTU e-ShikshanaProgram / VTU EDUSATProgram
- http://.ac.in/courses.php?disciplineID=111
- http://www.class-central.com/subject/math(MOOCs)
- http://academicearth.org/
- http://www.bookstreet.in.
- https://onlinecourses.nptel.ac.in/noc21_ma12/preview
- https://www.udemy.com/course/fourier-and-laplace-transforms/?

UNIT OPERATIONS + LAB			
Course Code	21BT32	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:1:2:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- To know the fundamental concepts of fluid mechanics, heat and mass transfer.
- To understand the design concepts of fluid and particulate technology.
- To solve engineering problems related to fluid flow, heat and mass transfer.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (10 Hours)

FUNDAMENTALS OF FLUID MECHANICS:

Fluiddefinitionandclassificationoffluids,typesoffluids,Rheologicalbehaviouroffluids&Newton'sLawofviscosity.Fluidstatics-Pascal'slaw,Hydrostaticequilibrium,Barometricequationandpressuremeasurement(problems), Basic equations of fluid flow, Continuity equation, Euler's equation and Bernoulliequation;Typesofflow:laminarandturbulent;Reynoldsexperiment;Flowthroughcircularandnon-circular conduits,Hagen Poiseuille equation (no derivation). Flow through stagnant fluids, theory of Settling andSedimentation, Equipment(cyclones,thickeners)Conceptualnumericals.

LAB EXERCISES:

- ❖ Batch Sedimentation
- ❖ Flow through circular/non-circular pipes / packed bed flow

Module-2 (10 Hours)

FLOW MEASUREMENTS & MECHANICAL OPERATIONS:

Different types of flow measuring devices (Orifice meter, Venturimeter, Rotameter) with derivations, flowmeasurements. Pumps: types of pumps (Centrifugal & Reciprocating pumps), Energy calculations andcharacteristics of pumps. Size reduction, characteristics of comminute products, sieve analysis, Propertiesand handling of particulate solids: characterization of solid particles, average particle size, screen analysis,Conceptualnumericalsofdifferentialandcumulativeanalysis.Sizereduction,crushinglaws,workingprinciple of ball mill. Filtration & types, filtration equipment (plate and frame, rotary drum). Conceptualnumericals.

LAB EXERCISES:

- ❖ Flow measurements using Venturi /Orificemeter.
- ❖ Ball Mill and Sieve Analysis

Module-3 (10 Hours)

CONDUCTIVE & CONVECTIVE HEAT TRANSFER:

Modes of heat transfer; Conduction: steady state heat conduction through unilayer and multilayer walls,cylinders; Insulation, critical thickness of insulation. Convection: Forced and Natural convection, principles ofheat transfer co-efficient, log mean temperature difference, individual and overall heat transfer co-efficient,foulingfactor;Condensation: filmwiseanddropwise(noderivation).Heattransfer equipment: doublepipe heat exchanger, shell and tube heat exchanger (with working principle and construction with applications).Conceptualnumericals.

LAB EXERCISES:

- ❖ Natural convection in bare tubes
- ❖ Heat transfer in packed bed / DPHE

Module-4 (10 Hours)

BASICSOFMASSTRANSFER:

Diffusion: Fick'slawofdiffusion.Typesofdiffusion.Steadystate molecular diffusion in fluids at rest and laminar flow (stagnant/unidirectional and bidirectional). Measurement of diffusivity,Mass transfer coefficientsandtheircorrelations. Conceptualnumericals.

LAB EXERCISES:

- Mass transfer coefficient in Humidification and Dehumidification
- Diffusionoforganicsolvent (CCL4) inair
- Effect of temperature on the diffusion co-efficient

Module-5 (10 Hours)

MASS TRANSFER OPERATIONS:

Basic concepts ofLiquid-liquid extraction: equilibrium, stage typeextractors (belt extraction and basket extraction). Distillation: Methods of distillation, distillation of binarymixturesusingMcCabeThielemethod. Drying operations,batchandcontinuousdrying.Conceptual numericals.

LAB EXERCISES:

- Liquid-Liquid Extraction
- Distillation of binary mixtures
- Tray drying characteristics

Course outcomes (Course Skill Set)

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

- Describethenature andpropertiesoffluids.
- Perform various flow measurements using differentinstruments.
- Explain theprinciplesofvariousmechanical operations like sizereductions,conveying equipment,sedimentationand mixingtanks.
- Illustrate thelawsgoverningtheheat andmasstransferoperations.
- Analyse theconstruction details of heatand mass transferequipmentforspecificrequirements.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **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 **(duration 02/03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) 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)

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

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 12 (40% of maximum marks-30) in the theory component and 08 (40% 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 35% of the maximum marks to qualify in the SEE. Marks scored out of 100 marks are reduced proportionally to 50 marks

Suggested Learning Resources:

- Unit operations in ChemicalEngineering, Warren L.McCabe,Julian, C.Smith & PeterHarriot, McGraw-HillEducation (India) Edition, 2014
- PrinciplesofUnitOperations Alan SFoust, L.A. Wenzel, C.W.Clump,L. Maus, and L.B.Anderson JohnWiley&Sons, 2nd edition, 2008.
- Unit Operations of ChemicalEngineering,VolI&II Chattopadhyaya KhannaPublishers,Delhi-6 1996.
- FluidMechanics, K LKumar SChand &CompanyLtd, 2008.
- IntroductiontoChemical Engineering, BadgerW.I.andBanchero,J.T.,TataMcGrawHillNewYork. 1997.
- HeatTransfer JPHolman McGrawHill InternationalEd., 10th Edition, 2010.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://nptel.ac.in/courses/103103155
- https://nptel.ac.in/courses/103107127
- https://www.youtube.com/watch?v=ntjyr9kXuCs
- https://nptel.ac.in/courses/103103155
- https://nptel.ac.in/courses/103107127
- https://www.youtube.com/watch?v=ntjyr9kXuCs
- https://onlinecourses.nptel.ac.in/noc20_ch27/preview
- https://www.classcentral.com/course/swayam-mechanical-unit-operations-14193
- https://www.isa-lille.com/academics/master-programs/food-science/course-unit-operations/N

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

- Group Discussion of Case studies

- Model Making and poster presentations

BIOCHEMISTRY +LAB			
Course Code	21BT33	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- To Get an overview of the main aspects of biochemistry by relating molecular interactions to their effects on the organism as a whole.
- To Understand the organization of macromolecules through a discussion of their hierarchical structure and study their assembly into complexes, responsible for specific biological processes.
- To Comprehend the different metabolic pathways and their interconnections into tightly regulated networks

Teaching-Learning Process (General Instructions)

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

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

Module-1(10 Hours)

INTRODUCTION:

Chemical foundations of Biology: Water in biological system: Physical and chemical properties ofwater, weak interactions in macromolecular structure and function, Water as solvent for biochemical reaction. Ionisation of water, Concentration of solutions, pH, Henderson Hesselbalch equation, preparation of buffers. Buffering against pH changes in biological systems.

Lab exercises:

- ❖ Preparation of strength of solutions (percentage, normality, molarity, molality)
- ❖ Preparation of buffers of different concentrations and pH measurements (via pH paper and pH meter)

Module-2(10 Hours)

CARBOHYDRATES AND LIPIDS:

Carbohydrates: Structure and function of monosaccharide, disaccharide and polysaccharide. Reducing and non-reducing sugars, Carbohydrate metabolism: glycolysis, tricarboxylic acid cycle,gluconeogenesis, Glycogenesis, glycogenolysis and pentose phosphate pathway. Fates of pyruvate.

Lipids: Classification and function of lipids (fatty acids, triacyl glycerol, phospholipids, glycolipids, spingolipids, lipoproteins and steroids). Lipid metabolism: Digestion, Mobilization and transport of fats, Biosynthesis of palmitic acid, and biodegradation of fatty acids (beta oxidation).

Lab exercises:

- ❖ Estimation of reducing sugars by DNS, Nelson-Somogyi methods
- ❖ Qualitative tests for carbohydrates

Module-3(10 Hours)

PROTEINS AND NUCLEIC ACIDS:

Amino Acids: Classification, structure and properties of amino acids. Titration curves of amino acids, Proteins: primary, secondary, tertiary and quaternary structures of proteins. Biodegradation of amino acids- deamination, decarboxylation, transamination and urea cycle.

Nucleic acids: Structure, properties and functions of nucleotides. Types, forms, structures and functions of DNA and RNA. Biosynthesis (denovo and salvage pathway) and degradation of Nucleotides.

Lab exercises:

- ❖ Estimation of DNA
- ❖ Estimation of amino acid by ninhydrin method
- ❖ Estimation of proteins: Comparison of Lowry's method, Bradford and Biuret methods.

Module-4(10 Hours)

BIOENERGETICS:

Introduction, energy flow cycle, thermodynamic laws, Standard free energy change-equilibrium constant. High energy compounds, structure and properties of ATP, biological oxidation - Electron transport chain, ATP synthesis. Oxidative phosphorylation. Photosystems and photophosphorylation (synthesis of ATP and NADPH), Inhibitors of oxidative phosphorylation, Shuttle pathway – Glycerol phosphate Shuttle, Malate aspartate Shuttle.

Lab exercises:

- Coupled enzyme-based assay utilizing ATP or NADH
- Separation of Chlorophyll and Chloroplast.

Module-5(10 Hours)

DISORDERS OF METABOLISM:

Disorders of carbohydrate (lactose intolerance, galactosemia, glycogen storage disease, diabetes), lipid (atherosclerosis, ketone bodies (acidosis-kesosis), Gaucher disease and Tay-Sachs disease,LDL-hypercholesterolemia) and amino acids (phenylketonuria, alkaptonuriea, tyrosinemia, homocystinuria, and maple syrup urine disease), Nucleic acid (Gout, lesh-nyhn syndrome, hyper and hypo uricemia, adenosine deaminase deficiency).

Lab exercises:

- Estimation of urea by DAMO method
- Qualitative tests for amino acids.
- Qualitative tests for Lipids.

Course outcomes (Course Skill Set)

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

- Explain the fundamentals of biologically important molecules such as structures, functions and interactions
- Understand complex biochemical pathways within living cells and the associated metabolic disorders
- Comprehend biochemical principles and apply them to biological systems/samples
- Perform basic biochemical experiments, analyse, interpret and present the 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 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **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 **(duration 02/03 hours)** at the end of the 15th week of the semester /after

completion of all the experiments (whichever is early) 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)

4. The question paper will have ten questions. Each question is set for 20 marks.Marks scorded shall be proportionally scaled down to 50 Marks
5. 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.
6. 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 12 (40% of maximum marks-30) in the theory component and 08 (40% 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 35% of the maximum marks to qualify in the SEE. Marks scored out of 100 marks are reduced proportionally to 50 marks

Suggested Learning Resources:

- Principles of Biochemistry, Donald Voet, Judith G. Voet, Charlotte W. Pratt, 4th Edition, John Wiley & Sons, 2012.
- Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, 67h Edition, W.H. Freeman, 2017.
- Biochemistry, U Satyanarayana, 5th EditionBooks & Allied Ltd., 2017.
- Biochemistry, Denise Ferrier, Lippincott, Williams & Wilkins, 2017.
- Harper's Illustrated Biochemistry by Victor W. Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil,Thirty-First Edition (A & L LANGE SERIES), 2018.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://ocw.mit.edu/courses/7-012-introduction-to-biology-fall-2004/resources/lecture-2-biochemistry-1/
- https://onlinecourses.nptel.ac.in/noc22_cy06/preview
- https://ocw.mit.edu/courses/5-111-principles-of-chemical-science-fall-2008/resources/lecture-36/
- https://cosmolearning.org/courses/biochemistry-i/video-lectures
- https://ocw.mit.edu/courses/7-012-introduction-to-biology-fall-2004/resources/lecture-2-biochemistry-1/
- https://onlinecourses.nptel.ac.in/noc22_cy06/preview
- https://ocw.mit.edu/courses/5-111-principles-of-chemical-science-fall-2008/resources/lecture-36/
- https://www.udemy.com/course/introduction-to-biochemistry/
- https://www.edx.org/learn/biochemistry

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

- Beer lamberts law and Determination of lambda$_{max}$ of colored solutions/molecules.
- Importance of Biochemistry in drug discovery (with case studies)
- Regulation of metabolic pathways (with examples)
- Group Discussion of Case studies

- Model Making and poster presentations

MICROBIOLOGY			
Course Code	21BT34	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To understand the details of classification, structural features and functional aspects of prokaryotic and eukaryotic microorganisms.
- To learn different techniques of microscopy and be able to describe microbial techniques for growth, cultivation and characterization of microorganisms.
- To explain microbial metabolism, growth and control of microorganisms.
- To describe and relate the occurrence of microbes caused diseases.
- To analyse various industrial applications of microbiology.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 hours)

OVERVIEW OF MICROBIOLOGY AND MICROORGANISMS:

Scope and History of Microbiology (Major milestones). Prokaryotes, Archaea and Eukaryotes. Microbial diversity and Taxonomy. Classification, characteristics and reproduction of Bacteria, Viruses, Fungi, Protozoa, Algae. General features of true bacteria (Rickettsia, Mycoplasma and Chlamydia), Prions, Spirochetes, Actinomycetes. Case studies.

Module-2 (8 hours)

METHODS AND TECHNIQUES IN MICROBIOLOGY:

Basic principles of Microscopy, Bright-Field, Dark-Field, Phase-Contrast, Acoustic, Fluorescence, Electron Microscopy: SEM, TEM. Micrometry. Media: types and preparation. Pure culture Techniques (streak-plate, spread plate, pour plate). Staining techniques (Simple and differential). Case studies.

Module-3 (8 hours)

MICROBIAL GROWTH, METABOLISM AND CONTROL:

Microbial growth: Phases, Factors affecting growth, growth measurement and enumeration. Microbial Genetics (Brief introduction to Transformation, Transduction and Conjugation). Metabolism; Primary and Secondary metabolites with examples, metabolic pathways important in microorganisms- Respiration and Fermentation (EMP, HMP, ED, Phospho ketolase, Mixed acid, TCA).Quorum sensing. Control of growth (Sterilization and disinfection techniques).Case studies.

Module-4 (8 hours)

MICROBIOLOGY AND DISEASES:

Common diseases caused by microbes: viruses (Polio, H1N1, SARS, Covid-19, HIV, Hepatis), bacteria (TB, Cholera, Typhoid, Pneumonia, Plague, Diphtheria, *Ecoli* infections), Protozoans (Malaria, Leishmaniasis and Amebiasis).Common types of fungal infections (ringworm, yeast infection). Case studies.

Module-5 (8 hours)

ENVIRONMENT AND INDUSTRIAL MICROBIOLOGY:

Aerobiology, Air sampling techniques. Microbiology of potable water and wastewater treatment. Microbiology of soil, Beneficial Microbes, Biofertilizers, VAM, Rhizobium. Microbes in Bioremediation. Case studies. Industrially important

microbes: Enzymes, SCP production, Penicillin, vitamin B12 and Glutamate production.

Course outcomes (Course Skill Set)

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

- Correlate the structure, function and metabolic pathways of microorganisms.
- Apply the principles of microbial culture for identifying the appropriate technique used in culture and characterization of microorganisms under aseptic conditions.
- Analyze the role of microorganisms in environmental protection, industrial applications and infectious diseases.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally scaled down 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. Marks scored out of 100 marks are reduced proportionally to 50 marks

Suggested Learning Resources:

- General Microbiology: Roger Y Stanier, John L Ingraham, and Mark L Wheels Macmillan Press Ltd, V Edition (International Edition). 1999.
- Ananthanarayanand Paniker, Textbook of Microbiology. Orient Blackswan, 2006.
- Microbiology Michael J Pelczar, J R Chan ECS, Noel R Krieg Tata McGraw-Hill Education Pvt. 2013.
- Harley, Klein. Microbiology Prescott, McGraw Hill Seventh Edition.1996.
- Industrial Microbiology, Prescott and Dunn, CBS Pub. 4th Edition, 2004.
- Black J, Microbiology: Principles and Explorations, 7th Edn. John Wiley and Sons, USA. 2010.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://www.udemy.com/course/basics-of-medical-microbiology/
- https://www.edx.org/learn/microbiology
- https://www.coursera.org/courses?query=microbiology
- https://www.futurelearn.com/courses/introduction-to-microbiology
- https://alison.com/course/introduction-to-microbiology
- e- books:
  http://books.pakchem.net/microbiology-books.html
  http://www.austincc.edu/rohde/noteref.htm

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

- Demos in classes (by groups of students)
- AV presentation by students (on topics as per choice of the teacher)
- Collection of case studies on topics covered with contamination, pandemic and allied
- Group Discussions on recent advancements

MICROBIOLOGY LAB			
Course Code	21BTL35	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	03

Course objectives:

- To develop ability to use basic instruments in the microbiology lab
- To prepare required media and sterile the glassware for culturing microbes
- To be able to characterize and enumerate different microorganisms
- To analyse the bacterial growth curves and phases of growth
- To isolate and study the microbes from various sources in day-today life

Sl.NO	**EXPERIMENTS**
1	Study of Lab Instruments (Autoclave, Hot air oven, Incubator, LAF, microfuge/centrifuge) and Observation of bacterial (prokaryotic) and fungal (eukaryotic) specimen under 10x, 40 x microscopes
2	Media preparation, plugging and sterilization (media, Petri plates and tubes), Plating techniques (Serial dilution, streak, pour and spread - plates)
3	Morphological characterization, Enumeration of microbes (Plate count, haemocytometer), size determination using micrometry.
4	Staining techniques I: Gram staining, Capsule staining, and endospore staining
5	Staining techniques II: Acid Fast Staining, Flagella staining and Fungal staining
6	Characterization of bacteria by Biochemical Tests: IMViC, Starch hydrolysis, carbohydrate fermentation, Catalase, Urease, hydrogen sulphide, Gelatin Liquifaction.
7	Growth of microbes (Static and shake flask conditions), Growth curve studies
8	Bacterial motility studies
9	Isolation and identification of actinomycetes and rhizobium
10	Isolation and identification of microorganisms from air, water & soil
11	Antibiotic susceptibility test of a selected bacterium
12	Microbial quality assessment of milk and water

Course outcomes (Course Skill Set)

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

- Apply the theoretical knowledge and execute experiments pertaining to methods of sterilization, microbial identification and characterization.
- Apply the basic techniques of Microbiology in various experiments related to Agriculture, Food and Environment.
- Analyze the relationship of microbes with human health.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE).

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 8th week of the semester and the second test shall be conducted after the 14th 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. Rubrics suggested in Annexure-II of Regulation book
- 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 15% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

- Experiments in Microbiology, Plant Pathology and Biotechnology by K. R. Aneja, , New Age International,2003
- Microbiology: A Lab Manual by Cappuccino, Pearson Education, 2007
- Lab Ref Jane Roskams, Linda Rodgers, Cold Spring Harbor, N.Y., 2002

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resourcehttps://www.labster.com/microbiology-virtual-labs
- https://www.mheducation.com/highered/microbiology.html
- https://asm.org/Articles/2020/December/Virtual-Resources-to-Teach-Microbiology-Techniques
- https://www.cnm.edu/programs-of-study/math-science-engineering/microbiology-lab-manual
- http://faculty.collin.edu/dcain/CCCCD%20Micro/tutorial.htm
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4844744
- https://asm.org/Articles/2020/December/Virtual-Resources-to-Teach-Microbiology-Techniques

ABILITY ENHANCEMENT COURSE-III

DATA PRESENTATION, ERROR ANALYSIS AND INFERENCES			
Course Code	21BT381	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To enable the students to develop an understanding of data, its occurrence and usefulness.
- To enable the students to learn the means to analyze errors in data for various purposes.
- To enable the students to learn to infer and present the data in various formats for various sectors that generate or use data.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

INTRODUCTION TO DATA:

Definition. Representation of data in mathematical (quantitative) terms. Characteristics of data, its types. Occurrence of data across BT sectors and disciplines.Practical applications and discussion of case studies based upon real-time data.

Module-2 (3 Hours)

DATA PRESENTATION:

Techniques to present data in textual, tabular, and graphical forms. Purposes and Key methods to present the data. Use of MS Exceland Google sheets. Practical applications and discussion of case studies based upon real-time data gathered from lab sessions.

Module-3 (3 Hours)

DATA ANALYSIS:

Meaning and processing data for analysis by using statistical or logical techniques in BT. Methods of data analysis: descriptive, diagnostic, inferential, predictive and prescriptive.Practical applications and discussion of case studies based upon real-time data gathered from lab sessions.

Module-4 (3 Hours)

ERROR ANALYSIS:

Sources of errors. Types of errors (massive, specific and incidental) in Biotechnology labs, research and industrial scales. Meaning of error analysis and its stages. Methods and means to minimize errors.Practical applications and discussion of case studies based upon real-time data gathered from lab sessions.

Module-5 (3 Hours)

DATA INFERENCE:

Need to identify trends and key points in data presentation(highlighting the inference, using relevant images for enhancing impact of presentation, visually ppresentation the numbers, stepwise orstage wise presentation of information). Practical applications and discussion of case studies based upon real-time data gathered from lab sessions.

Course outcomes (Course Skill Set)

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

- Understand the sources of data, present the data for specific purposes/application.
- Gain ability to analyse the occurrence of errors in data sets.
- Demonstrate the ways to draw inferences from data.

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)**at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- Introduction to data and data analysis, Deepak Shrivastava, 2020
- A General Introduction to Data Analytics, Moreira Joao. John Wiley and Sons Ltd. Anonym. 2018
- Does presentation format matter? The impact of data presentation on decision making, By Anonym, Grin Verlag Gmbh. 2015

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource https://nptel.ac.in/courses/110104094
- https://www.simplilearn.com/learn-data-analytics-for-beginners-skillup
- https://www.coursera.org/professional-certificates/google-data-analytics
- https://upgradcampus.com/data-analytics-ads-lp/
- https://www.simplilearn.com/big-data-and-analytics/senior-data-scientist-masters-program-training
- https://intellipaat.com/data-scientist-course-training/
- https://www.edx.org/learn/data-science
- https://www.udemy.com/topic/data-science/free/

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

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

BIO LAB MANAGEMENT AND RISK ASSESSMENT			
Course Code	21BT382	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To enable the students to develop an understanding biolab management and risk and its assessment.
- To enable the students to learn the methods to minimize and mitigate the risks at various steps of lab processes.
- To enable the students to performthe risk-benefit analysis inbiotechnological processes.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

BIO LABORATORY MANAGEMENT:

Essentials of lab management- Designing the lab, spacing, inventory organization and its management, automation via use of technology, documentation, safety requirements, biosafety levels, planning experiments, storage space, waste generation and its disposal. Case studies.

Module-2 (3 Hours)

INTRODUCTION TO RISK ASSESSMENT:

Definition and meaning of Risk. Difference between risk and hazard. Probability of occurrence of risk. Risk assessment, risk control, risk review, risk management tools, HACCP, risk ranking and filtering. Case studies.

Module-3 (3 Hours)

BASICS OF BIOSAFETY:

Biosafety- meaning, levels of biosafety- BSL 1, BSL2, BSL 3 and BSL 4, examples, applications of each and hazards involved thereinfor products derived out of biotechnology.International protocols and Case studies.

Module-4 (3 Hours)

BIOSAFETY AND RISK ASSESSMENT:

Principles of safety assessment (for infectious organisms, agents, microbes- genetically altered/ metabolically engineered, transgenic plants, GMOs /LMOs used in food, pharma, bioremediation etc., Sequential steps in risk assessment; concepts of familiarity and substantial equivalence; environmental risk assessment and food and feed safety assessment. Case studies.

Module-5 (3 Hours)

RISK MINIMIZATION AND/OR RISK MITIGATION:

Risk assessment through omics approach. Ethical, legal, and social implications of health privacy and policy laws for mitigation/minimization (Indian and Global contexts). risk characterization and development of analysis plan. Case studies.

Course outcomes (Course Skill Set)

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

- Apply principles of biology to understand risk and its assessment
- Deduce methods to minimize and mitigate the risks
- Evaluate risk-benefit analysis of different genetic engineering interventions based upon case studies.
- Correlate laws pertaining to biological risk to the sustainable use of GMOs in different applications

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- Biotechnology risk: Complete Self-Assessment Guide, by Gerardus Blokdyk, 2018
- Laboratory Biorisk Management Biosafety and Biosecurity, Reynolds M. Salerno, Jennifer Gaudioso,2015

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource Features of Risk
- Assessments of Genetically Modified Crops. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). Euphytica
- An Overview of General divisions/csurv/geac/annex-5.pdf F. (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436.
- https://www.who.int/publications/i/item/9789240011458
- https://www.youtube.com/watch?v=yKsGC_XFwKU
- https://www.youtube.com/watch?v=0QwJB1sH3Oc
- https://www.labmanager.com/business-management/lab-management-fundamentals-2641
- https://www.altexsoft.com/blog/lims-systems/
- https://www.who.int/publications/i/item/9789240011458
- https://www.youtube.com/watch?v=yKsGC_XFwKU
- https://www.youtube.com/watch?v=0QwJB1sH3Oc

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

- Assessment of surface contaminants in labs
- Group Discussion of Case studies
- Model Making and poster presentations

BIODIVERSITY AND CONSERVATION LAW			
Course Code	21BT383	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To give an insight into Biodiversity and species evolution.
- To acquire knowledge of ecological threats, habitat destruction and extinction of species.
- To enable an understanding of Environmental law and IP issues.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

BIODIVERSITY:

Concept and definition Scope and Constraints of Biodiversity Science, Composition and Scales of Biodiversity: Genetic Diversity, Species/Organismal Diversity, Ecological/Ecosystem Diversity, Landscape/Pattern Diversity, Agrobiodiversity, Biocultural Diversity and Urban Biodiversity. Case studies.

Module-2 (3 Hours)

CAUSES OF BIODIVERSITY ORIGIN OF SPECIES /SPECIATION:

History of the Earth and Biodiversity patterns through Geological times; Current Centers of Biodiversity. Values of Biodiversity Instrumental/Utilitarian value and their categories, Direct use value; Indirect/ Non-consumptive use value. Case studies.

Module-3 (3 Hours)

ECOLOGICAL ECONOMICS:

Monetizing the value of Biodiversity; Intrinsic Value; Ethical and aesthetic values, Anthropocentrism, Biocentrism, Ecocentrism and Religions. Threats to Biodiversity Habitat Destruction, Fragmentation, Transformation, Degradation and Loss: Causes, Patterns and consequences on the Biodiversity of Major Land and Aquatic Systems, Case studies.

Module-4 (3 Hours)

INVASIVE SPECIES:

Biological impacts of invasive species on terrestrial and aquatic systems.Pollution: Impacts of Pesticide pollution, Water pollution and Air Pollution on biodiversity, Overexploitation: Impacts of Exploitation on Target and Non-target Terrestrial and Aquatic species and Ecosystems Extinction, Types of Extinctions, Processes responsible for Species Extinction. Case studies.

Module-5 (3 Hours)

ENVIRONMENT AND LAWS:

Traditional Knowledge and Environment, International Convention for the Protection of New Varieties of Plants (UPOV Convention), Emergence of International Environmental Law, Fundamental Principles, Application of International Environmental Law, Introduction to Trade & Environment, UNFCCC - 1992 & Kyoto Protocol - 1997, Treaty on Antarctic & Polar Regions – 1961, UN Convention of Law of the Sea - 1982 and Regional Seas Convention, Convention on Biodiversity (CBD) and its key elements.

Course outcomes (Course Skill Set)

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

- Understand ecological systems and apply the same to Biodiversity and evolution of species.
- Comprehend Ecological economics and analyse the values of biodiversity.
- Analyse the impacts of species, terrestrial and aquatic ecosystems towards extinction of fauna.
- Apply Environmental law and ethical guidelines towards conservation of species.

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- Principles of Conservation Biology. Groom, M. J., Meffe, G. R. and C. R. Carroll. Sinauer Associates, Inc.2006.
- Textbook of Biodiversity. Krishnamurthy, K. V. Science Publication. 2003.
- Essentials of Conservation Biology. Primack, R. Sinauer Associates, Inc., USA,2006.
- Conservation, 2nd Edition, Clive Hambler, University of Oxford, Susan M. Canney, 2013.
- Conservation Biology: Foundations, Concepts, Applications by Fred Van Dyke, Springer. 2010.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://www.youtube.com/watch?v=OrY1cr0m97M
- https://www.tutorialspoint.com/environmental_studies/environmental_studies_conversation_of_biodiversity.htm
- https://www.tutorialspoint.com/environmental_studies/environmental_studies_biodiversity.htm
- https://portals.iucn.org/library/sites/library/files/documents/EPLP-029.pdf
- https://programsandcourses.anu.edu.au/2017/course/LAWS8280

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

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

LINUX PROGRAMMING FOR BIOLOGISTS			
Course Code	21BT384	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To Identify and use UNIX/Linux utilities to create and manage simple file processing operations.
- To organize directory structures with appropriate security.
- To develop shell scripts to solve problems.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

BRIEF HISTORY:

History of LINUX, architecture of LINUX, features of LINUX,. What is linux/unix Operating systems, Difference between linux/unix and other operating systems, Features and Architecture. Various packages of LINUX.

Module-2 (3 Hours)

INSTALLATION, BOOTING AND SHUTDOWN PROCESS:

Installation, Booting and shutdown process, Removing software. Introduction to text editors, Vi editor, Introduction to files, file permissions, changing file permissions. System Management and Layout, File permissions, Login process, Granting user permissions. Managing users.

Module-3 (3 Hours)

BASIC LINUX COMMANDS:

PATH, man, echo, printf, script, passwd, uname, who, date, stty, pwd, cd, mkdir, rmdir, ls, cp, mv, rm, cat, more, wc, lp, od, tar, gzip, , process utilities, disk utilities, networking commands, unlink, du, df, mount, umount, find, unmask, ulimit, ps, w, finger, arp, ftp, telnet, rlogin.

Module-4 (3 Hours)

TEXT PROCESSING UTILITIES AND BACKUP UTILITIES:

Text Processing utilities and backup utilities, tail, head, sort, nl, uniq, grep, egrep, fgrep, cut, paste, join, tee, pg, comm, cmp, diff, tr, awk, cpio. Working with text editors: creating, editing and deleting files.Disk partitions & sizes. Filter commands: pr, head, tail,cut, sort,uniq, tr.

Module-5 (3 Hours)

BASICS OF SHELL PROGRAMMING:

Basics of shell programming, Types of shell, shell programming in bash, conditional statements and looping statements. Illustrative programs: area of a triangle, finding greatest of 3 numbers, greeting a user, basic arithmetic operations, To check eligibility to vote, to print n natural numbers.

Course outcomes (Course Skill Set)

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

- Understand the basic set of commands and editors in Linux operating system.
- Solve simple problem using shell scripting.
- Apply the basics to appreciate LINUX as an operating system.

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- Sumitabha Das, Unix Concepts and Applications, Tata McGraw-Hill Education, 2006.
- Michael Jang RHCSA/ RHCE Red Hat Linux Certification: Exams (Ex200 & Ex300) (Certification Press), 2011.
- Nemeth Synder& Hein, Linux Administration Handbook, Pearson Education, 2nd Edition ,2010.
- Beginning Linux Programming, 4th Edition, N.Matthew, R.Stones,Wrox, Wiley India Edition. 2007.
- Unix for programmers and users, 3rd Edition, Graham Glass, King Ables, Pearson Education, 2003.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://nptel.ac.in/courses/117106113
- https://www.mooc-list.com/tags/linux
- https://www.udemy.com/course/linux-administration-bootcamp/
- https://www.youtube.com/watch?v=aaEoyVIowk8
- https://biohpc.cornell.edu/lab/doc/Linux_workshop_Part1.pdf
- http://nebc.nerc.ac.uk/nebc_website_frozen/nebc.nerc.ac.uk//support/training/course-notes/past-notes/intro-bl7.html
- https://www.futurelearn.com/courses/linux-for-bioinformatics
- https://www.bioinformatics.org/ftp/pub/bio-linux/IntroductionToBio-Linux8_Dec2015.pdf
- https://www.udemy.com/course/learn-linux-in-5-days/

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

- Installation of LINUX and work with basic commands and shell scripting.
- Develop simple problem-solving strategies in LINUX platform
- Security control for different uses
- Development of simple applications

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme and Syllabus of Teaching and Examinations 2021
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
IV Semester

-
-

PYTHON PROGRAMMING + LAB			
Course Code	21BT42	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- ToreadandwritesimplePythonprograms.
- TodevelopPythonprogramswithconditionalsandloops.
- TodefinePythonfunctionsandcallthem.
- TousePythondatastructures–lists,tuples,dictionaries.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (10 Hours)

ALGORITHMICPROBLEMSOLVING:

Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code,flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms(iteration,recursion).Illustrativeproblems:findminimuminalist,insertacardinalistofsortedcards,and guessanintegernumber inarange,Towersof Hanoi.

LAB EXERCISES:

- ❖ Installation and running of latest version of python from website.
- ❖ Introduction of console
- ❖ Check data types

Module-2 (10 Hours)

DATA EXPRESSION:

Pythoninterpreterandinteractivemode;valuesandtypes:int,float,boolean,string,andlist;variables,expressions, statements, tuple assignment, precedence of operators, comments; modules and functions, function definitionanduse,flowofexecution, parameters andarguments.

LAB EXERCISES:

- ❖ Write a program to demonstrate different number datatypes in python.
- ❖ Write a program to perform different arithmetic operations on numbers in python.
- ❖ Write a program to create, concatenate and print a string and accessing substring from a given string.
- ❖ Write a python script to print the current date in following format "Sun May 29 02:26:23 IST 2017"

Module-3 (10 Hours)

STATEMENTS,CONTROLFLOW:

Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance betweentwopoints.Conditionals:Booleanvaluesandoperators,conditional(if),alternative(if-else),chainedconditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Strings: string slices, immutability,stringfunctions and methods, stringmodule.

LAB EXERCISES:

- ❖ Write a python program to find largest of three numbers.
- ❖ Write a python program to convert temperature to and from Celsius to Fahrenheit.
- ❖ Write a python program to print prime numbers less than 20.

- Write a python program to find factorial of a number using recursion.

Module-4 (10 Hours)

FUNCTIONS,LISTS TUPLES,DICTIONARIES:
Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Lists asarrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binarysearch.Lists:listoperations,list slices,list methods,list loop,mutability,aliasing,cloninglists,listparameters.

LAB EXERCISES:

- Create a function calculator to do basic mathematical operations
- Write a python program to define a function to find Fibonacci Numbers
- Construct a module and reuse the module in a program to create a personalized birthday song.
- Write a program to enrol students to multiple games using list (maximum team size is 11)

Module-5 (10 Hours)

TUPLES, DICTIONARIES:
Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: selection sort, insertion sort, mergesort, histogram.

LAB EXERCISES:

- Write a Python program to create a tuple with different data types.
- Write a Python program to check whether an element exists within a tuple
- Write a python program to create a dictionary and access an element from dictionary
- Write a python program to check if a key already exists in dictionary.

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

- Developalgorithmicsolutionstosimplecomputationalproblems.
- Read,write,debug, executesimplePythonprograms.
- StructuresimplePythonprogramsforsolvingproblems.
- DecomposeaPythonprogramintofunctions.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **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 **(duration 02/03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) 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)

7. The question paper will have ten questions. Each question is set for 20 marks.Marks scorded shall be proportionally scaled down to 50 Marks
8. 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.
9. 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 12 (40% of maximum marks-30) in the theory component and 08 (40% 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 35% of the maximum marks to qualify in the SEE. Marks scored out of 100 marks are reduced proportionally to 50 marks

Suggested Learning Resources:

- ThinkPython:HowtoThinkLike aComputer Scientist AllenB. Downey. ShroffO'ReillyPublishers 2nd edition,2016.
- An Introduction to Python –Revised andupdatedforPython 3.2 Guido vanRossumand FredL. DrakeJr NetworkTheoryLtd., 2011.
- Introduction to Computer ScienceusingPython:AComputational Problem-SolvingFocus CharlesDierbach WileyIndiaEdition, 2013.
- Introduction to Programming inPython: An Inter-disciplinaryApproach RobertSedgewick,KevinWayne, RobertDondero Pearson India EducationServicesPvt. Ltd, 2016.
- FundamentalsofPython:First Programs KennethA. Lambert CENGAGELearning, 2012.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://nptel.ac.in/courses/106106182
- https://www.youtube.com/watch?v=_uQrJ0TkZlc
- https://www.udemy.com/course/pythonforbeginners/
- https://www.udemy.com/topic/python/
- https://www.coursera.org/courses?query=python
- https://www.freecodecamp.org/news/best-python-courses/
- https://www.codecademy.com/catalog/language/python
- https://www.edx.org/learn/python

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

- Installation of the software and execution of programs.
- Group Discussions and Presentations of Case studies.

CELL BIOLOGY & CELL CULTURE TECHNIQUES + LAB			
Course Code	21BT43	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- To gain basic understanding of cellular processes, pathways and cytoskeletal organization.
- To get a thorough understanding of microbiological procedures for the development, culture, and characterization of industrially important microorganisms.
- To explain the fundamental principles and procedures of genetic engineering. Animal cell lines and plant tissue culture gene transfer technologies.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (10 Hours)

CYTOLOGY AND CELL CYCLE STUDIES

Prokaryotic and eukaryotic cell, physio-chemical nature of plasma membrane structure and functions of cell organelle; nucleus, mitochondria, chloroplast, ribosomes, peroxisomes, Golgi bodies and endoplasmic reticulum. Cell cycle studies; mitosis and meiosis. Chromosomal morphology and study of nucleosome model, Cell Birth, lineage and death: Asymmetrical cell division, patterns of stem cell division.

LAB EXERCISES:

- ❖ Study of divisional stages in mitosis and meiosis.
- ❖ StudyofPolytene and Lampbrushchromosomes

Module-2 (10 Hours)

CELL SIGNALLING :

Signalling molecules and cell surface, receptors; intracellular signal transduction; G protein coupled receptors; plant growth factorsand hormones,Eukaryotic and Prokaryotic cell to cell signaling, endocrine signaling, quorum sensing and intercellular signalling, Signal peptides, biofilm formation, Apoptosis and Necrosis.

LAB EXERCISES:

- ❖ Culturing and detection of Biofilms
- ❖ Preparation and Observation of slides of Eukaryotic and Prokaryotic cells.

Module-3 (10 Hours)

MEMBRANE TRANSPORT AND APOPTOSIS:

Membrane transport, passive and active transport; transport into prokaryotic cells; endocytosis, exocytosis; entry of viruses and toxins into cells Membrane traficking: Translocation of secretory proteins across the ER membrane; protein modifications, folding and quality control in the ER; export and sorting of proteins to mitochondria, chloroplast and peroxisomes.

LAB EXERCISES:

- ❖ Isolation of chloroplasts
- ❖ Simple Cellular Transport experiments

Module-4 (10 Hours)

PLANT CELL CULTURE TECHNIQUES:

Plant Tissue culture lab layout, Equipment and Instrumentation, Media for Plant Tissue Culture, Optimization, Callus induction, Cellular Totipotency, and its applications, Production of secondary metabolites, , Organogenesis, Cytodifferentiation. Somatic Embryogenesis, Production of haploids, double haploids, Triploids, immobilization techniques.

LAB EXERCISES:

- ❖ Preparation of plant tissue culture media
- ❖ Callus Induction Techniques and development of Synthetic Seeds.

Module-5 (10 Hours)

ANIMAL CELL CULTURES TECHNIQUES:

Cell culture lab layout, Equipment and Instrumentation, media optimization, culturing of animal cell lines, Continuous cell lines; Organ culture, techniques, advantages, disadvantages, applications; Primary cell culture; Development, characterization and maintenance of cell lines, Application of animal cell culture for *in vitro* testing of drugs;

LAB EXERCISES:

- ❖ Preparation of animal cell culture media
- ❖ Cell viability studies (Trypan blue assay)

Course outcomes (Course Skill Set)

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

- ➢ Understand the cellular structures and their functions with emphasis on the cell cycle events.
- ➢ Apply the concepts of cell- cell signalling, transport of molecules and cell death in cell culture methods.
- ➢ Comprehend the applications of plant tissue culture techniques in Agriculture, Food and Medicine.
- ➢ Analyze the principles of animal cell culture in drug and toxicity testing.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **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 **(duration 02/03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) 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)

10. The question paper will have ten questions. Each question is set for 20 marks.Marks scorded shall be proportionally scaled down to 50 Marks
11. 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.
12. The students have to answer 5 full questions, selecting one full question from each module. Marks scored out of 100 marks are reduced proportionally to 50 marks

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

- The minimum marks to be secured in CIE to appear for SEE shall be the 12 (40% of maximum marks-30) in the theory component and 08 (40% 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 35% of the maximum marks to qualify in the SEE. Marks scored out of 100 marks are reduced proportionally to 50 marks

Suggested Learning Resources:

- The Cell – A Molecular Approach, Cooper & Hausman,ASM Press, 2004.
- Cell and molecular biology. EDPDe Robertis, EMF De Robertis, Lea &. Febiger Intl. ed.1991.
- Animal Cell Culture and Technology, Michel buttler. Taylor & Francis, 2003.
- Culture of Animal Cells: A Manual of Basic Technique, R. Ian Freshney, John Wiley, 5th Edition, 2005.
- Plant Tissue Culture: An Introductory Text , Sant Saran Bhojwani, Prem Kumar Dantu, Springer, 2013.
- Molecular Biology of the Cell, B. Alberts, et al., Garland Science, 4th ed. 2002.
- Molecular Cell Biology Hardcover ,James E. Darnell, Harvey Lodish,, David Baltimore,1999.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource https://www.youtube.com/watch?v=LFyjJBiltFI
- https://www.biologyonline.com/tutorials/biological-cell-introduction
- https://study.com/academy/topic/cell-biology.html
- https://www.edx.org/learn/cellular-biology
- https://onlinecourses.swayam2.ac.in/cec19_bt12/preview

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

- Demonstrate/performthebasiccellculture techniques*invitro.*
- Toanalyzetheeffectsofphysio-chemical factorsandgrowthhormonesfor thegrowthand development ofthecultures*in vitro*
- Group Discussion of Case studies
- Model Making and poster presentations

MOLECULAR BIOLOGY & GENETIC ENGINEERING			
Course Code	21BT44	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To Acquire the fundamentals of molecular biology and genetic engineering principles.
- To Understand the protocols of isolation of Nucleic acids and their analysis.
- To Develop a conceptual application of gene libraries and various interactions.
- To Learn the strategies for gene manipulation, editing technologies and its applications.

Teaching-Learning Process (General Instructions)

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

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

Module-1(8 Hours)

CENTRAL DOGMA OF MOLECULAR BIOLOGY:

Replication of DNA in Prokaryotic cell andEukaryotic cell. Mechanism of action of telomerase, DNA damage, and repair: Base excisionrepair, mismatch excision repair, photo-reactivation, nucleotide excision, and SoS repair.Transcription in the prokaryotic and eukaryotic cell: Initiation, elongation, and termination.Processing of mRNA. Translation in the prokaryotic and eukaryotic cell: Initiation,elongation, and termination. Wobble Hypothesis Post-translational modification of proteins. Protein targeting.

Module-2(8 Hours)

GENE REGULATION:

Regulation of gene expression in prokaryotes (lac-operon and trp-operon). Positive and negative gene regulation, riboswitches. Regulation of gene expression in eukaryotes: Transcriptional control, RNA processing control, Translational control, and post-translational level control. Hormonal control of gene expression in eukaryotes (steroid hormone, auxin, and gibberellic acid). Gene silencing: antisense technique, RNA interference, Ribozymes.

Module-3(8 Hours)

INTRODUCTION TO GENETIC ENGINEERING:

Basics of Genetic Engineering,Vectors for gene cloning: Cloning and Expression vectors. Plasmids, Phages, Cosmids, Fosmids, Phagemids, and Artificial chromosomes. Viral vectors.Molecular tools for gene cloning: Restriction and Modification systems:Restriction Endonucleases, Methylases, Ligases. Polynucleotide kinases, Phosphatases, DNA and RNA polymerases, Reverse transcriptase, Terminal transferase, DNAses (Extremophiles), Nuclease. RNases, Topoisomerase. Cloning Techniques: Restriction digestion based cloning. Linkers and adapters, Strategies for cloning TA cloning. Ligase free cloning.

Module-4(8 Hours)

GENE TRANSFER TECHNIQUES:

Physical, chemical and biological methods, Competent cells: Chemical and Electro-competent. Transformation/ transfection in plants and animals.Construction of genomic and cDNA libraries: Screening of DNA libraries for clone identification. Characterization of clones. Methods of nucleic acid detection; Polymerase chain reaction (PCR) - techniques and requirements, types of PCR, applications. Blotting techniques (Southern, Northern and Western), Radioactive and non-radioactive labelling of nucleic acids.

Module-5(8 Hours)

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. Genome-Editing Technologies: Types, Principles and Applications; CRISPR- associated protein – Cas 9.

Course outcomes (Course Skill Set)

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

- Understand the basic concepts of genetic engineering for augmentation of traits.
- Apply and comprehend the principles of gene manipulation, expression and interaction of genes and proteins.
- Evaluate the screening and interaction studies using classical/conventional and high through put methods.
- Design the strategies for gene cloning and gene editing.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be scaled down 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. Marks scored out of 100 marks are reduced proportionally to 50 marks

Suggested Learning Resources:

- Gene Cloning and DNA Analysis – An Introduction; T.A.Brown; Wiley-Blackwell Science; 7th edn;2018.
- From Genes to Genomes, Concepts and applications of DNA Technology. Jeremy W. Dale and MV Schantz. 2nd edition, 2018.
- Lewin's genes XII Burlington, Massachusetts: Krebs, Jocelyn E., Goldstein, Elliott S., Kilpatrick, Stephen T., Jones & Bartlett Learning, 2018.
- Molecular Biotechnology – Principles and applications of recombinant DNA, B.R. Glick, J.J. Pasternak and C.L Patten; ASM Press; 6th edn; 2017.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://www.coursera.org/courses?query=molecular%20biology
- https://www.edx.org/learn/molecular-biology
- https://www.classcentral.com/tag/molecular-biology
- https://www.cdc.gov/labtraining/training-courses/basic-molecular-biology/index.html
- https://pll.harvard.edu/subject/molecular-biology
- https://onlinecourses.swayam2.ac.in/cec19_bt02/preview
- https://nptel.ac.in/courses/102103013
- https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/7%3A_Microbial_Genetics/7.23%3A_Genetic_Engineering_Products/7.23B%3A__Applications_of_Genetic_Engineering

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

- Group Discussion of Case studies

- Model Making and poster presentations

BIOLOGY FOR ENGINEERS			
Course Code	21BE45	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0:0	SEE Marks	50
Total Hours of Pedagogy	25	Total Marks	100
Credits	02	Exam Hours	02

MOLECULAR BIOLOGY & GENETIC ENGINEERING LAB			
Course Code	21BTL46	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	03

CourseLearningObjectives:

- Tounderstand the methods related to isolation, quantification, characterizationandamplificationof nucleicacids.
- Toperformexperiments related to Genetic transformation and recombinants.
- To learn protocols related to separation of Proteins and DNA.

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	Agarose gel electrophoresis and quantification of nucleic acids
5	Isolation of total RNA from bacteria/plant/animal samples
6	Estimation of RNA Using Orcinol Method
7	Characterization of DNA by Spectrophotometric Assay and Melting Temperature (Tm)
8	Isolation of plasmid DNA from bacteria
9	Restriction Digestion of plasmid pUC18
10	Amplification of DNA by PCR
11	Separation of Proteins - SDS-PAGE
12	Genetic transformation of *E.coli* and blue-white screening

Course outcomes (Course Skill Set)

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

- Apply the principles of molecular biology and genetic engineering.
- Conduct experiments related to isolation, separation, quantification, digestion and amplification of nucleic acids.
- Interpret and discuss the outcome of the experiments formally through written reports.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE).

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. Rubrics suggested in Annexure-II of Regulation book
- 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 15% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

- Gene Cloning and DNA Analysis – An Introduction; T.A.Brown; Wiley-Blackwell Science; 7th edn;2018.
- Laboratory manual for genetic engineering. Vennison S John. Phi learning publishers. 2009.
- Basic techniques in molecular biology by Surzycki, Stefan. Springer Science & Business Media, 2012.
- Basic Techniques in Biochemistry, Microbiology and Molecular Biology: Principles and Techniques by Aakanchha Jain et al., Springer Protocols Handbooks, 2020.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://onlinecourses.nptel.ac.in/noc21_bt35/preview
- https://www.mitconbiopharma.com/training/bio-tech-training/certificate-course-in-genetic-engineering/
- https://alison.com/course/understanding-molecular-biology
- https://stores.biotecnika.org/products/molecular-biology-techniques-certification-course
- https://onlinecourses.swayam2.ac.in/cec20_ma13/preview

ABILITY ENHANCEMENT COURSE - IV

HYDROPONICS, AQUAPONICSAND AEROPONICS			
Course Code	21BT481	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To Learn about the basics of aquaponics, aeropinics and hydroponics systems.
- To Learn how to set up an aquaculture system, aeroponic system, and hydroponics system.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

HYDROPONICS:

History of hydroponics, General hydroponics, benefits, food production, organic foods versus hydroponics foods, Systems of Hydroponic/Soilless Culture.

Module-2 (3 Hours)

MEDIA FOR HYDROPONICS:

Build your own system, Media and supplies, Minerals, macro and micro Nutrients, mixing, Advanced nutrients, super nutrients, Mineral deficiencies, case studies of foods grown via hydroponics, Hydroponic Cropping.

Module-3 (3 Hours)

APPLICATION OF HYDROPONICS:

CO2 utilization, Problems in hydroponics, Pest Control, post-harvest handling, hydroponic terminologies, Diagnostic Testing Procedures, The Hydroponic Greenhouse, Educational Role for Hydroponics.

Module-4 (3 Hours)

AQUAPONICS:

History of Aquaponics, System design and management, Establishing and Maintaining the Fish Tank, Seed Germination and Planting, Plant Selection and Care, Plant Nutrient Requirements, Photosynthesis, Transpiration and Light, Plant Physiology & Light.

Module-5 (3 Hours)

AEROPONICS:

History of Aeroponics, The Aeroponic Value Proposition, Aeroponic Science.Aeroponics Innovations, Aeroponic Business, Practice of Aeroponics. Current research. Case studies.

Course outcomes (Course Skill Set)

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

- Demonstrate the basics of aquaponics, aeroponics and hydroponics systems.
- Apply the learnings to set up an aquaculture system, plant culture, aeroponics and hydroponics system.

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- Hydroponics and aquaponics for beginners, by Viktor Garden, Independent Publishing, 2021.
- DIY Hydroponic Gardens: How to Design and Build an Inexpensive System for Growing Plants in Water by Tyler Baras - Cool Springs Press, 2018.
- Aquaponic Gardening: A Step-By-Step Guide to Raising Vegetables and Fish Together by Sylvia Bernstein - New Society Publishers, 2011.
- Hydroponic Food Production: A Definitive Guidebook of Soilless Food-growing Methods by Howard M. Resh - Woodbridge Press Publishing Co ,U.S. 1980.
- Hydroponics: Hydroponics Essential Guide: by Andy Jacobson , Createspace Independent Publishing Platform, 2016.
- Hydroponics by Kevin Espiritu, Cool Springs Press, 2019.
- Aeroponics, by Thomas W. Gurley CRC Press, 2020.

Web links and Video Lectures (e-Resources):

- https://rocketskills.in/course/best-hydroponics-course?
- https://www.udemy.com/topic/hydroponics/
- https://www.edx.org/course/aquaponics-the-circular-food-production-system
- https://www.acseduonline.com/courses/horticultural-crops-20/aquaponic-production-bht319-569.aspx
- https://mycourseguru.in/hydroponic-courses/
- Lakkireddy, Kiran & Kondapalli, Kasturi & Sambasiva Rao, K.R.S.. (2012). Role of Hydroponics and Aeroponics in Soilless Culture in Commercial Food Production. Research & Reviews : Journal of Agricultural Science and Technology (RRJoAST). Volume 1. Pages 26-35.
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

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

QUALITY CONTROL AND QUALITY ASSURANCE			
Course Code	21BT482	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To understand the various aspects of quality control and quality assurance in BT industries.
- To know the various guidelines and regulations, tools and tests, documentation, certifications, etc.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

INTRODUCTION TO QUALITY: Definition of Quality, Dimensions of Quality, Principles of Quality. Concept of Quality and Quality Management; Quality vs. Reliability; Quality statements – vision, mission, Policy.

Module-2 (3 Hours)

TOOLS FOR QUALITY CONTROL:

Checklists, Fishbone diagram, Control chart, Stratification, Pareto chart, Histogram, Scatter Diagram, Use of statistical tools, concept of Six Sigma.

Module-3 (3 Hours)

QUALITY ASSURANCE:

Concept, meaning and importance in Biotechnology industry (products and services). QC and QA of pharmaceuticals/drugs, biologics, medical devices, foods, seeds and testing. Role of regulatory bodies (FDA, DCGI, FSSAI, BIS etc).

Module-4 (3 Hours)

GLP, GCP AND GMP GUIDELINES:

GLP, GCP and GMP guidelinesas per WHO and EMEA. Organization and personnel responsibilities, maintenance, sanitation, environmental control, utilities and maintenance of sterile areas, control of contamination and Good Warehousing Practice.

Module-5 (3 Hours)

TOTAL QUALITY MANAGEMENT:

Meaning, tools and techniques, Quality Management Systems, Role of documentation, Audits and ISO 9001:2008, 9001:2015, ISO14001:2004.

Course outcomes (Course Skill Set)

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

- Apply the Principles of Quality Management, QC and QA in the BT industry.
- Understand the various guidelines and apply the same in the Pharma and Food industry.
- Analyse raw materials and finished products in line with the standards.

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- FDA Compliance Program 7382.845 Inspections of Medical Device Manufacturers, February 2, 2011.
- Quality Assurance of Pharmaceuticals. A Compendium of Guidelines and Related Material Vol. 1 and Vol. 2, WHO 2007.
- Good Manufacturing-Practices for Pharmaceuticals, by Graham Bunn and Joseph 6th Ed. D. Nally 2006.
- Quality Assurance Guide by organization of Pharmaceutical Procedures of India, 3rd revised edition, Volume I & II, Mumbai, 1996.
- Good Laboratory Practice Regulations, 2nd Edition, Sandy Weinberg Vol. 69, Marcel Dekker Series, 1995.
- Quality Assurance of Pharmaceuticals- A compedium of Guide lines and Related materials Vol I & II, 2nd edition, WHO Publications, 1999.
- How to Practice GMP's – P P Sharma, Vandana Publications, Agra, 1991.
- The International Pharmacopoeia – vol I, II, III, IV & V - General Methods of Analysis and Quality specification for Pharmaceutical Substances, Excepients and Dosage forms, 3rd edition, WHO, Geneva, 2005.
- Good laboratory Practice Regulations – Allen F. Hirsch, Volume 38, Marcel Dekker Series, 1989.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=TU6sSgIpkn8
- https://www.youtube.com/watch?v=qu4Qz9rsryM
- https://www.coursera.org/courses?query=quality%20control
- https://www.edx.org/learn/quality-control
- https://www.udemy.com/topic/quality-assurance/
- https://asq.org/training/catalog/topics/quality-control
- https://www.mooc-list.com/tags/quality-assurance
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

- Validation and Calibration of equipment/Instruments
- Group Discussion of Case studies
- Model Making and poster presentations

BIOPESTICIDES AND BIOFERTILIZERS			
Course Code	21BT483	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To familiarize the students about the biopesticides and biofertilizers which are free from harmful chemicals and are more environment friendly for the purposes of achieving better crop production

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

PATHOGENS AND PESTS MANAGEMENT :

Pathogens and Pests Management, Natural Enemies, Reduviids and Their Merits in Biological Control, Weaver Ants and Biocontrol of the Nuisance Pest Luprops tristis (Coleoptera: Tenebrionidae), Ground Beetles (Coleoptera: Carabidae): Their Potential as Bio-agents in Agroecosystems, Eco-friendly Control of Three Common Mosquito Larvae Species by Odonata Nymphs, Spiders as Potential Ecofriendly Predators Against Pests.

Module-2 (3 Hours)

BIOFERTILIZERS:

Types and importance of biofertilizers, Biopesticides and bioagents in agriculture and organic farming system, History of biofertilizers production Classification of biofertilizers microorganisms used in biofertilizers production.

Module-3 (3 Hours)

NITROGEN FIXATION:

Concept of Nitrogen fixation. Structure and characteristic features of bacterial biofertilizers - Azotobacter, Bacillus, Rhizobium; Cynobacterial biofertilizers - Anabaena, and fungal biofertilizers - VAM.

Module-4 (3 Hours)

BIOPESTICIDES :

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, Bacillus thuringiensis, Mechanism of phosphate solubilization and phosphate mobilization, K solubilization. Botanicals: botanical pesticides, and biorationales. Botanicals and their uses. Plant Essential Oils and Pest Management

Module-5 (3 Hours)

PRODUCTION AND QUALITY CONTROL :

Strain selection, sterilization, growth and fermentation, mass production of biofertiizers. Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers/Biopesticides, FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers, etc.

Course outcomes (Course Skill Set)

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

- Corelate the principles of Microbiology towards Biofertilizers and Bioinsecticides.
- Comprehend Pest-Plant interactions and apply the same in Agriculture.
- Understand strain selection and apply the same to scale up production of Biofertilizers and Bioinsecticides.

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- Biofertilizer Technology, Marketing and Usage, Motsara, I.M.R., Bhattacharyya, P. and Srivastava, B. 1995.
- Biofertilizers in Agriculture and Forestry, Subba Rao, N.S. Oxford and IBH. Publ. Co., New Delhi. 1993.
- Formulation of Microbial Biopesticides: Beneficial microorganisms, nematodes and seed treatments, H. D. Burges, Spingerlink, 1998.
- Biofertilizer and Biopesticide by Shalini Suri (Author)Aph Publishing Corporation 2011.
- Biological control of insect pest suppression. Coppel H.C. and J.W. Martin. Springer. 1977.
- Biofertilizers and Biopesticides by Krishnendu Acharya, Surjit Sen, Techno World; 2019.

Web links and Video Lectures (e-Resources):

- http://courseware.cutm.ac.in/courses/certificate-course-bio-fertilizer-preparation/
- https://onlinecourses.swayam2.ac.in/cec21_ag03/preview
- https://www.udemy.com/course/basics-of-fertilizers/
- https://www.youtube.com/watch?v=Qxv-IEGucFs
- https://knowledge.unccd.int/e-learning-course-organic-fertilizer-sustainable-agriculture
- http://www.digimat.in/nptel/courses/video/102105058/L55.html
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

- Study of biological agents like anabena, nostoc, VAM and Rhizobium
- Group Discussion of Case studies
- Model Making and poster presentations

R PROGRAMMING FOR BIOLOGISTS			
Course Code	21BT484	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To Master the use of the R and RStudio interactive environment.
- To Expand R by installing R packages.
- To Explore and understand how to use the R documentation.
- To Read Structured Data into R from various sources.
- To Understand the different data types in R.
- To Understand the different data structures in R.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

INTRODUCTION:

Basic fundamentals, installation and use of software, data editing, Downloading and installation of R from CRAN on windows and Linux OS. Getting help from CRAN website and the internet and the help commands. Command packages: standard command packages, running and manipulating the commands, Establishment of R programming.

Module-2 (3 Hours)

DATA TYPES:

R & R Studio Installation, Scalar, Vectors, Matrix, List, Data frames, Factors, Handling date in R, Conversion of data types, Operators in R, importing data and manipulating data in R.

Module-3 (3 Hours)

CONDITIONAL STATEMENTS AND FUNCTIONS:

If …else, For loop, While loop, Repeat loop, Apply(), sApply(), rApply(), tApply. conditional executions and loops, data management with sequences. Data management with repeats, sorting, ordering, and lists.

Module-4 (3 Hours)

DATA MANAGEMENT:

Vector indexing, factors, Data management with strings, display and formatting. data management with display paste, split, find and replacement, manipulations with alphabets, evaluation of strings, Data frames, import of external data in various file formats.

Module-5 (3 Hours)

STATISTICS:

Basics of statistics, statistical functions, compilation of data. Data Visualization in R using GG Plot: Box Plot, Histograms, Scatter Plotter, Line chart, Bar Chart, Heat maps Misc. functions and Data Visualization using Plotly:3D-view, Geo Maps, Null Handling, Merge, Grep, Scan.

Course outcomes (Course Skill Set)

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

- Download and install R and RStudio
- Use of operators and functions in R
- Solve fundamental problems
- Apply R in data management and visualization

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- R For Dummies 2nd Edition by Andrie de Vries and Joris Meys, 2015.
- R in a Nutshell 2e: A Desktop Quick Reference Paperback by Joseph Adler, 2012.
- Learning R: A Step-By-Step Function Guide to Data Analysis Paperback by Richard Cotton, 2013.
- R Programming for Beginners: Fast and Easy Learning Rby Steven Keller, 2016.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/111104100
- https://www.youtube.com/watch?v=fDRa82lxzaU
- https://www.udemy.com/topic/r-programming-language
- https://www.udemy.com/course/r-programming/
- https://www.mygreatlearning.com/great-lakes-pgpdsba?
- https://www.coursera.org/learn/r-programming
- https://www.edx.org/learn/r-programming
- https://www.udemy.com/topic/r-programming-language/
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

- Installation and working with R
- Executing simple programs in R
- Using graphical data visualization
- Problem solving using R

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme and Syllabus of Teaching and Examinations 2021
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
V Semester

BIOKINETICS & BIOREACTION ENGINEERING			
Course Code	21BT51	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Todiscussthedifferentmodelsofchemicalreactionsandhowvariousfactorssuchastemperatureaffect reactionrate.
- Tostudytheperformanceanddistinguishbetweenthedifferenttypes of ideal andnonidealreactors.
- TodeterminetheoptimumpH,temperatureandconcentrationofanenzyme.
- To understand the aspects of substrateaffinityandenzyme inhibition.
- Todescribemediumrequirementsandmediumformulationformaximizing the yields.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION:

Law of mass action and rate equation, definitions and examples of elementary and nonelementary reactions,theories of reaction rate and temperature dependency, analysis of experimental reactor data - evaluation of rateequationbyintegralanddifferentialanalysisfor constantvolumesystem.Conceptualnumericals.

Module-2 (8 Hours)

BIOREACTORS:

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

Module-3 (8 Hours)

ENZYME KINETICS:

Enzymes and their Classifications Enzymeactivesite,Unitsofenzymeactivity typesofenzymespecificities,initialvelocitystudies,formation of ES complex, derivation of Michaelis-Menton equation, definition of Km and Vmax, Lineweaver-BurkandEadie-Hofsteeplots.,Enzymeinhibition:competitive,uncompetitive and non-competitive; Regulations – allosteric and feedback regulation. Conceptualnumericals.

Module-4 (8 Hours)

KINETICS OF MICROBIAL GROWTH:

Batch growth kinetics, Elemental balance of biological conversion with and without extracellular product formation, Degree of reduction, Theoretical prediction of yield coefficients, Factors affecting microbial growth,Monod growth kinetics, Conceptualnumericals.Case studies.

Module-5 (8 Hours)

MEDIA OPTIMIZATION :

Medium requirements for fermentation processes- Carbon, nitrogen, minerals, vitamins and othercomplexnutrients;oxygenrequirements;Mediumformulationforoptimalgrowthandproductformation, examples of simple and complex media; thermal death kinetics of microorganisms; Batchandcontinuous heat – Sterilization of Liquid media;Filtersterilization ofliquid media. Case studies.

Course outcomes (Course Skill Set)

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

- Detailthemechanismandkineticsofchemical,enzymeandmicrobialreactions.
- Identifyandsummarizetheparametersfroma range ofreactionstooptimizereactordesignanddevelopment.
- Demonstratetheuseofvariousscientificparameterstoimprovetheperformanceoffermentationprocess.
- Formulate asuitablemedia for maximized microbialgrowthand product yields, byanalysingvariousparameters.

Course objectives:

- To familiarize the students with the basic biological concepts and their engineering applications.
- To enable the students with an understanding ofbiodesign principles to create novel devices and structures.
- To provide the students an appreciation of how biological systems can be re-designed as substitute products for natural systems.
- To motivate the students develop the interdisciplinary vision of biological engineering.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (5 Hours)

BIOMOLECULES AND THEIR APPLICATIONS (QUALITATIVE):

Carbohydrates (cellulose-based water filters, PHA and PLA as bioplastics), Nucleic acids (DNA Vaccine for Rabies and RNA vaccines for Covid19, Forensics – DNA fingerprinting), Proteins (Proteins as food – whey protein and meat analogs, Plant based proteins), lipids (biodiesel, cleaning agents/detergents), Enzymes (glucose-oxidase in biosensors, lignolytic enzyme in bio-bleaching).

Module-2 (5 Hours)

HUMAN ORGAN SYSTEMS AND BIO DESIGNS - 1 (QUALITATIVE):

Brain as a CPU system (architecture, CNS and Peripheral Nervous System, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease).Eye as a Camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye).Heart as a pump system (architecture, electrical signalling - ECG monitoring and heart related issues, reasons for blockages of blood vessels, design of stents, pace makers, defibrillators).

Module-3 (5 Hours)

HUMAN ORGAN SYSTEMS AND BIO-DESIGNS - 2 (QUALITATIVE):

Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine).Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems).Muscular and Skeletal Systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis).

Module-4 (5 Hours)

NATURE-BIOINSPIRED MATERIALS AND MECHANISMS (QUALITATIVE):

Echolocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf). Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self-cleaning surfaces), Plant burrs (Velcro), Shark skin (Friction reducing swim suits), Kingfisher beak (Bullet train).Human Blood substitutes - hemoglobin-based oxygen carriers (HBOCs) and perflourocarbons (PFCs).

Module-5 (5 Hours)

TRENDS IN BIOENGINEERING (QUALITATIVE):

Bioprinting techniques and materials, 3D printing of ear, bone and skin. 3D printed foods. Electrical tongue and electrical nose in food science, DNA origami and Biocomputing, Bioimaging and Artificial Intelligence for disease diagnosis. Self-healing Bioconcrete (based on bacillus spores, calcium lactate nutrients and biomineralization processes) and Bioremediation and Biomining via microbial surface adsorption (removal of heavy metals like Lead, Cadmium, Mercury, Arsenic).

Course outcomes (Course Skill Set)

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

- Elucidate the basic biological concepts via relevant industrial applications and case studies.
- Evaluate the principles of design and development, for exploring novel bioengineering projects.
- Corroborate the concepts of biomimetics for specific requirements.
- Think critically towards exploring innovative biobased solutions for socially relevant problems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 2 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 SEE question paper will be set for 100 marks and marks scored will be proportionately reduced to 50 marks

Suggested Learning Resources:

- Human Physiology, Stuart Fox, Krista Rompolski, McGraw-Hill eBook. 16th Edition, 2022.
- Biology for Engineers, Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M.K., Tata McGraw-Hill, New Delhi, 2012.
- Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011.
- Biomedical Instrumentation, Leslie Cromwell, Prentice Hall, 2011.
- Biology for Engineers, Sohini Singh and Tanu Allen, Vayu Education of India, New Delhi, 2014.
- Biomimetics: Nature-Based Innovation, Yoseph Bar-Cohen, 1st edition, 2012, CRC Press.
- Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies, D. Floreano and C. Mattiussi, MIT Press, 2008.
- Bioremediation of heavy metals: bacterial participation, by C R Sunilkumar, N Geetha A C Udayashankar Lambert Academic Publishing, 2019.
- 3D Bioprinting: Fundamentals, Principles and Applications by Ibrahim Ozbolat, Academic Press, 2016.
- Electronic Noses and Tongues in Food Science, Maria Rodriguez Mende, Academic Press, 2016.
- Blood Substitutes, Robert Winslow, Elsevier, 2005.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://nptel.ac.in/courses/121106008
- https://freevideolectures.com/course/4877/nptel-biology-engineers-other-non-biologists
- https://ocw.mit.edu/courses/20-020-introduction-to-biological-engineering-design-spring-2009
- https://ocw.mit.edu/courses/20-010j-introduction-to-bioengineering-be-010j-spring-2006
- https://www.coursera.org/courses?query=biology
- https://www.classcentral.com/subject/biology
- https://www.futurelearn.com/courses/biology-basic-concepts

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

- Group Discussion of Case studies
- Model Making and seminar/poster presentations
- Design of novel device/equipment like Cellulose-based water filters, Filtration system mimicking the kidney, Bioremediation unit for E-waste management, AI and ML based Bioimaging,

Course objectives:

- To familiarize the students with the basic biological concepts and their engineering applications.
- To enable the students with an understanding ofbiodesign principles to create novel devices and structures.
- To provide the students an appreciation of how biological systems can be re-designed as substitute products for natural systems.
- To motivate the students develop the interdisciplinary vision of biological engineering.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (5 Hours)

BIOMOLECULES AND THEIR APPLICATIONS (QUALITATIVE):

Carbohydrates (cellulose-based water filters, PHA and PLA as bioplastics), Nucleic acids (DNA Vaccine for Rabies and RNA vaccines for Covid19, Forensics – DNA fingerprinting), Proteins (Proteins as food – whey protein and meat analogs, Plant based proteins), lipids (biodiesel, cleaning agents/detergents), Enzymes (glucose-oxidase in biosensors, lignolytic enzyme in bio-bleaching).

Module-2 (5 Hours)

HUMAN ORGAN SYSTEMS AND BIO DESIGNS - 1 (QUALITATIVE):

Brain as a CPU system (architecture, CNS and Peripheral Nervous System, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease).Eye as a Camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye).Heart as a pump system (architecture, electrical signalling - ECG monitoring and heart related issues, reasons for blockages of blood vessels, design of stents, pace makers, defibrillators).

Module-3 (5 Hours)

HUMAN ORGAN SYSTEMS AND BIO-DESIGNS - 2 (QUALITATIVE):

Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine).Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems).Muscular and Skeletal Systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis).

Module-4 (5 Hours)

NATURE-BIOINSPIRED MATERIALS AND MECHANISMS (QUALITATIVE):

Echolocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf). Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self-cleaning surfaces), Plant burrs (Velcro), Shark skin (Friction reducing swim suits), Kingfisher beak (Bullet train).Human Blood substitutes - hemoglobin-based oxygen carriers (HBOCs) and perflourocarbons (PFCs).

Module-5 (5 Hours)

TRENDS IN BIOENGINEERING (QUALITATIVE):
Bioprinting techniques and materials, 3D printing of ear, bone and skin. 3D printed foods. Electrical tongue and electrical nose in food science, DNA origami and Biocomputing, Bioimaging and Artificial Intelligence for disease diagnosis. Self-healing Bioconcrete (based on bacillus spores, calcium lactate nutrients and biomineralization processes) and Bioremediation and Biomining via microbial surface adsorption (removal of heavy metals like Lead, Cadmium, Mercury, Arsenic).

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

- Elucidate the basic biological concepts via relevant industrial applications and case studies.
- Evaluate the principles of design and development, for exploring novel bioengineering projects.
- Corroborate the concepts of biomimetics for specific requirements.
- Think critically towards exploring innovative biobased solutions for socially relevant problems.

Assessment Details (both CIE and SEE)
The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:
Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**
(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).
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:

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

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 2 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 SEE question paper will be set for 100 marks and marks scored will be proportionately reduced to 50 marks

Suggested Learning Resources:

- Human Physiology, Stuart Fox, Krista Rompolski, McGraw-Hill eBook. 16th Edition, 2022.
- Biology for Engineers, Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M.K., Tata McGraw-Hill, New Delhi, 2012.
- Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011.
- Biomedical Instrumentation, Leslie Cromwell, Prentice Hall, 2011.
- Biology for Engineers, Sohini Singh and Tanu Allen, Vayu Education of India, New Delhi, 2014.
- Biomimetics: Nature-Based Innovation, Yoseph Bar-Cohen, 1st edition, 2012, CRC Press.
- Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies, D. Floreano and C. Mattiussi, MIT Press, 2008.

- Bioremediation of heavy metals: bacterial participation, by C R Sunilkumar, N Geetha A C Udayashankar Lambert Academic Publishing, 2019.
- 3D Bioprinting: Fundamentals, Principles and Applications by Ibrahim Ozbolat, Academic Press, 2016.
- Electronic Noses and Tongues in Food Science, Maria Rodriguez Mende, Academic Press, 2016.
- Blood Substitutes, Robert Winslow, Elsevier, 2005.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://nptel.ac.in/courses/121106008
- https://freevideolectures.com/course/4877/nptel-biology-engineers-other-non-biologists
- https://ocw.mit.edu/courses/20-020-introduction-to-biological-engineering-design-spring-2009
- https://ocw.mit.edu/courses/20-010j-introduction-to-bioengineering-be-010j-spring-2006
- https://www.coursera.org/courses?query=biology
- https://www.classcentral.com/subject/biology
- https://www.futurelearn.com/courses/biology-basic-concepts

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

- Group Discussion of Case studies
- Model Making and seminar/poster presentations
- Design of novel device/equipment like Cellulose-based water filters, Filtration system mimicking the kidney, Bioremediation unit for E-waste management, AI and ML based Bioimaging,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally scaled down 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.

Suggested Learning Resources:

- Elementsof Chemical ReactionEngineering Fogler,H.S PrenticeHall 3rdEdition, 2004.
- Bioprocess Engineering:BasicConcepts FikretKargi,Matthew DeLisa,andMichael L.

ShulerPrenticeHall Third Edition,2017.
- EnzymeKineticsand Mechanism PaulFCook&W W Cleland GarlandScience, 2007.
- ChemicalReaction Engineering Levenspiel O JohnWiley 3rdEdition, 1998.
- BioenergeticsDavidNicholls AcademicPress 4thEdition,2013.
- ChemicalReactorAnalysis andDesign Forment GFand BischoffKB JohnWiley 3rdEdition, 2010.

Web links and Video Lectures (e-Resources):

- https://www.coursera.org/lecture/toxicology-21/physiologically-based-biokinetic-modeling-GdoGG
- https://onlinecourses.nptel.ac.in/noc22_bt19/preview
- https://alison.com/course/bioreactor-design-fed-batch-and-continuous-bioreactors
- https://onlinecourses.nptel.ac.in/noc21_bt28/preview
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

- Industrial visit with assessment.
- AV presentation by students (on specific topics).
- Online surprise quizzes.
- Discussion of case studies based on research findings.
- Model making and Poster presentations.

IMMUNOTECHNOLOGY+ LAB			
Course Code	21BT52	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- To Learn the underlying concepts of molecular and cellular mechanisms involved in the development and regulation of the immune response
- To Describe the cause for Immune System Disorders.
- To Learn the techniques of Immunodiagnostics.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (10 Hours)

IMMUNE SYSTEM:

Introduction; Immunity-innate and acquired immunity; Haematopoiesis; Cells of immune system – lymphoid cells, mononuclear cells, granulocytes, dendritic cells & mast cells; organs of immune system - primary and secondary lymphoid organs; Humoral and Cell mediated immunity; Antigens: Chemical and biological Factors affecting antigenicity/Immunogenicity and molecular nature, Haptens, adjuvants; Antibodies: structure and function, Immunoglobulin classes and subclasses (isotypic, allotypes, idiotypes and anti-idiotytopic antibodies).

LAB EXERCISES:

- ❖ Agglutination Technique: ABO typing
- ❖ Isolation of lymphocytes from peripheral blood and differential counting of WBC

Module-2 (10 Hours)

HUMORAL AND CELL MEDIATED IMMUNITY:

B-lymphocytes and their activation, development and maturation. antibody genes and generation of diversity, Class switching mechanism; production of monoclonal antibodies, polyclonal antibodies and applications;

Thymus derived lymphocytes (T cells):activation, development and maturation, their ontogeny and typesMajor histocompatibility Complex (MHC) Complex, MHC Class I and II molecules. Antigen processing and presentation process.

LAB EXERCISES:

- Bacterial Agglutination reaction-Widal test (Tube / slide agglutination)

Module-3 (10 Hours)

IMMUNE SYSTEM IN HEALTH AND DISEASE:

Complement system, pathways of complement activation and its functions, Hypersensitivity: Gell and Coombs classification of Hypersensitivity,Autoimmune disorders-types, animal model and treatment; Immune response to infections: immunity to viruses, bacteria, fungi and parasites; Immunodeficiency disorders: Primary and secondary immunodeficiencies (AIDS); Injury and inflammation, Vaccines and their types, production of recombinant vaccine – vaccine for hepatitis B surface antigen.

LAB EXERCISES:

- Ouchterlony Double Diffusion (ODD)
- Rocket immune-electrophoresis (RIEP)

Module-4 (10 Hours)

TRANSPLANTATION AND TUMOR IMMUNOLOGY:

Transplantation and its classification, Immunologic basis of graft rejection and its mechanism, transplantation antigens, tissue typing, role of MHC molecules in allograft rejection, Clinical transplantations, bone marrow, HSC transplantation and immunosuppressive therapy; Tumours of the immune system-tumour antigens and immune response to tumours, tumour immune-therapy.

LAB EXERCISES:

- Counter-current immune-electrophoresis (CCIEP)
- Enzyme-linked immunosorbent assay (ELISA)

Module-5 (10 Hours)

MOLECULAR IMMUNOLOGY &IMMUNODIAGNOSIS:

Antigen antibody interaction – Precipitation reactions, Agglutination reactions; ABO Blood typing principles; Principles and applications of ELISA, Radio Immuno Assay (RIA), western blot analysis, immunoelectrophoresis, Immunofluorescence, Fluorescence Activated Cell Sorting (FACS) analysis. Role of stem cells technology in immunology, Production of humanized monoclonal antibodies (Single chain fragment variable).

LAB EXERCISES:

- Western blotting
- Complement fixation test

Course outcomes (Course Skill Set)

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

- Outline the molecular and cellular mechanisms involved in the development and regulation of the immune response,
- Detail the cause, challenges and treatment for Immune System Pathologies and Dysfunctions.
- Apply the major immunological laboratory techniques and their application to both clinical analysis and experimental research.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **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 **(duration 02/03 hours)** at the end of the 15th week of the semester /after completion of all the experiments (whichever is early) 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)

13. The question paper will have ten questions. Each question is set for 20 marks.Marks scorded shall be proportionally scaled down to 50 Marks
14. 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.
15. 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 12 (40% of maximum marks-30) in the theory component and 08 (40% 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 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

- Kuby Immunology by by Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen, WH Freeman; 8th ed. 2018.
- Immunology – an Introduction by Tizard Thomson. Saunders College Publising, 1984
- Immunology &Immunotechnology, Ashim K Chakravarthy, Oxford University Press. 2006.
- Immundiagnostics by S C Rastogi, New Age International. 1996.
- Essential Immunology by Roitt I. Blackwell Scientific Publications,13th Edition, 2017.
- Immunology: A Short Course Richard Coico, Geoffrey Sunshine Wiley-Blackwell 7th Edition, 2015.
- Understanding Immunology by Peter Wood, Pearson Education, 2001.

Web links and Video Lectures (e-Resources):

- https://www.coursera.org/courses?query=immunology
- https://www.edx.org/learn/immunology
- https://www.tangolearn.com/best-immunology-courses-classes-online/
- https://www.classcentral.com/course/swayam-immunology-14117
- https://onlinecourses.nptel.ac.in/noc20_bt43/preview
- https://pll.harvard.edu/course/hmx-immunology?delta=1
- 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 specific topics).
- Online surprise quizzes.
- Discussion of case studies based on research findings.
- Model making and Poster presentations.

STRUCTURAL BIOLOGY & ANALYTICAL TECHNIQUES			
Course Code	21BT53	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To learn the fundamentals of biomolecular structure-function hypothesis.
- To gather knowledgeof various biophysical, spectroscopic,chromatographictechniquesandtheir applications.
- Tobeabletounderstand and select the specific analyticaltechniquefor required case study.

Teaching-Learning Process (General Instructions)

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

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

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

Module-1 (8 Hours)

STRUCTURE AND CONFORMATION OF PROTEINS:
Composition and primary structures ofproteins, peptide geometries, phi, psi,omega angles, Ramachandran or steric contour diagram, allowedchiangles of side chains inproteins,Conformational analysis and forces that determine protein structures, hydrogenbonding,disulphidebonds,hydrophobicinteractions,vanderwaalsforces,potential energy calculations. Secondary structures: alpha helices, beta sheets, turns. Thermodynamic aspects of protein folding. Relationship between the primary,secondary,andtertiarystructureofproteins.StructureofIgG,fibrousproteins(structureofcollagen, keratin). Quaternary structures – dimers (homo & heterodimers),trimers,tetramers;Popular Proteinfolds,structuralfamiliesandclasses, multifunctionaldomains(qualitativeexamples).

Module-2 (8 Hours)

STRUCTUREAND CONFORMATION OFNUCLEICACIDSANDBIOMEMBRANES:
General characteristics of nucleic acid structures (A, T, G, C, U), forces and stabilizing geometries,glycosidic bond, rotational isomers. Stabilizing ordered forms of DNA (A, B and Z), base pairingtypes, base stacking, tertiary structure of DNA (Supercoiled DNA), Melting of the DNA doublehelix (Hyperchromicity), Interaction with small ions and small molecules. Ribose puckering andTertiary structure of tRNA.
Structure and conformational properties of cell membranes, Singer andNicholson model, integral proteins in membranes, conformational variations during ion transport,Signaltransduction andmolecularreception (qualitative).

Module-3 (8 Hours)

BIOPHYSICALTECHNIQUES:
Rayleighscattering,ultra-centrifugation,viscometry.Electronmicroscopy(SEM, TEM,AFM),luminescence (fluorescence & phosphorescence), Calorimetry, DSC, DTA/TGA, Mass spectrometry,MALDI-TOF,VoltageClampand Patch Clamp(measurements ofmembranepotentials). Flowcytometry.

Module-4 (8 Hours)

SPECTROSCOPICTECHNIQUES:
X-ray diffraction: structure determination via single crystal diffraction, fibre diffraction; Neutrondiffraction. XPS, XAFS. NMR spectroscopy (structure determination). ORD/CD, UV, IR, Laser Raman,ESR/EPR.

Module-5 (8 Hours)

ELECTROPHORETICTECHNIQUES:
Agarosegelelectrophoresis,gradientelectrophoresis,horizontalandverticalgelelectrophoresis,isoelectricfocusing, immuno-electrophoresis. capillaryelectrophoresis and applications. Chromatographic Techniques: Normal phase, adsorption,reversephase,ionexchange,sizeexclusion,hydrophobicinteraction,bio-affinityandpseudoaffinity techniques. GC, Paper chromatography, TLC and HPLC and their applications.

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

- ➢ Describe the structural aspects of macormoleucles like proteins, nucleic acids and biomembranes.
- ➢ Demonstrate their structure function hypothesis via suitable techniques.
- ➢ Apply thespecific biophysical, spectroscopic,chromatographictechniquesfor various case studies.

Course objectives:

- ➢ To familiarize the students with the basic biological concepts and their engineering applications.
- ➢ To enable the students with an understanding ofbiodesign principles to create novel devices and structures.
- ➢ To provide the students an appreciation of how biological systems can be re-designed as substitute products for natural systems.
- ➢ To motivate the students develop the interdisciplinary vision of biological engineering.

Teaching-Learning Process (General Instructions)
These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

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

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

Module-1 (5 Hours)

BIOMOLECULES AND THEIR APPLICATIONS (QUALITATIVE):
Carbohydrates (cellulose-based water filters, PHA and PLA as bioplastics), Nucleic acids (DNA Vaccine for Rabies and RNA vaccines for Covid19, Forensics – DNA fingerprinting), Proteins (Proteins as food – whey protein and meat analogs, Plant based proteins), lipids (biodiesel, cleaning agents/detergents), Enzymes (glucose-oxidase in biosensors, lignolytic enzyme in bio-bleaching).

Module-2 (5 Hours)

HUMAN ORGAN SYSTEMS AND BIO DESIGNS - 1 (QUALITATIVE):
Brain as a CPU system (architecture, CNS and Peripheral Nervous System, signal transmission, EEG, Robotic arms for prosthetics. Engineering solutions for Parkinson's disease).Eye as a Camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye).Heart as a pump system (architecture, electrical signalling - ECG monitoring and heart related issues, reasons for blockages of blood vessels, design of stents, pace makers, defibrillators).

Module-3 (5 Hours)

HUMAN ORGAN SYSTEMS AND BIO-DESIGNS - 2 (QUALITATIVE):
Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine).Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems).Muscular and Skeletal Systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis).

Module-4 (5 Hours)

NATURE-BIOINSPIRED MATERIALS AND MECHANISMS (QUALITATIVE):
Echolocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf). Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self-cleaning surfaces), Plant burrs (Velcro), Shark skin (Friction reducing swim suits), Kingfisher beak (Bullet train).Human Blood substitutes - hemoglobin-based oxygen carriers (HBOCs) and perflourocarbons (PFCs).

Module-5 (5 Hours)

TRENDS IN BIOENGINEERING (QUALITATIVE):
Bioprinting techniques and materials, 3D printing of ear, bone and skin. 3D printed foods. Electrical tongue and electrical nose in food science, DNA origami and Biocomputing, Bioimaging and Artificial Intelligence for disease diagnosis. Self-healing Bioconcrete (based on bacillus spores, calcium lactate nutrients and biomineralization processes) and Bioremediation and Biomining via microbial surface adsorption (removal of heavy metals like Lead, Cadmium, Mercury, Arsenic).

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

- ➢ Elucidate the basic biological concepts via relevant industrial applications and case studies.
- ➢ Evaluate the principles of design and development, for exploring novel bioengineering projects.
- ➢ Corroborate the concepts of biomimetics for specific requirements.
- ➢ Think critically towards exploring innovative biobased solutions for socially relevant problems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 2 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 SEE question paper will be set for 100 marks and marks scored will be proportionately reduced to 50 marks

Suggested Learning Resources:

- Human Physiology, Stuart Fox, Krista Rompolski, McGraw-Hill eBook. 16th Edition, 2022.
- Biology for Engineers, Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M.K., Tata McGraw-Hill, New Delhi, 2012.
- Biology for Engineers, Arthur T. Johnson, CRC Press, Taylor and Francis, 2011.
- Biomedical Instrumentation, Leslie Cromwell, Prentice Hall, 2011.
- Biology for Engineers, Sohini Singh and Tanu Allen, Vayu Education of India, New Delhi, 2014.
- Biomimetics: Nature-Based Innovation, Yoseph Bar-Cohen, 1st edition, 2012, CRC Press.
- Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies, D. Floreano and C. Mattiussi, MIT Press, 2008.
- Bioremediation of heavy metals: bacterial participation, by C R Sunilkumar, N Geetha A C Udayashankar Lambert Academic Publishing, 2019.
- 3D Bioprinting: Fundamentals, Principles and Applications by Ibrahim Ozbolat, Academic Press, 2016.
- Electronic Noses and Tongues in Food Science, Maria Rodriguez Mende, Academic Press, 2016.
- Blood Substitutes, Robert Winslow, Elsevier, 2005.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://nptel.ac.in/courses/121106008
- https://freevideolectures.com/course/4877/nptel-biology-engineers-other-non-biologists
- https://ocw.mit.edu/courses/20-020-introduction-to-biological-engineering-design-spring-2009
- https://ocw.mit.edu/courses/20-010j-introduction-to-bioengineering-be-010j-spring-2006
- https://www.coursera.org/courses?query=biology

- https://www.classcentral.com/subject/biology
- https://www.futurelearn.com/courses/biology-basic-concepts

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

- Group Discussion of Case studies
- Model Making and seminar/poster presentations
- Design of novel device/equipment like Cellulose-based water filters, Filtration system mimicking the kidney, Bioremediation unit for E-waste management, AI and ML based Bioimaging,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally scaled down 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Principles of protein structure by G Schulz and R H Schrimer, Springer Verlag, 1979.
- Introduction to Protein Science by Arthur M Lesk, Oxford University Press, 2010
- Biophysical Chemistry by Cantor R. and Schimmel P.R, W. H. Freeman, 1980.
- Biophysical Principles of Structure & Function by Fred M. Snell & Sidney Shulman, Addison-Wesley Publishing, 1965.
- Introduction to Protein Structure by Carl Branden and John Tooze, Garland Publishing,1998.
- Proteins Structure – A Practical Approach by Creighton, Oxford University Press, 1989.
- Biophysical Chemistry, by Upadhyay, Himalaya Publishing House, 2010
- Biophysical chemistry: 'Techniques for the study of biological structure and function', CR Cantor and PR Schimmel. WH Freeman and Co, Oxford Press. 1980.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc21_bt14/preview
- https://www.udemy.com/course/sbio-101/
- https://www.ebi.ac.uk/training/search-results?query=structural-biology&domain=ebiweb_training&page=1&facets=
- https://web.stanford.edu/class/sbio228/
- https://www.coursera.org/lecture/bioinformatics-methods-2/introduction-i6Q2J
- https://www.biophysics.org/education-careers/education-resources/additional-education-resources/free-online-courses
- 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 specific topics).
- Online surprise quizzes.
- Discussion of case studies based on research findings.
- Model making and Poster presentations.

GENOMICS, PROTEOMICS AND BIOINFORMATICS			
Course Code	21BT54	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Toinculcatethe fundamentals of Genomics, Proteomics and Bioinformatics.
- Tocomprehendthe applicationsof Genomics, Proteomics and Bioinformatics in biotechnology research.
- Toimpart knowledgeofvarious softwaretoolsused in Genomics, Proteomics and Bioinformatics studies.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION:

Polymorphisms–typesofpolymorphism,genomesequencesanddatabasesubscriptions.Earlysequencingefforts.ExtractionofDNA,Methodsofpreparing genomicDNAforsequencing,DNAsequenceanalysismethods-Maxam &GilbertMethod,SangerDi-deoxymethod,Fluorescence method,shot-gun approach.NGS methodsand their principles. BioinformaticstoolsandautomationinGenomeSequencing,analysisofrawgenomesequencedata, Transcriptome (RNA) sequencing, Exome sequencing, Genome Annotation, Using NGS to detect sequence variants, Utilityof EST database in sequencing.

Module-2 (8 Hours)

GENOMICS:

Generalarchitectureofprokaryoticandeukaryotic genome. Regulationoftranscription,transcriptionfactorsandtheco-ordinationofgeneexpression, Gene variation and Single Nucleotide Polymorphisms (SNPs),Bioinformatics in detection of Polymorphisms - dbSNP, Gene-disease association, diagnostic genes and drug targets, genotypingtools-DNAChips. Genome projects of Model systems: Drosophila,Yeast, *C.elegans.E. coli*.,Arabidopsisandrice;Humangenome projectandthegeneticmap.InterferenceRNA, RNA silencing, SiRNA. Genetic and physical maps: Breeding requirements for mapping. Molecular markers - RFLP, RAPD, AFLP,Micro-array in functionalgenomics.Bioinformaticstoolsinmicroarraydataanalysis.Toolsforcomparativegenomics:BLAST2,Vista,MUMmer,COG, VOG. Mummer, COG, VOG.

Module-3 (8 Hours)

PROTEOMICS:

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

Module-4 (8 Hours)

DATABASES& SEQUENCEANALYSIS:

Bioinformatics resources: NCBI,EBI, ExPASy, RCSB. Significance of databases towards informatics projects. Databases and classifications.GenBank,DDBJ,EMBL, PIR,Uniprot-KB,SWISS-PROT, TrEMBL.Genebank flatfile.ProteinDataBank (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, HiddenMarkovModels(HMMs).Phylogeneticanalysis: Alignment, Tree Building, and Tree Evaluation,Tree - Building Methods-Distance based and character-based methods, Evaluating Trees and Data- Bootstrapping(parametricandnon-parametric),Phylogeneticsoftwares(CLUSTAL-omega,PHYLIPetc),

Module-5 (8 Hours)

INSILICO APPLICATIONS:

Detecting Functional Sites in the Prokaryotic and Eukaryotic Genomes (promoters, transcription factor binding sites,translation initiation sites), Integrated Gene Parsing, finding RNA Genes, Web based tools (GENSCAN,GRAIL,GENEFINDER). Protein Identity based on composition, Physical propertiesBasedonsequence,secondarystructureandfoldingclasses,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 Modeling indrugdiscovery,moleculardocking,quantitativestructure-activityrelationship(QSAR),derivingthePharmacophoricPattern,ReceptorMapping,EstimatingBiologicalActivities, Ligand-ReceptorInteractions:Dockingsoftwares(AUTODOCK,HEX), EnergyCalculations(no derivation).

Course outcomes (Course Skill Set)

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

- Detailthe basic concepts in Genomics, Proteomics and Bioinformatics.
- Demonstarte the applicationsof Genomics, Proteomics and Bioinformatics in biotechnology research.
- Applyvarious softwaretoolsused in Genomics, Proteomics and Bioinformatics for specific case studies.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally scaled down 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

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

Web links and Video Lectures (e-Resources):

- 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

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

- 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.

BIOINFORMATICS LAB			
Course Code	**21BTL55**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	03

Course objectives:

- ToLearn the usage of onlineresources,databasesand tools relatedtobiologicaldata.
- ToLearntheunderlyingconceptsof Bioinformatics and their diverse applications.
- ToLearntheutilities of variouscomputational toolsfor specific biological probems.

Sl.NO	Experiments
1	Pairwisecomparisonofsequences–Analysisofparametersaffectingalignment
2	Multiplealignmentsof sequencesandpatterndeterminationusingPROSITE
3	Evolutionarystudies/ Phylogeneticanalysis–Analysisofparametersaffectingtrees
4	Identificationof functionalsitesinGenes/ Genomes
5	Secondarystructure and Tertiary structure prediction of proteinsandnucleicacids(DNA/RNA)
6	Studyof posttranslationalmodificationsusingrelevanttools
7	Restrictionmapping:Analysisofmapsforsuitablemolecularbiologyexperiment
8	PrimerDesign:Factorsaffectingprimerdesign.
9	ComparativeModellingof homologoussequencesandvalidationof modelledstructures
10	Determinationofligand-proteininteractionsusingSPDBV/LIGPLOT
11	Dockingstudies– Analysisof substrate/ ligandbindingusinghomologousstructures
12	Derivationofpharmacophorepatternsforselectiveligands

Course outcomes (Course Skill Set)

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

- Comprehendtheunderlyingconceptsof Bioinformatics and their requirements.
- Detailtheutilities of relevantonlineresources,databasesandsoftwaretools for case-specific problems.
- Applyvarious software tools for diverse case-studies and analyse the results for optimized solutions.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE).

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 8th week of the semester and the second test shall be conducted after the 14th 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. Rubrics suggested in Annexure-II of Regulation book
- 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 15% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

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

Web links and Video Lectures (e-Resources):

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

ABILITY ENHANCEMENT COURSE - V

BIOINNOVATION AND START-UPS			
Course Code	21BT581	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

BIO-INNOVATION AND REGULATORY AFFAIRS:

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

Module-2 (3 Hours)

IPR AND BIO-INNOVATION:

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

Module-3 (3 Hours)

MAKE-IN-INDIA AND DIGITAL INDIA:

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

Module-4 (3 Hours)

START-UP SCHEMES AND FUNDING AGENCIES:

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

Module-5 (3 Hours)

PROJECT MANAGEMENT AND BUSINESS PLAN:

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

Course outcomes (Course Skill Set)

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

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

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- EntrepreneurshipDevelopment by S.S.Khanka S.Chand &Co, 2006.
- PracticalApproachtoIPR by Rachana SinghPuri, IKIntl. Ltd. 2009.
- Bioethics&Biosafety by RRallapalli &GeethaBali, APHPublication, 2007.
- Bioethics&Biosaftey by SateeshM K, IKPublishers, 2008.
- Intellectual PropertyRightsinthe WTOand developingcountry, by WatalJayashree, OxfordUniversityPress 2001.

Web links and Video Lectures (e-Resources):

- https://www.coursera.org/courses?query=regulatory%20affairs
- https://www.ilearngira.com/courses/free-regulatory-affairs-e-learning/
- https://www.coursera.org/courses?query=startup
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://www.digitalindia.gov.in/
- https://www.makeinindia.com/

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

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

EXTRACTION METHODS AND HERBAL PRODUCTS			
Course Code	21BT582	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To Understand the various extraction processes.
- To Understand classification and isolation of phytoconstituents.
- To Understand the aspects of quality control related to herbal extracts/products.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

HISTORY HERBAL DRUGS :

Definition, history, scope and development of herbal drugs, Sources of Drugs – Plants, Animals, Marine & Tissue culture Organized drugs, unorganized drugs (dried latex, dried juices, dried extracts, gums and mucilages, oleoresins and oleo-gum -resins).

Module-2 (3 Hours)

EXTRACTION METHODS:

Introduction, Importance of herbs, Extractions- Maceration, Infusion, Digestion, Decoction, Percolation, Soxhlet extraction, Microwave-assisted extraction, Ultrasound-assisted extraction, super critical fluid extraction.Extraction of essential oils.

Module-3 (3 Hours)

EXTRACTION METHODS FOR SPECIFIC PHYTOCHEMICALS:

Methods of extraction for extracting specific phytoconstituent such as, alkaloids, carotenoids, fixed oils, fats, waxes, glycosides, phenolic compounds, proteins, polysaccharides.

Module-4 (3 Hours)

FACTORS AFFECTING EXTRACTION FROM HERBS:

Types of Extracts - aqueous extracts (Decoction, Infusion, Digestion, Tinctures, Liquid extracts, Soft extracts, Dry extracts) Raw Materials – particle size, shape and porosity of solid samples, size reduction procedure, storage, Choice of Solvent several aspects for selecting solvents such as solvent power (selectivity), boiling temperature, reactivity, viscosity, safety, cost, vapor pressure, and recovery.

Module-5 (3 Hours)

QUALITY CONTROL OF EXTRACTED PRODUCTS:

Introduction, Quality Control of Medicinal Plants and their Products , Biological and Chemical Standardization of Drugs-Chemical Standardization and Markers, Analytical Techniques for Quantifying a Marker, Validation of Analytical Procedures, HPLC and HPTLC in quality control of herbal product evaluation (with a case study).

Course outcomes (Course Skill Set)

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

- Demonstrate the utilization of herbs as medicine for specific ailments.
- Extract and isolate the therapeutically active constituents from herbs.
- Apply the conventional methods for assessing the quality of herbal extracts/products with established authentic standards.

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- Phytochemical Methods : A Guide To Modern Techniques Of Plant Analysis, Harborne J.B. Chapman and Hall Press, 1998.
- Extraction technologies for medicinal and aromatic plants, by Suckdev Swami Handa, Suman Preet Singh Khanuja, Gennaro Longo, and Dev Dutt Rakesh. United Nations Industrial Development Organization.UNIDO Publications.2008.
- Quality Control Methods For Medicinal Plant Materials, World Health Organization. 1998.
- Textbook Of Pharmacognosy And Phytochemistry, Edwin And Edwin, CBS Publication, 2010.
- Textbook Of Pharmacognosy And Phytochemistry, Jarald E.E., CBS Publisher, 2018.
- Natural Products Chemistry Paperback by J. Singh , Ali, Jaya Singh, Pragati Prakashan, 2010.
- Plant Drug Analysis by Wagner, Springer Verlag Publication, 2009.

Web links and Video Lectures (e-Resources):

- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://www.udemy.com/course/how-to-create-herbal-extracts-tinctures-salves-and-more/
- https://www.coursera.org/courses?query=herbal%20medicine
- https://www.youtube.com/watch?v=OhItAlUzwUY
- https://www.youtube.com/watch?v=-mYTaUJtle0
- https://www.youtube.com/watch?v=sIlGJz1wdPk
- https://www.youtube.com/watch?v=sIlGJz1wdPk
- https://www.youtube.com/watch?v=95vx4RRZlmE

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

- Demonstration of types of herbal extracts from different parts of the plants
- Demonstration of various extraction methods.
- Demonstration of HPLC and GCMS for quality assurance of herbal extracts/products

MODELING AND SIMULATIONS IN BIOLOGY			
Course Code	21BT583	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

- To Understand the basics of modelling and simualtions for specific problems in Biology.
- To learn the three steps (i) formulate and construct a mathematical model (ii) mathematicallyanalyze and apply a model, and (iii) interpret and evaluate the results in the context of the experimental knowledge.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

MODELS OF SYSTEM:

Systems, models modelling, classification, constraint on model structure, misuses of model. Modelling process Qualitative & Quantitative Model Formulation. Numerical Techniques. Parameter Estimation. Model Validation, Analysis. Uses of modelling including examples for e.g. batch reactor models, pandemic models etc.

Module-2 (3 Hours)

STRUCTURE OF MODELS AND MODEL OBJECTIVES:

Simple algebraic model construction e.g microbial growth and decay kinetics in an activated sludge process, Variables and parameters, Predictive study based on parameter changes. Applications: Photosynthesis & Plant Growth, Hormonal Control, Population and Individual, Chemostat, Diseases.

Module-3 (3 Hours)

MODELING MOLECULAR PROCESSES IN CELL :

Modeling MolecularReceptor-Ligand Interactions, Modeling Enzymatic Processes, Modeling Transcription and Translation processes Modeling of Biochemical Systems, Specific Biochemical Systems. Model Fitting. Analysis of High Throughput Data. Gene Expression model. Stochastic Systems and variability. Optimality and Evolution Simulation.

Module-4 (3 Hours)

SIMULATION PERSPECTIVE:

Continuous, Discrete, Hybrid discrete/continuous. Numeric Consideration – Errors, Differential Equations and Integration, Random Numbers. Algorithms – Monte Carlo Method, Metropolis Algorithm. Assumptions in biomolecular simulation.

Module-5 (3 Hours)

MOLECULAR DYNAMICS SIMULATION:

Idea of MD, structure of MD code (Initialization, force computation, numerical integration of Newton equation of motion(verlet algorithm), constraints in MD (RATTLE, SHAKE)), MD program packages (CHARMM, NAMD, AMBER).

Course outcomes (Course Skill Set)

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

- Detailthe basic aspects of modelling and simualtions for specific problems in Biology.
- Apply the key steps of problem formulation, mathematical modeling, simulation for specif case suidies.
- Deduce the inferences from these theoretical studies and compare them with experimental results.

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

- Biological Modeling and Simulation. Russell Schwartz. MIT Press: Cambridge, MA, 2008.
- Computer Simulation in Biology: a BASIC introduction. Keen, R.E. and Spain, J.D Wiley-Liss. 1991.
- Modeling Biological Systems: Principles and Applications. Haefner, James W. Springer, 2005.
- Modeling and Computer Simulation, Dragan Cvetković, Immtech Open, 2019.
- Modeling Life The Mathematics of Biological Systems, Alan Garfinkel, Jane Shevtsov, Yina Guo Alan Garfinkel, Jane Shevtsov, Yina Guo, 2017.

Web links and Video Lectures (e-Resources):

- https://www.ebi.ac.uk/training/search-results?query=molecular-modelling&domain=ebiweb_training&page=1&facets=
- https://www.learntoupgrade.com/s/store/courses/description/Molecular-Modelling
- https://nptel.ac.in/courses/104101095
- https://nanohub.org/resources/7570/share
- https://ocw.mit.edu/courses/3-320-atomistic-computer-modeling-of-materials-sma-5107-spring-2005/resources/lecture-13-molecular-dynamics-i/
- https://www.coursera.org/lecture/dense-gases-liquids-solids/molecular-dynamics-h2Mtp
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
- https://nptel.ac.in/courses/102103056

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

- AV presentation by students (on specific topics)
- Online surprise quizzes
- Collection of case studies based on research findings

GOOD MANUFACTURING AND LABORATORY PRACTICES			
Course Code	21BT584	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:0:1	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	01

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1 (3 Hours)

INTRODUCTION:

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

Module-2 (3 Hours)

GOOD MANUFACTURING PRACTICE :

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

Module-3 (3 Hours)

GOOD LABORATORY PRACTICES:

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

Module-4 (3 Hours)

INTERNATIONAL COUNCIL ON HARMONISATION GUIDELINES (ICH):

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

Module-5 (3 Hours)

VALIDATION:

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

Course outcomes (Course Skill Set)

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

- Apply principles of biology & basic management to comprehend the aspects of GLP, GMP & GCP
- Identify situations wherein deviations in regulatory compliance have occurred on the basis of case examples/studies
- Corelate & distinguish between the compliance requirements for GLP,GMP & GCP in their respective contexts

Assessment Details fboth CIE and SEE)

Methods of CIE need to be defined topic wise i.e.- Tests, MCQ, Quizzes, Seminar or micro project/Course Project, Term'Paper)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

The student has to obtain a minimum of 35% of maximum marks in SEE and a minimum of 40% of maximum marks in CIE. Semester End Exam (SEE) is conducted for 50 marks (One hour duration).

Based on this grading will be awarded.

The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE [Continuous Internal Evaluation] and SEE [Semester End Examination] taken together.

Continuous Internal Evaluation:

Three Unit Tests each of 20 Marks (duration 01 hour)

First test at the end of 5th week of the semester

Second test at the end of tlie 10th week of the semester

Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of 10 Marks.

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Report writing /Group discussion/Seminar any one of three suitably planned to attain the C0s and POs for **20 Marks (duration 0l hour)** at the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and 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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for subject SEE paperwill be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE is 0l hour.

Suggested Learning Resources:

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

Web links and Video Lectures (e-Resources):

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

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

- Industrial visit with assessment
- 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.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme of Teaching and Examinations 2021
Outcome-BasedEducation (OBE) and Choice Based Credit System (CBCS)
VI SEMESTER

BIOBUSINESS MANAGEMENT AND ENTREPRENEURSHIP			
Course Code	21BT61	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Tomake the students learnabouttheprinciples of Biobusinessmanagement.
- To enable the students understand the concepts of IPR, Bioethics, Biosafety and Regulations.
- Tomotivate the studentsexplorevarious entrepreneurial opportunities.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

BIOENTERPREUNERSHIP:

Introductiontobio-business,fromtheIndiancontext,SWOTanalysisofbio-business.Ownership,DevelopmentofEntrepreneurship;StagesinentrepreneurialprocessRoleofentrepreneursinEconomicDevelopment; Entrepreneurship in India; Entrepreneurship, its barriers. Small scale industries: Definition;Characteristics;Needandrationale;Objectives;Scope;MarketFeasibilityStudy;TechnicalFeasibilityStudy; Financial FeasibilityStudy&Social FeasibilityStudy.Globalbiobusiness andindustryfuturetrends.

Module-2 (8 Hours)

ENTREPRENEURSHIPOPPORTUNITYINAGRIBIOTECHNOLOGY:

Business opportunity, Essential requirement, marketing, strategies, schemes, challenges and scope-with casestudyonPlantcellandtissueculturetechnique,polyhouseculture.Herbalbulkdrugproduction,Nutraceuticals,valueadded herbalproducts.Bioethanolproductionusing Agriwaste,Algalsource.Integration ofsystembiologyforagriculturalapplications.BiosensordevelopmentinAgrimanagement.

Module-3 (8 Hours)

ENTREPRENEURSHIPOPPORTUNITYININDUSTRIALBIOTECHNOLOGY:

Business opportunity, Essentialrequirement,marketingstrategies,schemes,challengesandscope-withcasestudy-PollutionmonitoringandBioremediationforIndustrialpollutants,Pesticides,Herbicidesetc.Integratedcompostproduction-microbe enriched compost.Bio pesticide/insecticide production. Fermented products-probiotic andprebiotics.Stemcellproduction,stemcellbank,contractresearch.Productionofmonoclonal/polyclonal antibodies,Singlecellproteinandsecondarymetaboliteproduction.Contactresearchinmicrobialgenomics.

Module-4 (8 Hours)

PROJECT MANAGEMENT, IPR AND STARTUP SCHEMES:

Building Biotech business challenges in Indian context-biotech partners (BICEPS, BIRAC,DBT, Incubationcenters.Etc.,),operationalbiotechparksinIndia.IndianCompanyactforBiobusiness-schemesandsubsidies. MeaningofProject;ProjectIdentification;ProjectSelection;ProjectReport;NeedandSignificance 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; TechnicalFeasibility Study;Financial Feasibility Study & Social FeasibilityStudy. Patentexpiry and Entrepreneurshipopportunity,Principlesof Technology leasing,licensing andtransfer,StartupschemesinIndiangovernment,Businessincubationsupportschemes,Successfulstart-ups-casestudy.

Module-5 (8 Hours)

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.

Course outcomes (Course Skill Set)

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

- Understand the importance of Bio-business and Entrepreneurial opportunities.
- Knowtheimportance ofbioethics,biosafetyand IPR in Bubusiness.
- Planaproject with aworkplan, budget andschedule.
- Exploit the opportunities under start-up schemes.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

First test at the end of 5th week of the semester

Second test at the end of the 10th week of the semester

Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

First assignment at the end of 4th week of the semester

Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally scaled down 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- PrinciplesofManagement by P.C.Tripathi, P.N.Reddy. TataMcGrawHill FifthEdition,2012.
- EntrepreneurshipDevelopment by S.S.Khanka. S.Chand &Co Publishing, 2006.
- PracticalApproachtoIPR by Rachana SinghPuri, IKIntl. Ltd. 2009.
- Bioethics & Biosafety by R Rallapalli & Geetha Bali. APH Publication, 2007.
- Bioethics&Biosaftey by SateeshM K, IKPublishers, 2008.
- Management Fundamentals -Concepts,Application,Skill Development by RobersLusier Cengage Learning, 1996.
- Intellectual PropertyRightsinthe WTOand developingcountry by WatalJayashree, OxfordUniversityPress,2001.

Web links and Video Lectures (e-Resources):

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

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

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

BIOPROCESS PRINCIPLES, CONTROL & AUTOMATION + LAB			
Course Code	21BT62	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- ToUnderstandthebasicsof processdynamics,principlesandinstrumentation.
- ToStudyvarioustypesofinput functionsandits response.
- ToStudythe differenttypesofcontrollers and their design stability aspects.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (10 Hours)

INSTRUMENTATION:

Instrumentation-principles,Introductiontoflow,pressure,temperatureandliquidlevelmeasurements,measurement of important physico-chemical and biochemical parameters, methods of on-line and off-linebiomassestimation,flow injectionanalysisformeasurementofsubstrates,productsandothermetabolites.On-linedataanalysisforstateandparameter estimationtechniquesforbiochemicalprocesses.

LAB EXERCISES:

- ❖ Characteristics of Transducers (Flow)
- ❖ Characteristics of Transducers (Pressure and Temperature)

Module-2 (10 Hours)

FIRSTORDERSYSTEMS:

Process characteristics, Laplace and inverse laplace transforms, first order systems – examples, mercury in glass thermometer,liquid level system, Mixing process (without reaction), CSTR with first order reaction, response of first order system for Step, Impulse, Linear and Sinusoidal changes in input. Conceptual numericals.

LAB EXERCISES:

- ❖ Dynamics of First order system (mercury thermometer) for step input and pulse input
- ❖ Dynamics of First order system (Single tank System) for step input and pulse input

Module-3 (10 Hours)

SECONDORDERSYSTEMS

Series of first order system: - Interactingandnon-interactingsystemsandtheirdynamicresponsetostep,inputs;conceptual numerical.

Secondordersystemswithtransferfunctions(spring-damper,controlvalve,U-tubemanometer),responseof secondordersystemtostep,impulse–Over-damped, Under-damped, Un-dampedandCriticallydamped for second ordersystem, Various terms used to describe under-damped system, Transportationlag.

LAB EXERCISES:

- Interacting System responses to step input and pulse input
- Non-interacting system responses to step input and pulse input

Module-4 (10 Hours)

CONTROLLERSANDFINALCONTROLELEMENTS

Actuators, Positioners, Valve body, Valve plugs, Characteristics of final control elements (Transfer function for control valve), controllers – twoposition control, proportional control, derivative control, integral control, P-I (proportional-integral) control, P-D(proportional-derivative)control,P-I-D(proportional-integral-derivative)control,Blockdiagrams rules and deduction, servo andregulatoryproblems,conceptualnumericals.

LAB EXERCISES:

- Temperature controller – responses to set point / load change
- Pressure controller – responses to set point / load change
- Effect of agitation on DO and OD

Module-5 (10 Hours)

CONTROLLER DESIGN AND STABILITY:

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

LAB EXERCISES

- pH controller – responses to set point / load change
- Flow controller – responses to set point / load change

Course outcomes (Course Skill Set)

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

- Elaboratethebasicsofprocessprinciples, dynamics,andinstrumentation.
- Apply varioustypesof input functionsandstudy itsresponse.
- Performstudies ondifferenttypesof controllers for their design and stability aspects

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

Two Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Scaled-down marks of two tests and two assignments added will be CIE marks for the theory component of IPCC for **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 **(duration 02/03 hours)** at the end of the 15th week of the semester /after

completion of all the experiments (whichever is early) 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)

16. The question paper will have ten questions. Each question is set for 20 marks.Marks scorded shall be proportionally scaled down to 50 Marks
17. 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.
18. 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 12 (40% of maximum marks-30) in the theory component and 08 (40% 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 35% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.

Suggested Learning Resources:

- ProcessSystemanalysisandControl byDonaldRCoughanowr,McGraw-Hill,2013.
- ChemicalProcessControl byGeorgeStephanopoulos,Prentice-HallofIndia,1982.
- BioprocessEngineeringPrinciples byPaulineM.Doran, AcademicPress,2011.
- BiochemicalEngineeringFundamentals byBaileyand Ollis, McgrawHill,2nd Edition,2001.
- Essentialsof ProcessControl byLuybenandLuyben, McGraw-HillEducation,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.

ENZYME TECHNOLOGY			
Course Code	21BT63	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Tounderstandtheclassification, catalytic actions and diverse applications of enzymes.
- Tounderstandthetechniques and protocols related to purification, activity, immobilization and engineering ofenzymes.
- To understand the kineticsofenzyme catalyzed reactions.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION:

Introduction to enzymes, Classification, Sources, Strategies of purification of enzymes, molecular weightdetermination,Mechanismofenzymecatalysis(Acid-base,Covalent,Metalioncatalysis,Substratestrain&entropyeffects),criteriaofpurityandcharacterizationofenzymes.AdvantagesofBiocatalystvsChemicalcatalysts,IsolatedEnzymesversuswholecellsystems,Applicationofenzymesindifferent industry.

Module-2 (8 Hours)

ENZYMEASSAY ANDCO-ENZYMES:

Enzyme and isoenzyme measurement methods with two examples (fixed incubation and kinetic methods);Enzymes in immunoassay techniques, Methods for investigating the kinetics of Enzyme catalyzed reactions: Initialvelocitystudies (MM and LB plots),rapid-reactiontechniques.Standardizationandoptimizationmethods,stabilityof enzymes (pH, Temperature).Mechanismofaction of coenzymes(NAD/NADP,FAD/FADH2,PLP,CoenzymeA,TPP,Biotin). Allosteric Enzymes.

Module-3 (8 Hours)

ENZYMATICTECHNIQUES:

Techniques of enzyme immobilization; kinetics of immobilized enzymes, effect of solute, partition &diffusiononthekineticsofimmobilizedenzymes,designandconfigurationofimmobilizedenzymereactors;applications ofimmobilizedenzymetechnology,Economicargumentforimmobilization.Biocatalystsfromextremophiles microorganisms(extremozymes) and their applications.

Module-4 (8 Hours)

ENZYMEENGINEERING:

The design and construction of novel enzymes, artificial enzymes, Host Guest Complexation chemistry andenzyme design using steroid templates. Activators and Inhibitors, In vitro Biotransformation of drugs (hydroxylation of Steroids),Therapeuticenzymes -Acetylcholinesteraseandpseudocholinesterase,Angiotensinconvertingenzyme(ACE)andInhibitors,HMGCoAreductaseinhibitors,glucose-6-phosphatedehydrogenase(GPD), Immuno-reactive trypsinogen(IRT)andamylaseisoenzymes.

Module-5 (8 Hours)

APPLICATIONS:

Importanceofenzymesindiagnostics,EnzymepatternindiseaseslikeMyocardialinfarctions(SGOT,SGPT& LDH). Isoenzymes (CK, LD, ALP). Use of isozymes as markers in cancer and other diseases. Enzymes usedindetergents,useofproteasesinfood,leatherandwoolindustries;methodsinvolvedinproductionofglucose syrup from starch (using starch hydrolyzing enzymes), production of maltose and sucrose, glucose fromcellulose,usesoflactaseindairyindustry, glucoseoxidaseand catalase infood industry;

Course outcomes (Course Skill Set)

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

- Describe theclassification, catalytic actions and divese applications of enzymes.
- Applythe techaniques and protocols realted to purification, activity, immobilization and engineering ofenzymes.
- Elaborate about the kineticsofenzyme catalyzed reactions.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks (duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be scaled down 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- EnzymeTechnology byMartin Chaplinand ChristopherBucke,CambridgeUniversityPress,1990.
- Enzymes byDixon and Webb, AcademicPress2nd Edition,1964.
- Principles of Enzymology fortechnologicalApplications byButterworthHeinemann.Oxford UniversityPress,1993.
- PurifyingProteinsforProteomics byRichardJ Simpson, IKInternational, 2003.
- FundamentsofEnzymology by Pricesand Stevens. OxfordPress. ThirdEdition, 1999.
- Enzymesin Industry:Production andApplications by W.Gerhartz. Wiley-VCHPublishers 3rdEdition, 2007.

Web links and Video Lectures (e-Resources):

- https://www.classcentral.com/course/swayam-enzymology-19860
- https://www.udemy.com/course/enzymology/
- https://onlinecourses.swayam2.ac.in/cec20_bt20/preview
- https://www.coursera.org/lecture/industrial-biotech/engineering-enzymes-i-directed-evolution-b8hmZ
- https://stores.biotecnika.org/products/enzymology-certification-courseVTU 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)
- Collection of case studies based on research findings
- Model making and Poster presentations on specific case studies.

PROFESSIONAL ELECTIVE COURSE - I

HUMAN ANATOMY AND PHYSIOLOGY			
Course Code	21BT641	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To understand the fundamentals of Anatomy & Physiology.
- To provide an in-depth instruction in the organization, structures, and functions of the human body.
- To learn about the pathology of each body system and how they interrelate to maintain homeostasis.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION TO HUMAN BODY:

Definition and scope of anatomy and physiology, levels of structural organization and body systems, basic life processes, homeostasis, basic anatomical terminology.

Skeletal system: Divisions of skeletal system, types of bone, salient features and functions of bones of axial and appendicular skeletal system Organization of skeletal muscle.

Lymphatic system: Lymphatic organs and tissues, lymphatic vessels, lymph circulation and functions of lymphatic system

Peripheral nervous system: Classification of peripheral nervous system: Structure and functions of sympathetic and parasympathetic nervous system. Origin and functions of spinal and cranial nerves.

Special senses: Structure and functions of eye, ear, nose and tongue and their disorders.

Module-2 (8 Hours)

TISSUES, SKELETAL & MUSCULAR SYSTEM:

Epithelial tissue, Connective tissues (Blood, Bones, cartilages), Muscular tissues, Nervous tissue, Cartilage and bone; Comparison between cartilage and bone; Functions of skeletal system; Joints; Muscles of limb movement. Principal types of muscles; General properties of muscles; Mechanism of muscle contraction and relaxation, Red and white muscle fibers.

Module-3 (8 Hours)

DIGESTIVE SYSTEM:

Overview of digestive system, functional anatomy of digestive system: mouth, pharynx, oesophagus, the stomach the small and large intestine. Digestive glands, Enzymes; Physiology of Digestion and Absorption.

EXCRETORY SYSTEM: Methods of excretion; Physiological processes involved in excretion; Kidneys; Anatomy andphysiology, Nephron and its structure. Functions of nephron; Nephron physiology and mechanism of urine formation; Regulation of urine formation; Osmoregulation by kidney.

Module-4 (8 Hours)

RESPIRATORY & CIRCULATORY SYSTEM:

Structure of respiratory organs; Mechanism of breathing; pulmonary air volumes, Gas exchange in the lungs. Kinds of respiration; Transport of respiratory gases in the blood Structure, Composition and functions of blood. Blood Groups and Rh factor. Blood clotting mechanism, Basic anatomy of the heart, Physiology of heart, blood vessels and circulation. Basic understanding of Cardiac cycle, electrocardiogram.Blood pressure and its regulation. Brief outline of cardiovascular disorder like hypertension, hypotension, arteriosclerosis, angina, myocardial infarction, congestive heart failure and cardiac arrhythmias.

Module-5 (8 Hours)

NERVOUS AND ENDOCRINE SYSTEM:

Role of nervous system; Types of neurons. Types of glial cells and its function. Main properties of nervous tissue Mode of action of nerves; Conduction of nerve impulses; Central nervous system; The brain; The spinal cord; Peripheral nervous system Endocrine systems of vertebrates; Pituitary gland; Thyroid gland; Parathyroid gland; Pancreas; Adrenal or suprarenal glands; Sex glands; Gastrointestinal mucosa; Thymus gland; Pineal gland; Summary of different endocrine glands; their hormones and influence; Summary of the effect of hyper secretion and hyposecretion of some important endocrine glands.

Course outcomes (Course Skill Set)

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

- Apply the basic knowledge of physiology as a process of various human anatonomical systems.
- Co-relate functioning of different tissue and organ systems in the context of health and disease.
- Analyze the interface between different organ systems essential for maintenance of health & well-being.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Human Physiology by Stuart Fox, Krista Rompolski, McGraw-Hill eBook. 16th Edition, 2022.
- Ross and Wilson Anatomy and Physiology in Health and Illness byAnne Waugh, Allison Grant.Churchill Livingstone 11th Edition, 2010.
- Fundamentals of Human Physiology by Lauralee Sherwood Brooks/Cole, Belmont 4thEdn, 2012.
- Anatomy and Physiology for nurses (including notes on their clinical application) by Evelyn Pearce. JAYPEE Publishers,1993.
- Essentials of human physiology for pharmacy by Laurie Kelly Mccorry. CRC Press 2nd Edn, 2008.
- Concise Medical Physiology by Sujit K Chaudhari, New Central Book Agency Pvt. Ltd 5th Edn, 2003.

Web links and Video Lectures (e-Resources):

- https://www.udemy.com/course/anatomy-and-physiology-1-the-foundations/
- https://www.mindluster.com/certificate/123?
- https://www.edx.org/learn/human-anatomy
- https://oli.cmu.edu/courses/anatomy-physiology-i-ii-v2-academic/
- https://www.coursera.org/courses?query=anatomy
- 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.

BIOCHEMICAL THERMODYNAMICS AND BIOENERGETICS			
Course Code	21BT642	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Toknowthebasicconceptsof thermodynamicsinprocessindustry.
- Tounderstandthesignificanceof zeroth,I,II& IIIlawsof thermodynamics.
- To understandthe thermodynamic properties of fluids, their equationsofstate and applications.
- Torealizetheimportanceof Biochemical Energetics.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

BASIC CONCEPTS & LAWS OF THERMODYNAMICS:

System,Surrounding&Processes,ClosedandOpensystems,StateProperties,Intensive&ExtensivePropertiesStateandPathfunctions,Equilibrium state, enthalpy, specific heat, ReversibleandIrreversibleprocesses.ZerothlawofThermodynamics, General statement of First law of Thermodynamics, First law for Cyclic Process, Non- FlowProcess, Flow process, Heat capacity. Heat reservoir and Heat engines. General statements of the second law,Conceptofentropy,Carnotprinciple,Calculationofentropychanges,ThirdlawofThermodynamics.Numericals.

Module-2 (8 Hours)

PVTBEHAVIOURANDCOMPRESSIBILITYCHARTS:

PVT Behavior of pure fluids, equations of state & ideal gas law, Processes involving ideal gas law: Constantvolume, constant pressure, constant temperature, adiabatic & polytrophic processes, Equations of state forreal gases: Vander Waals equation, Redlich-Kwong equation, Peng-Robinson equation, virial equation.Numericals.Principlesofcorrespondingstates,generalizedcompressibilitycharts,Heateffectsaccompanyingchemical reactions,Standardheatofreaction,formation,combustion,Hess'slawofconstant heatsummation,effectoftemperatureonstandardheat ofreaction.Numericals.

Module-3 (8 Hours)

PROPERTIESOFPUREFLUIDS:

Reference properties, energy properties, derived properties, work function, Helmholtz free energy, Gibbs freeenergy, Relationships among thermodynamic Properties: Exact differential equations, fundamental propertyrelations, Maxwell's equations, Clapeyron equations, modified equations for internal energy (U) &

enthalpy(H),EffectoftemperatureonU,H&Entropy(S).Gibbs-Helmholtzequation.ConceptofFugacity,Fugacity coefficient, effect of temperature and pressure on fugacity, Determination of fugacity of pure gases, solids andliquids,Activity:Effectof temperature andpressure onactivity. Numericals.

Module-4 (8 Hours)

PROPERTIESOFSOLUTIONS&PHASEEQUILIBRIA:

Partial molar properties of solution and its determination , chemical potential –effect of temperature andpressure, lewis – randall rule, Raoults law for ideal solutions, fugacity in solutions, Henry's law and dilutesolutions, ideal behavior ofrealsolutionsand Henry'slaw, Activity in solutions, Activity coefficients: effect of temperature and pressure, Gibbs - Duhem equation, calculation of activity coefficients using Gibbs-Duhemequation. Numericals. Criteria of phase Equilibria, criterion of stability, Duhem's theorem, Vapour-Liquid Equilibra in ideal andnon-Ideal solutions. Numericals.

Module-5 (8 Hours)

BIOCHEMICALENERGETICS:

Bioenergetics and Energy Flow, Coupled reactionsandenergy richcompounds,ReactionStoichiometry,criteriaofbiochemicalreactionequilibrium,equilibriumconstantandstandardfreeenergychange,effectoftemperature,pressureonequilibrium constants and other- factors affecting equilibrium conversion – Le – chatelier's principle, liquidphasereactions,heterogeneousbioreaction equilibria,phaseruleforreactingsystems,Liquid-LiquidEquilibriumdiagrams. Numericals.

Course outcomes (Course Skill Set)

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

- Describetheconceptsofsystem,surrounding,process,entropy and lawsof thermodynamics.
- ExplainthePVTbehaviourof purefluids&gasesand deriveequationsofstateforreal gases.
- Determinethepartial molarproperties andactivitycoefficientsofthesolution.
- Illustratethephaseruleforreactingsystemsandeffectof temperature,pressureonequilibrium constants
- Correlate these aspects to biochemical reactions and energetics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall

be proportionally reduced to 50 marks

Suggested Learning Resources:

- Introduction to ChemicalEngineeringthermodynamics byJ.M.Smith, H.C. Van Ness& M.M. Abbott. MGH Publication, 6th Editon. 2003.
- BiochemicalCalculations by IrwinH.Segel. JohnWiley&Sons 2nd Edition.1976.
- EngineeringThermodynamics by RK Singal and Mridual Singal.IKIntl.2010.
- ChemicalEngineering Thermodynamics by Y.V.C. Rao, NewAgeInternational. 1997.
- ATextbookof Chemical EngineeringThermodynamics by K.V.Narayanan. PHI 1st Edition, 2001.

Web links and Video Lectures (e-Resources):

- https://www.classcentral.com/subject/thermodynamics
- https://learncheme.com/screencasts/kinetics-reactor-design/
- https://www.udemy.com/course/an-introduction-to-mechanical-engineering-thermodynamics/?
- 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
- Poster presentations on specific case studies.

BIOLOGICAL DATA MANAGEMENT AND ANALYSIS			
Course Code	21BT643	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Tounderstandthetypesofdatabasesandtheirdataformats.
- TostudytheimportanceofvariousOmicsexperiments,datagenerationtechniques,datamanagement strategies andtheireffective utilization.
- Tocomprehendthenatureof ClinicalData,itsManagement andrelatedbasicoperations.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

DATABASES:

Databases Overview: PubMed, GenBank, EMBL, DDBJ, SwissProt, Uniprot, TrEMBL, PDB, EST, SCOP,Pfam, SMART; Interaction Databases, (BIND, STRING), Pathway Databases, (KEGG), Signal Transductiondatabase (STKE), Organism Specific database (Yeast, OMIM, HGNC, Flybase, wormbase), Genome databases(GOLD),Pathogen database (PATRIC), About the January Issue of Nucleic Acids Research journal and thecatalog of biological databases. Data Models: Relational, Object Oriented. Hierarchical, Semi-structured,Unstructured(e.g.Text),Model ofQuerying: SQL,Information Integration,DataMiningforvarious applications.

Module-2 (8 Hours)

MICROARRAY DATA ANALYSIS:

Why areMicroArray Important? What is a DNA MicroArray?, Designing a MicroArray Experiment-TheBasic steps, Types of MicroArray. NCBI and MicroArray Data Management, GEO (Gene ExpressionOmnibus), MAML, The benefits of GEO and MAML, The Promise of MicroArray Technology in TreatingDisease.MicroArrayDataPreprocessing,Datanormalization,MeasuringDissimilarityofExpressionPattern-Distance Motifs and Dissimilarity measures, Visualizing MicroArray Data. Principal ComponentAnalysis,MicroArray Data. NCBI and MicroArray Data Management, GEO (Gene Expression Omnibus),MAML,ThebenefitsofGEOandMAML,ThePromiseofMicroArrayTechnologyinTreatingDiseases. DataMiningforspecificapplications.

Module-3 (8 Hours)

NGS DATA ALAYSIS:

Importance of Omic Technologies, NGS data collection and Bioinformatics principles. Data standards for omicdata:thebasisofdatasharingandreuse.Omicdatamanagementandannotation.Dataandknowledgemanagement in cross omics research projects. Statistical analysis principles for omic data. Statistical methodsand models for bridging Omics data levels. Analysis of time course omic datasets. The use and abuse of Omes.ComputationalanalysisofHighThroughputSequencingDataAnalysisofSNPincasecontrolstudies. BioinformaticsforRNomics.TheENCODEproject consortium.DataMiningforspecificapplications.

Module-4 (8 Hours)

OMICSDATAMANAGEMENT:

Qualitative and Quantitative Proteomics. Bioinformatics for Mass spectrometry and 2D gels. Concepts ofMetabolomics, Transcriptomics and Interactomics. Computational Analysis Workflows for Protein Array DataInterpretation. Integration, Warehousing, and Analysis Strategies of Data. Integration.Data for signalingpathways,interactomereconstructionandfunctionalanalysis.NetworkInferencefromTimeDependentdata. Omics-Bioinformatics in the context of diseases, Omics-Based Identification of Pathophysiological Processes.DataMiningMethodsin Omics-Based BiomarkerDiscovery.

Module-5 (8 Hours)

CLINICALDATAANALYTICS:

OverviewofClinicalDataManagementplan,CRF designconsideration,DatacleaningissuesandDataprocessing issues, Database design consideration: Making design decisions, Operating procedures for databasedesign,Dealing with problem data, modifying data, Quality control through database audits, Identifying andmanaging discrepancies, Quality control and assurance, Managing laboratory data, Storing lab data, Creatingreportandtransferringdata,Clinicaldatamanagementsystems,Electronicdatacapturesystems,System Validation, Migrating, data integration and archiving data. Data Normalization and Querying Techniques. DataMiningfordesired applications.

Course outcomes (Course Skill Set)

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

- Decipherthe differencesinthetypes ofdatabasesand theirdata formats.
- Applytheknowledgeofvariousomicsexperiments,datageneration techniques,datamanagement concepts, dataminingstrategiesandtheireffective utilization.
- Comprehend theaspectsof ClinicalData,dataintegration,dataManagement,dataminingfordefinedapplications.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- BioinformaticsDatabaseSystems by Byronet al., CRCPress, 2017.
- DataMiningin Bioinformatics by Wangetal.(eds), Springer, 2005.
- Computational BiologyandGenomeInformatics by Wangetal.(eds) WorldScientific, 2003.
- PatternDiscoveryinBiomolecularData:Tools,Techniquesand Applications by Wangetal.(eds)Oxford UniversityPress, 1999.
- MicroarrayTechnologyandIts Applications UweR.Muller, DanV. Nicolau Springer, 2005.
- MicroarrayBioinformatics byDovStekel, CambridgeUniversityPress, 2003.
- Data Analysis tools for DNAMicroarray by Draghic S.,Chapman Hall/ CRCPress, 2002.
- OMICS: Biomedical Perspectives and Applications by Debmalya Barh, Kenneth Blum, Margaret A.Madigan, CRC Press, 2017.

Web links and Video Lectures (e-Resources):

- https://www.udemy.com/topic/clinical-research/?
- https://www.coursary.com/search?
- https://www.coursera.org/learn/clinical-data-management
- https://www.udemy.com/course/clinical-data-management-cdm-online-course/
- 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.

STEM CELL TECHNOLOGY			
Course Code	21BT644	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To provide a broad overview of stem cells, reviewing the different types and how they are cultured.
- To familiarize the students with stem cell technology and its bioengineering applications.
- To understand the potential of Stem cells towards treatment of human diseases.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

STEM CELLS AND TYPES:

Stem cells: Definition, Classification, Sources and Properties –Types of stem cells: methods of isolation, study of stem cells and their viability IPSC, embryonic stem cells, cancer stem cells. Preservations of Stem cell. Embryonic stem cell: Isolation, Culturing, Differentiation, Properties – Adult stem cell: Isolation, Culturing, Differentiation, Trans-differentiation, Plasticity, and Properties, Molecular mechanisms. fate mapping, application.

Module-2 (8 Hours)

STEM CELL MEDIA ANDREGENERATION:

Cell Culture Media, Cell culture methods, Cell isolation, selection, maintenance of primary and early passage cultures. Clinical potential of stem cells: Organ and tissue regeneration. Germ cells, hematopoietic organs, and kidney, cord blood transplantation, donor selection, HLA matching, patient selection, peripheral blood and Hematopoietic Stem Cell Disorders and bone marrow transplantation, Stem cell Techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging.

Module-3 (8 Hours)

STEM CELLS IN PLANTS AND ANIMALS:

Stem cell and founder zones in plants–particulary their roots– stem cells of shoot meristems of higher plants. Skeletal muscle stem cell – Mammary stem cells – intestinal stem cells – keratinocyte stem cells of cornea – skin and hair follicles –tumour stem cells.

Module-4 (8 Hours)

STEM CELL IN DRUG DISCOVERY AND TISSUE ENGINEERING:

Target identification, Manipulating differentiation pathways, stem cell therapy Vs cell protection, stem cell in cellular assays for screening – stem cell based drug discovery, drug screening and toxicology. Tissue engineering application – production of complete organ - kidney – eyes - heart – brain.

Module-5 (8 Hours)

APPLICATIONS AND ETHICAL ISSUES :

Gene therapy – genetically engineered stem cells – stem cells and Animal cloning – transgenic animals and stem cells – Therapeutic applications – Cardiovascular treatment, Cell deficiency therapy, treatment of brain related defects. Neurological disorder (AD,PD),limb amputation, heart disease - spinal cord injuries – diabetes –burns - HLA typing-hepatic and pancreatic disorders. Stem cell policy and ethics, stem cell research: Hype, hope and controversy.

Course outcomes (Course Skill Set)

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

- Understand the basics of stem cell biology, the various types and their isolation and identification.
- Correlate stem cell technology in treatment of various diseases and disorders.
- Apply the basics of stem cells in drug discovery and tissue engineering in line with ethical considerations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Stem cells by C.S Potten., Elsevier, 2006.
- Essentials of Stem Cell Biology by Robert Lanza., fourth edition. Elsevier 2014.
- Stem cell biology and Gene Therapy by Peter Quesenberry., First Edition, Wiley-Liss, 1998.
- Embryonic Stem cells – Protocols by KursadTurksen., Second Edition Humana Press, 2002.
- Stem Cells: From Bench to Bedside by AriffBongso, EngHinLee., World Scientific Publishing Company, 2005.
- Stem cells in clinic and Research by Ali Gholamrezanezhad., Intech, 2013.

Web links and Video Lectures (e-Resources):

- https://www.coursera.org/learn/stem-cells
- https://online.stanford.edu/courses/xgen204-stem-cell-therapeutics
- https://www.classcentral.com/course/stem-cells-10745
- https://pll.harvard.edu/course/stem-cell-and-regenerative-biology-1?delta=3
- https://elearninguoa.org/course/health-nanotechnology-nanomedicine/stem-cells-and-regenerative-medicine
- https://www.stemcellscourse.com/
- 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.

OPEN ELECTIVE COURSE – I

ECOLOGY AND ECOSYSTEM			
Course Code	21BT651	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION:

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

Module-2 (8 Hours)

ECOLOGY:

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

Module-3 (8 Hours)

ENERGY FLOW AND TROPHIC DYNAMICS:

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

Module-4 (8 Hours)

POLLUTION AND ITS EFFECTS ON ECOLOGY:

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

Module-5 (8 Hours)

PRODUCTIVITY:

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

Course outcomes (Course Skill Set)

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

- Understand the importance of the ecosystem, different types and their impact on the environment.
- Correlate the energy flow in ecosystems to maintain ecological balance.

- Analyse the impact of Pollution on the Ecosystem.
- Appreciate the ethical context of environmental issues and the links between human and natural systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

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

Web links and Video Lectures (e-Resources):

- 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-the-environment-ecology-and-ecosystems/content-section
- https://teachers-ab.libguides.com/c.php?g=710613&p=5063458
  https://www.coursera.org/courses?query=food%20science
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

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

FOOD, NUTRITION AND HEALTH			
Course Code	21BT652	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

FOOD, NUTRITION AND HEALTH:

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

Module-2 (8 Hours)

BALANCED DIET AND NUTRITION:

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

Module-3 (8 Hours)

NUTRITIONAL DEFICIENCIES AND DISEASES:

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

Module-4 (8 Hours)

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

Module-5 (8 Hours)

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

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

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

Assessment Details (both CIE and SEE)
The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:
Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**
(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).
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:
Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Food Science byPotter, Norman. M. and Hotchkiss, Jospeh. N. 5th e book edition ,2021. CBS Publishers,
- Foods: Facts and Principles by Manay, S and Shadakshara Swamy M. 4 th Ed. New Age Publishers. 2004.
- Food Science by B. Srilakshmi, New Age Publishers, 2002.

- Food Processing Principles and Applications by Ramaswamy H and Marcott M. CRC Press. 2006.
- Food Chemistry by Meyer. New Age Publishers, 2004.

Web links and Video Lectures (e-Resources):

- 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:
- https://teachers-ab.libguides.com/c.php?g=710613&p=5063458
- https://www.coursera.org/courses?query=food%20science

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

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

FORENSIC SCIENCE			
Course Code	21BT653	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1(8 Hours)

INTRODUCTION:

Introduction to Forensics, Definition and scopes of forensics, History and chronology of the events in forensics, and important milestones in the forensics, importance and significance of court in forensics; procedure and protocol: Inquest and medical examiners systems, powers of courts, documentary evidences and witness, (Doctors guide to court), application of the forensics: Forensic anthropology, Forensic entomology, Forensic psychiatry, Forensic odontology. Forensic pathology: Rigor mortis, livor mortis, algor mortis.

Module-2(8 Hours)

CRIME LAB AND FORENSIC ANALYSIS:

Organization of crime lab at various levels in India (Center and State), facilities offered by various laboratories. Services of the crime lab, basic services of the crime lab, optional services. Crime scene- Identification (Race, Sex, Age), Preservation and record, methodic search for evidence. Analysis of the physical evidences- definition, importance and source of evidence, type, collection and preservation, expert unit men, handling, package and sealing of physical evidence, FRYE standard and DAUBERT criteria.

Module-3(8 Hours)

FORENSIC DIGITAL IMAGING, STATISTICS AND ENGINEERING: Digital imaging, acquisition of digital evidences, forensic imaging, maintaining chain of control with digital images, basic approach and process, digital videos, scanners, presenting pictures in the courtrooms, detecting compression and forgeries and maintaining records, analysis and recovery, advantages and disadvantages of digital imaging.
Probability, populations and samples, weight of evidence and the Bayesian likelihood ratio. Transfer evidence, application of statistics of forensic science. Forensic engineering DNA analysis, dactyloscopy- Definition, various events and its significance, fingerprints its classification and patterns (concept of LAW).

Module-4(8 Hours)

CYBER FORENSIC:
Introduction, history of computer forensics, Basics of computers, Media, Computer Forensic Lab, Forensic Computers, Mobile Units, Data Storage, collecting evidence from a single system, common mistakes in evidence collection, storing and retrieving data, processing the electronic crime scene, analysis of electronic data, forensic analysis of internet data, forensic investigation of internet communications, E-Mail analysis, mobile forensics. Corporate fraud,

Module-5(8 Hours)

TOXICOLOGY AND ETHICS IN FORENSIC SCIENCE:
Forensic toxicology,General Materials, Custodial Deaths, General Toxicology, Corrosive Poisons, Vegetable Alkaloid Poisons, Irritant Poisons, Non–Metallic& Metallic poisons, Inebriant Poisons Irrespirable Gases, Drug & Insecticides, Food Poisoning. Science and professional ethics: significance and limitations, code of conduct and code of ethics for forensics and their application, ethical requirement, ethical dilemmas and their resolutions.

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

- Describe the safety procedures and evidence handling at the crime scene and/or at the laboratory.
- Distinguish between different types of physical evidence and pattern evidence based upon approaches in forensic chemistry and biology.
- Analyse digital evidences and interpret the same via statistical means.
- Apply basics of biology in toxicological evidences without compromising on Ethical guidelines.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Criminalistics : An Introduction to Forensic Science by Richard Saferstein. Prentice Hall, 11th edition. 2014.
- Introduction to Forensic Sciences by William G Eckert, CRC Press 2nd edition, 2002.
- Principles of Forensic Toxicology by Barry Levine. AACC Press. 1999
- Textbook of Forensic Medicine and Toxicology by V.V. Pillay, Paras Medical Publishers 18th Ed.2017.
- Principles of Forensic Medicine by ApurbaNandy. New central book agency Ltd., 2010.
- Computer forensics: evidence collection and management by Robert C. Newman, Auerbach Publications 2007.
- Forensic Computer Crime Investigation by Thomas A Johnson, CRC Press, 2005.
- Introduction to Statistics for Forensic Scientists by David Lucy, Wiley publications 2005.

Web links and Video Lectures (e-Resources):

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

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

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

ROBOTICS IN HEALTHCAREAND AGRI TECH			
Course Code	21BT654	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To Provide knowledge on the applications of robotics in the field of health care and agriculture.
- To Learn about the sensor requirements for localization and tracking in medicineand agriculture.
- To Understand the design aspects of medical and agri-based robots.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION:

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

Module-2 (8 Hours)

LOCALIZATION AND TRACKING:

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

Module-3 (8 Hours)

REHABILITATION AND ROBOTS IN MEDICAL CARE:

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

Module-4 (8 Hours)

ROBOTS IN AGRI TECH:

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

Module-5 (8 Hours)

TECHNICAL CONSIDERATIONS:

Locomotion: Legged Mobile Robots, Wheeled Mobile Robots, Complex Wheels, Tracked Vehicles, Aquatic Vehicles, Flying Vehicles, Space Robots, Case studies.

Robot Kinematics: Coordinate frames, rotations, homogeneous coordinates, link coordinates, the direct kinematics problem, the inverse kinematics solution, Case studies.

Mobile Robot Kinematics: Kinematic Models and Constraints, Mobile Robot Maneuverability, Mobile Robot Workspace, Case studies.

Actuating: DC Motors, Gearing and Efficiency, RC Servo Motors, Stepping motors, Motor Control, Case studies.

Sensing I: Non-visual Sensors and Algorithms, Contact Sensors, Bumpers, Internal Sensors, Infrared Sensors, Sonar, Radar, Laser Range Finder, Lidar, Case studies.

Course outcomes (Course Skill Set)

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

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

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

Web links and Video Lectures (e-Resources):

- https://www.udemy.com/topic/robotics/
- https://www.coursera.org/courses?query=robotics
- https://www.edx.org/learn/robotics
- https://www.udemy.com/topic/robotics/
- https://www.futurelearn.com/subjects/it-and-computer-science-courses/ai-and-robotics
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

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

ENZYME TECHNOLOGY LAB			
Course Code	21BTL66	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2:0	SEE Marks	50
Credits	01	Exam Hours	03

Course objectives:

- To Understand the aspects involving isolation and purification of enzymes.
- To Understandthefundamentals of enzyme activity and the factors affectingenzymestability and kinetics.

Sl.NO	Experiments
1	Isolation of α- amylase enzyme from specific sources.
2	Partial purification of α- amylase via Ammonium Sulphate fraction.
3	Protein estimation (α- amylase) by Lowry's and Bradford methods
4	Determination of activity and specific activity of α- amylase.
5	Effect of substrate concentration on α- amylase.
6	Effect of Inhibitor on α- amylase.
7	Time course of α- amylase activity.
8	Effect of pH on α- amylase activity.
9	Effect of temperature on α- amylase activity.
10	Effect of metal ions and organic solvents on α- amylaseactivity.
11	α- amylase enzyme immobilization techniques and kinetics studies.
12	Determination of molecular weight of α- amylase by SDS-PAGE.

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

- Perform experiments related to enzyme isolation and purification.
- Perform experiments on different kinetic parameters and stability studies.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE).

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. Rubrics suggested in Annexure-II of Regulation book
- 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 15% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Rubrics suggested in Annexure-II of Regulation book

Suggested Learning Resources:

- EnzymeTechnology by Martin Chaplinand Christopher Bucke, CambridgeUniversityPress, 1990.
- Enzymes by Dixon and Webb, AcademicPress 2nd Edition,1964.
- Principles of Enzymology for technologicalApplications by Butterworth Heinemann. Oxford UniversityPress, 1993.
- PurifyingProteinsforProteomics by RichardJ Simpson, IKInternational, 2003.
- FundamentsofEnzymology by Pricesand Stevens. OxfordPress. ThirdEdition, 1999.
- Enzymesin Industry:Production andApplications by W.Gerhartz. Wiley-VCHPublishers 3rdEdition, 2007.

Web links and Video Lectures (e-Resources): ● https://www.youtube.com/watch?v=2sF11BlwvW8 ● https://www.youtube.com/watch?v=1_Nd0RBseDU ● https://www.vernier.com/video/enzyme-action-labquest/ ● https://www.khswaveriders.org/apps/video/watch.jsp?v=43181 ● https://www.stem.org.uk/resources/community/collection/492298/enzymes ● VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning ● Demos on experiments beyond the syllabus ● 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.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E. in BIOTECHNOLOGY
Scheme and Syllabus of Teaching and Examinations 2021
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
VII SEMESTER

UPSTREAM AND DOWNSTREAM BIOPROCESS TECHNOLOGY			
Course Code	21BT71	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To develop an understanding in students about the Upstream processes and the key aspects involved therein.
- To learn the various separation techniques in Downstram processing.
- To list the methods involved in product recovery and enrichment.
- To be able to deduce the methods for scaling up in bioprocess industries.

Teaching-Learning Process (General Instructions)

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

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

Module-1(8 Hours)

UPSTREAM PROCESSING (USP):

Basic principles, Techniques, general requirements of Plant cell / tissue culture techniques, Animal & Microbial Cell culture techniques. Strain improvement strategies and Product yield, Preservation of microbial culture, Elicitation. Fermentation:Introduction, types of fermentation Process, submerged and solid-state fermentation.Principle components of fermentor. Modes of fermentation: Batch, continuous and fed-batch.

Module-2(8 Hours)

FERMENTATION TECHNOLOGY FOR PRIMARY AND SECONDARY METABOLITES:

Microbial growth kinetics and Optimization of fermentation process and product yield. Production of primary and secondary metabolites. Process design criteria for various classes of by-products (high volume, low value products and low volume, high value products).Secondary metabolite production- Factors affecting secondary metabolites, industrial application of secondary metabolites. Production of alcoholic beverages and antibiotics.

Module-3(8 Hours)

DOWNSTREAM PROCESSING (DSP) AND PRIMARY SEPARATION TECHNIQUES:

Role of DSP. Challenges and requirements of by-product purification. Cell disruption methods for intracellular products, Separation techniques; flocculation and sedimentation, Centrifugation (ultra and differential), filtration methods and Precipitation methods with salts, organic solvents, and polymers, extractive separations. Aqueous two-phase extraction, supercritical extraction; In-situ product removal / integrated bioprocessing. Economics, cost cutting strategies in DSP.

Module-4(8 Hours)

PRODUCT ENRICHMENT & RECOVERY:

Chromatography- TLC, GLC, Ion Exchange, Gel Filtration Chromatography, Affinity Chromatography, HPLC – analytical and preparative./ Electrophoretic and hybrid separation technologies. Membrane separation- Design and configuration of membrane separation equipment; Solute polarization and cake formation in membrane ultra-filtration – causes, consequences and control techniques; Use of membrane diffusion, separation by solvent membranes; reverse osmosis. Case studies.

Module-5(8 Hours)

LAB TO INDUSTRIAL SCALING:

Scale Up concepts: Adjust your formula for larger scale (lab to pilot to industrial scale), Identify relevant building planning codes, Select the right equipment, anticipate changes to instrumentation and diagnostics, determine cleaning and

sterilization needs, Optimize your process and economic aspects. Quality and regulatory aspects - (QC/QA and GLP and GMP requirements).Industrial operations: Recovery and purification of products, Use of filtration and centrifugation, cell disruption, chemical methods, extraction, chromatographs methods, drying and crystallization, membrane process. Effluent treatment: Disposal methods, treatment process (aerobic and anaerobic treatments). Case studies.

Course outcomes (Course Skill Set)

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

- Develop complete understanding of the fermentation process.
- Correlate the concepts involved in USP and DSP.
- Analyze the methods involved in separation and product recovery techniques.
- Apply the design concepts for scale-up operations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Principles of fermentation Technology by P.F. Stanbury and A. Whitaker. Pergamon Press 3rd edition, 2016.
- Downstream Process Technology – A new horizon in Biotechnology byNooralabetta Krishna Prasad, PHI Learning Private Limited, 2010.
- Separation Processes in Biotechnology by Asenjo J. et al., CRC Press, 1990.
- Membrane separation processes by Nath, K. PHI Learning Pvt. Ltd., 2017.
- Bioprocess Engineering: Kinetics, Sustainability, and Reactor Design byLiu, S. . Elsevier, 2016.
- Bioseparation – Downstream processing for biotechnology by Belter P.A., Cussier E. and Wei Shan Hu., Wiley Interscience Pub. 1988.
- Scale-up of bioprocesses. In *Bioreaction Engineering Principles* byVilladsen, J., Nielsen, J., & Lidén, G. Springer US, 2011.

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-downstream-processing-in-microbial-fermentation/
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

- 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.

BIOETHICS AND BIOSAFETY			
Course Code	21BT72	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:0:0:1	SEE Marks	50
Total Hours of Pedagogy	25	Total Marks	100
Credits	02	Exam Hours	02

Course objectives:

- To introduce to the stduents about biosafety regulations.
- To understand the ethical concepts in biotechnology.
- To emphasize on IPR issues and need for knowledge in patents in biotechnology.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (5 Hours)

BIOTECHNOLOGY AND SOCIETY:

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

Module-2 (5 Hours)

BIOETHICS & LEGAL ISSUES:

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. 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.

Module-3 (5 Hours)

BIOSAFETY CONCEPTS AND ISSUES:
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

Module-4 (5 Hours)

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

Module-5 (5 Hours)

IPR, PATENTS AND PATENT LAWS:
Intellectual property rights-TRIP- GATT International conventions patents Methods of application of patents Legal implications Biodiversity and farmer rights Objectives of the patent system Basic principles and general requirements of patent law Biotechnological inventions and patent law. Legal development-Patentable subjects and protection in biotechnology .The patenting of living organisms.

Course outcomes (Course Skill Set)

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

- Describe the rules governing manufacture, use/import/export and storage of hazardousmicroorganisms/genetically engineered organisms or cells.
- Describe the ethical issues related to biotechnology research.
- Explain the various forms of IPR, methods of application of Patents, Protection of Plant varieties andfarmer rights.
- Overview of the Indian Patent Law, knowledge on patentability requirements, patentingbiotechnological inventions and innovations.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks MCQ (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

(All tests are similar to the SEE pattern i.e question paper pattern is MCQ)

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject SEE paperwill be set for 100 questions of each of 01 marks. The pattern of the question paper is MCQ.

The time allotted for SEE for this Two credit course is 02 hours. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Biotechnology and Safety Assessment by Thomas J.A., Fuch R.L Academic Press 3rd Edition 2002.
- Biological safety Principles and practicesby Fleming D.A., Hunt D. ASM Press 3rd. ed. 2000.
- Bioethics, by Ben Mepham, Oxford University Press, 2008.
- Bioethics & Biosafety by R Rallapalli & Geetha Bali APH Publication, 2007.
- Bioethics & Biosafety by Sateesh MK, IK Publishers, 2008.
- Biological Warfare in the 21st century, by M.R. Dando Brassies,London, 1994.

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.

PROFESSIONAL ELECTIVE COURSE - II

MEDICINAL CHEMISTRY AND CHEMOINFORMATICS			
Course Code	21BT721	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION:

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

Module-2 (8 Hours)

DRUGS AND THEIR ACTION:

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

Oxytocics (including oxytocin, ergot alkaloids and prostaglandins)
Module-3 (8 Hours)
MOLECULAR RECOGNITION IN DRUG-RECEPTOR BINDING: Molecular forces, Binding energetics, Enzyme Inhibitors, Modes of inhibition of Targets. Case studies a. Antibacterial Drugs and their resistance, Antiviral Drugs and their resistance, Anticancer Drugs and development of resistance, Neurotransmitters (adrenergic, cholinergic effects; psychopharmacology), CNS depressants (sedative/hypnotic, major/minor tranquilizers), CNS stimulants (Steroids)
Module-4 (8 Hours)
CHEMOINFORMATICS: Introduction Chemoinformatics definition, scope of chemoinformatics, history of chemoinformatics, why to use informatics methods in chemistry, Representations of chemical compounds Introduction, Computer Representations of Chemical Structures: Graph Theoretic Representations, Linear Notations, Connection Tables, Canonical Representations of Molecular Structures. 2D structure databases, Reaction Databases, The Representation of Patents and Patent Databases. Representations of 3D molecular structures: Experimental 3D Databases, 3D Database Searching.
Module-5 (8 Hours)
MOLECULAR DESCRIPTORS: Introduction, Descriptors Calculated from the 2D Structure: Simple Counts, Physicochemical Properties, Molar Refractivity. Structure Searching: Substructure Searching, Screening Methods, Similarity searching, Drug and Drug-Targets Drug: definition, “Drug-Likeness” and Compound Filters, rule of five. Lead Compound: definition, natural and synthetic resources of lead compounds. Drug targets: Enzymes, receptors, carrier proteins, structural proteins, nucleic acids, etc. Chemoinformatics tools for drug discovery Combinatorial Synthesis and Combinatorial Library, QSAR, 3D Pharmacophores. Screening Methods: High-throughput screening, Virtual Screening. Protein–Ligand Docking. The Prediction of ADMET Properties, Toxicity Prediction.
Course outcomes (Course Skill Set) **At the end of the course the student will be able to:** ➢ Apply the basic concepts of medicinal chemistry, databases and tools towards drug design. ➢ Apply the basic concepts of chemoinformatics, databases and toolsinvolved in drug design.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Foye's Principles of Medicinal Chemistry by Lemke, Thomas L. Williams, David A. , Lippincott, Williams & Wilkins 7th edition 2012.
- Burgers Medicinal Chemistry. Drug Discovery and Development, Edited by Donald J Abraham, Volumes 1 – 8, Wiley, 2021.
- Introduction to principles of drug design by Smith and Williams, CRC Press, 2005.
- Handbook of Chemoinformatics, volume 1, by John Gastiger, Thomas Engel, WILEYVCH pub 2003.
- An Introduction to Chemoinformatics, by Andrew R. Leach & Valerie j. Gillet, Springer 3. Instant Notes in Medicinal Chemistry, by G. Patrick, BIOS Scientific pub. 2001.
- Chemoinformatics: A Textbook by Johann Gasteiger and Thomas Engel, Wiley, 2003.
- Chemoinformatics in Drug Discovery: 23 (Methods & Principles in Medicinal Chemistry) by Tudor I. Oprea, Raimund Mannhold, Hugo Kubinyi and Gerd Folkers, Wiley, 2005.

Web links and Video Lectures (e-Resources):

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

- Discussion on recent advancements and case studies.

BIOREACTOR DESIGN AND SCALE UP			
Course Code	21BT722	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To Understandthefundamentalsofreactordesign.
- To Specifydesign criteriaformediumsterilization.
- To Understandthedesignacompletebioreactor basedontargets,constraintsandphysical properties.
- To Identifysuitableprocessinstrumentationformonitoringandcontrolofbioreactors.
- To Understand the challenges associated with process scale up.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION:

Microbial growth and product formation kinetics, Thermal death kinetics of microorganisms, Heterogeneousreaction kinetics, Enzyme kinetics, Multiple reactions – series, parallel and mixed. Basic Design Equations/Mole Balances: Batch, Fed Batch and Repetitive Batch Reactors, Continuous: Stirred tank and tubular flowreactors, Microbial death kinetics. Design criterion for sterilization. Batch and continuous sterilization of medium. Airsterilization

Module-2 (8 Hours)

FERMENTORS:

Processandmechanicaldesignoffermenters,volume,sparger,agitator, type,sizeandmotorpower,heattransfer calculationsforcoilandjacket, sterilization system.Fermenter design, aeration & agitation, Basic structure of fermenter body construction. Description of different parts of fermenter aseptic conditions. Different types of fermenters. Supply of oxygen, fluid rheology, factors affecting aeration and agitation. Scale up and scale down of aeration and agitation.

Module-3 (8 Hours)

NOVELBIOREACTORS:

Design of Immobilized enzyme packed bed Reactor. Fluidized bed reactors, Slurry Reactors, Air lift & Loopreactors, Packed bed and Hollow fiber membrane bioreactors, Bioreactors for waste treatment processes;Scale-upofbioreactors, SSFbioreactors. Conceptualnumericals. Bioreactors considerations for animal cell cultures –Production of Monoclonal antibodies and therapeutic proteins. Wave Bioreactors.

Module-4 (8 Hours)

NON-IDEALBIOREACTORS:

Non-ideal reactors, residence time distribution studies for pulse and step input, Exit age distribution offluid in reactors, RTD's for CSTR and PFR, calculations of conversions for First order reactions, tanks inseries models. Conceptual numericals.

Module-5 (8 Hours)

LAB TO INDUSTRIAL SCALE UP:

Scale Up concepts: lab to pilot to industrial scale, relevant building planning codes, Selection the right equipment, Anticipate changes to instrumentation and diagnostics, Determine cleaning and sterilization needs, Optimization of processes.Industrial operations: Recovery and purification of products, Use of filtration and centrifugation, cell disruption, chemical methods, extraction, chromatographs methods, drying and crystallization, membrane process.

Effluent treatment: Disposal methods, treatment process, aerobic and anaerobic treatment, byproducts. Economic aspects: Fermentation as a unit process, economy of fermentation, market potential. Legalization of products like antibiotics and recombinants.

Course outcomes (Course Skill Set)

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

- State the basic concepts of bioreactor design and optimize the parameters associated with fermentation process.
- Apply the principlesofupstream & downstream processes used in fermentation industry.
- Demonstarte the technqiues used in lab to industrial scale-up opearions.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Principles of fermentation Technology by P.F. Stanbury and A. Whitaker. Pergamon Press 3rd edition, 2016.
- Bioreactor Scale-Up: From Pilot to Commercial Scale in the Modern Era by Cheryl Scott and Brian Gazaille, eBook, 2019.
- Bioreactors: Analysis and Design byTapobrata Panda, McGraw-Hill, 2011.
- Bioreactor System Design by Juan A. Asenjo, CRC press, 1994.
- Bioreactors: Design, Operation and Novel Applications by Carl-Fredrik Mandenius, Wiley, 2016.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc22_bt19/preview
- https://www.coursera.org/lecture/industrial-biotech/microbial-fermentation-processes-and-bioreactor-design-35cbb
- https://www.classcentral.com/course/swayam-bioreactor-design-and-analysis-22924
- https://www.classcentral.com/course/swayam-bioreactors-5801
- https://biotechnologycourses.nl/courses/bioprocess-design-course/
- https://onlinecourses.nptel.ac.in/noc22_bt19/preview

- https://www.coursera.org/lecture/industrial-biotech/microbial-fermentation-processes-and-bioreactor-design-35cbb
- https://www.classcentral.com/course/swayam-bioreactor-design-and-analysis-22924
- https://www.classcentral.com/course/swayam-bioreactors-5801
- https://biotechnologycourses.nl/courses/bioprocess-design-course/
- https://www.youtube.com/watch?v=Q8QvApI9X3Q
- https://www.youtube.com/watch?v=8LEUksrrEfw
- https://www.youtube.com/watch?v=uooShNgPhIQ
- 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 via newspaper on topics covered
- Discussion on recent advancements and case studies.

BIOMEDICAL IMAGING AND HEALTH INFORMATICS			
Course Code	21BT723	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To Provide all students with basic skills and knowledge in health informatics.
- To Introduce students to problems, challenges and research practices that health informatics addresses.
- To Lead students in discussions around ethical and diversity issues in health informatics.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

BIOMEDICAL IMAGING:

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

Module-2 (8 Hours)

NUCLEAR IMAGING MODALITIES:

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

Module-3 (8 Hours)

HEALTH INFORMATICS:

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

Module-4 (8 Hours)

HOSPITAL MANAGEMENT AND INFORMATION SYSTEMS:

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

Module-5 (8 Hours)

ELECTRONIC HEALTH RECORDS:

Pathology Laboratory Module, Blood Bank Module, Operation Theatre Module, Medical Stores Module, Pharmacy Module, Inventory Module, Radiology Module, Medical Records Index Module, Administration Module, Personal Registration Module, Employee Information Module, Financial modules, Health & Family Welfare, Medical Research, Communication, General Information.

Course outcomes (Course Skill Set)

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

- Demonstrate basic skills and knowledge in health informatics for application in future health-related careers.
- Gain knowledge about problems, challenges and research practices that health informatics addresses.
- Demonstrate ability to identify genomic variants associated with a disease phenotype and Perform visualization and simple analysis for disease prognosis.
- Analyze ethical and diversity issues in health informatics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Radiological Imaging, The Theory of Image Formation, Detection, and Processing byHarrison Barrett and William Swindell, Academic Press,1996.
- Introduction to Biomedical Imaging by Andrew G. Webb, Wiley, 2017.
- Medical Imaging Systems by A. Macovski by R. Bracewell, Springer ebook, 2018.
- Medical imaging signals and systems by Jerry L Prince and Jonathan M Links, Prentice-Hall. 2005.
- Principles of magnetic resonance imaging byZhi-Pei Liang, Paul C. Lauterber, IEEE, 2000.
- NMR Imaging in Biomedicine by P. Mansfield and P. Morris, Elsevier, 1982.

- Digital Image Processing by K. Castleman, Pearson, 2011.
- Medical Imaging Technology by Mark A. Haidekker, Springer, 2013.
- Biomedical Informatics: Computer Applications in Health Care and Biomedicine by Edward H. Shortliffe, James J. Cimino, Michael F. Chiang, Springer, 2021.
- Consumer Health Informatics: Enabling Digital Health for Everyone by Catherine Arnott Smith, Alla Keselman, CRC Press, 2020.
- Health Informatics: Integrating Healthcare and Information Technology byLeonidas Waugh, Foster Academics, 2020.
- An Introduction to Healthcare Informatics, Building Data-Driven Tools by Peter Mccaffrey, Academic Press, 2020.

Web links and Video Lectures (e-Resources):

- https://www.medvarsity.com/courses/clinical-imaging/
- https://www.edx.org/learn/biomedical-imaging
- https://www.coursera.org/courses?query=radiology
- https://www.udemy.com/topic/medical-imaging/
- https://www.coursera.org/browse/health/health-informatics
- 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 via newspaper on topics covered
- Discussion on recent advancements and case studies.

METABOLIC ENGINEERING AND FUNCTIONAL GENOMICS			
Course Code	21BT724	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To Empower the students with the knowledge on stoichiometry, energetics of metabolism and principles of metabolic engineering.
- To Provide a quantitative basis, based on thermodynamics, enzyme kinetics, for the understanding of metabolic networks in single cells and at the organ level.
- To Enable the students to use organisms to produce valuable substances on an industrial scale in cost effective manner.
- To understand the diverse aspects and applications of functional genomics.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION :

Basic concepts of Metabolic Engineering, Overview of cellular metabolism, Different models for cellular reactions,Methods for metabolic characterization: genome, transcriptome, proteome, metabolome, fluxome Comprehensive models for cellular reactions. Case studies.

Module-2 (8 Hours)

COORDINATION OF METABOLIC REACTIONS:
Feedback inhibition, Energy charge, Multigene networks, Metabolic regulation network at enzyme level and whole cell level, Examples of metabolic pathway manipulations, Metabolic pathway synthesis algorithms, Metabolic flux analysis and its applications, Methods for experimental determination of metabolic fluxes, Metabolite Balancing, Tracer Experiments, MS and NMR in labelling measurement. Isotope labelling. Case studies.

Module-3 (8 Hours)

METABOLIC CONTROL ANALYSIS:
Metabolic control analysis (MCA) and the structure metabolic networks, Determination of Flux control coefficients, MCA of Linear and Branched pathways, Thermodynamics of cellular processes, Metabolic design: Gene amplification, Gene-disruption, Randomized and targeted strain development, New concepts for quantitative bioprocess research and development. Case studies.

Module-4 (8 Hours)

FUNDAMENTALS OF FUNCTIONAL GENOMICS :
Fundamental principles within functional genomics,emphasizing the transcriptome and proteome. Contribution of functional genomics to systems biology and systems medicine. Socio-ethical aspects of functional genomics in biomedicine and biotechnology, including perspectives on genetic risk information. Hypothesis generation/experimental design. Experimental model systems. Next generation HTP sequenching technology. Microarray-technology. Microarray-based techniques for RNA analysis (transcriptomics), different methods for global protein studies (proteomics) and current attempts at developing similar methodology for studies of metabolites and other small molecules (metabolomics).

Module-5 (8 Hours)

APPLICATIONS OF FUNCTIONAL GENOMICS:
Application of sequence based and structure-based approaches to assignment of gene functions –e.g. sequence comparison, structure analysis (especially active sites, binding sites) and comparison, pattern identification, etc. Use of various derived databases in function assignment, use of SNPs for identification of genetic traits. Gene/Protein function prediction using computational tools. Gross base composition of nuclear genome, Gene density, CpG islands, RNA-encoding genes, Functionally identical/similar genes, Diversity in size and organization of genes,Comparative Genomics: Overview of prokaryotic and eukaryotic genomes, Conservation and diversity of genomes, Comparative genomics as an aid to gene mapping and study of human disease genes.Functional genomics: Transcriptome and its analysis, gene silencing, Disease and genomics.

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

- Demonstrate knowledge on stoichiometry, energetics of metabolism and principles of metabolic engineering.
- Provide a quantitative basis, based on thermodynamics, enzyme kinetics, for the understanding of metabolic networks in single cells and at the organ level.
- Utilize organisms to produce valuable metabolites on an industrial scale in cost effective manner.
- Elaborate the basic aspects and applications of Functional Genomics.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be reduced proportionally 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.

Suggested Learning Resources:

- Metabolic Engineering: Concepts and Applications by Sang Yup Lee, Jens Nielsen, Gregory Stephanopoulos,Elsevier Science,2021.
- Metabolic Engineering by S. Y. Lee, E.T. Papoutsakis, Marcel Dekker, 2008.
- Understanding the Control of Metabolism byF.David, Portland Press, 2004
- The regulation of cellular systems by R. Heinrich and S., Schuster, , Springer Science & Business Media, 1996.
- Introduction to Genomics by Arthur M. Lesk, Oxford University Press, 2012.
- Bioinformatics and Functional Genomics by Jonathan Pevsner, Wiley-Blackwell, 2015.
- Functional Genomics by Meroni G, Intech Open, 2014.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc21_bt18/preview
- https://www.classcentral.com/course/swayam-metabolic-engineering-23049
- https://www.careers360.com/university/indian-institute-of-technology-kharagpur/metabolic-engineering-certification-course
- https://www.technologyed.org/amergradschool/metabolic-engineering-online-course-certificate/
- https://nptel.ac.in/courses/102104056
- 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 via newspaper on topics covered
- Discussion on recent advancements and case studies.

NANOBIOTECHNOLOGY			
Course Code	21BT725	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION:

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

Module-2 (8 Hours)

NANOMATERIALS AND THEIR CHARACTERIZATION :

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

Module-3 (8 Hours)

NANOMOLECULAR DIAGNOSTICS:

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

Module-4 (8 Hours)

BIOMEDICAL AND LIFE SCIENCES APPLICATIONS:

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

Module-5 (8 Hours)

ETHICS, SAFETY AND REGULATORY ASPECTS :

Introduction, ethical, legal and social implications of Nano medicine, and nano-bio-products, Safety concerns- Health Risks, and Challenges. Assessment of the toxic effects of nanoparticles based on in-vitro & In-Vivo experiments. Case studies. Environmental effects, public perceptions, Guidelines and regulatory aspects and evaluation of Nano

pharmaceuticals in India, Europe and USA, challenges and risks associated with Markets for Nano medicine. Trends in Research and education.

Course outcomes (Course Skill Set)

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

- Elaborate theprinciples and applicationsofnano-biotechnology.
- Apply the synthesis and characterization techniques in nanobiotechnology.
- Demonstrate thecurrentapplicationsof nanobiotechnology in diagnostics and therapeutics, knowing the safety issues.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Nanoparticle technology handbook byMasuo Hosokawa, Elsvier, 2012.
- Nanotechnology in biology and medicine by Tuvan ho Dhin, CRC press, 2006.
- The handbook of nanomedicine byKewal K. Jain, Humana press, 2008.
- Essential of nanotechnology byJereme Ramsden, Ventus publishing, 2006.
- NanoBiotechnology Protocols by 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 by Yubing Xie, CRC press, 2013.

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
- https://www.youtube.com/watch?v=ebO38bbq0_4
- https://www.coursera.org/lecture/nanotechnology/welcome-to-the-course-apP2j
- https://www.digimat.in/nptel/courses/video/102107058/L03.html
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

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

PROFESSIONAL ELECTIVE COURSE - III

SYSTEMS BIOLOGY & RATIONAL DRUG DESIGN			
Course Code	21BT731	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION :

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

Module-2 (8 Hours)

NETWORK BIOLOGY :

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

Module-3 (8 Hours)

MICROARRAYS AND GENE EXPRESSION:

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

Module-4 (8 Hours)

DRUG DESIGN AND DEVELOPMENT:
Rational Approaches to Drug Design and Development, Drug targets, Lead Identification and Modification, Computer-Aided Drug Design, Drug Delivery, Pre-clinical and Clinical Testing. Steps in Computational drug design: Molecular Modelling, Importance of the Bioactive Conformation, Molecular Mimicry, Structural Similarities and Superimposition Techniques,Three – Dimensional Description of Binding Site Environment and Energy Calculation, Automatic Docking Methods, Database Search Approaches, Structure Construction Methods with known and unknown 3D Structures of the Receptor, Web based programs available for molecular modelling, molecular docking, energy minimization techniques, ADME studies and validations.

Module-5 (8 Hours)

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

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

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

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

Web links and Video Lectures (e-Resources):

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

FOOD PROCESSING AND NUTRACEUTICALS			
Course Code	21BT732	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To acquaint students with fundamentals of foods and key factors for accessing the food nutritional quality.
- To develop understanding about food spoilage and methods to arrest the same.
- To make students learn and apply basics of food processing and the techniques involved.
- To open channels on nutraceuticals and the linked career opportunities.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

Introduction to Food and its qualities: Food: definition and broad connotation, types and groups of foods. Sources, nutritive value, Functions of food- physiological, psychological and social. Constituents: major nutrients: carbohydrates and dietary fibre, lipids and proteins; and minor nutrients: Vitamins- Fat and water soluble and, Minerals. Anti-nutritional factors in foods. Proximate analysis. Balance diet, BMI and calorie intake. Preventive healthcare through nutritive foods (local, seasonal and traditional). Dieting, food faddism and faulty food habits. Malnutrition (under and over nutritional conditions), Colloidal System in food

Module-2 (8 Hours)

Spoilage of food and its detection: Pre- and Post-harvest losses, food deterioration, contamination. Food spoilage - physical, chemical, biological (macrobiotic and microbial) sources. Factors affecting spoilageand its detection. Synopsis of common food-borne bacteria, genera of molds, genera of yeasts, Food borne infection and intoxication.

Module-3 (8 Hours)

Food Preservation Technologies and Fermentation:. Food Preservation: High and Low temperature, Radiation, drying and Chemical. Role of packaging and storage in preserving nutrients. Regulations and food safety. FSSAI, HACCP, ISO in food business.Food Fermentation: Fermented foods – Production of Bread, Cheese and Sauerkraut. Fermentation of wines, distilled liquor, vinegar, Fermented Dairy products.

Module-4 (8 Hours)

Food processing, Product Development and Entrepreneurship: Meaning and scope of Food Processing, principles and types. Sorting, grading and pre-processing steps for important food groups: Cereals, Pulses, Fruits and vegetables, Milk & milk products, Eggs, Meat, poultry and fish, Fats and Oils, Sugars. Effect of food processing on food, nutritional losses during processing, storage. Methods to minimize nutrient losses. Methods of Food Processing. Green technologies, 3-D printing, vegan products processing (mimetics), packaging and Labelling of Foods. Food Product Development, challenges, Market surveybvia Case studies and Food start ups/ Entrepreneurship. .

Module-5 (8 Hours)

Nutraceuticals: Meaning, functions, role as 'non-specific' biological therapies for promoting general well-being, and prevent malignant processes. Types: Dietary supplements, Functional food, Medicinal food, and Pharmaceuticals. Phytonutrients (carotenoids, flavonoids, phytoestrogens, phenolics etc) and Probiotics, applications. Immunity enhancement through nutraceuticals. Disease management through nutraceuticals. Health consciousness in consumers in post pandemic world. Indian market of nutraceuticals, potential.

Course outcomes (Course Skill Set)

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

- Understand the basics of food science and nutrition and apply its concepts in Food Processing.
- Apply the methods and techniques in Quality Control and Preservation to prevent Food borne infections.
- Apply the principles of Food Processing in product development and Entrepreneurship.
- Elucidate usefulness of nutraceuticals for managing health and wellbeing.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Food Science by Potter, Norman. M. and Hotchkiss, Jospeh. N., 5th e book edition. CBS Publishers, 2021.
- Foods: Facts and Principles byManay, S.; Shadakshara Swamy, M., , 4 th Ed. New Age Publishers. 2004.
- Food Processing Technology -Principles and Practice by P.J. Fellows.. A volume in Woodhead Publishing Series in Food Science, Technology and Nutrition (Third Edition). 2009.
- Food Processing: Principles and Applications byRamaswamy H and Marcott M.. CRC Press, 2006.
- Food Chemistry by Meyer. New Age Publishers, 2004

Web links and Video Lectures (e-Resources):

- https://alison.com/course/food-processing-technology-and-quality-of-food
- https://www.coursera.org/courses?query=food%20science
- https://www.futurelearn.com/subjects/nature-and-environment-courses/food-tech
- https://www.edx.org/learn/food-science
- https://www.classcentral.com/course/swayam-functional-foods-and-nutraceuticals-14069
- https://www.udemy.com/course/introduction-to-nutraceuticals/
- https://teachers-ab.libguides.com/c.php?g=710613&p=5063458
- https://www.coursera.org/courses?query=food%20science
- https://teachers-ab.libguides.com/c.php?g=710613&p=5063458
- https://www.coursera.org/courses?query=food%20science
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource OLRs:

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

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

PHARMACEUTICAL BT AND CLINICAL RESEARCH			
Course Code	21BT733	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Tolearnabout principles of drugdesign, formulation and manufacture.
- Tounderstandimportanceofpharmacokinetics&pharmacodynamicsstudy.
- Tounderstand thetechnqiues and applicationsof Pharmaceutical &ClinicalBiotechnology.

Teaching-Learning Process (General Instructions)

- ✓ 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.
- ✓ 8. Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

DRUGMANUFACTURE ANDFORMULATION:

Introductiontopharmaindustry,BiotechnologyandDrugdesign,Basicconceptsandapplications,composition, preparation, physicochemical considerations in manufacture of current biotech products & herbalmedicines.Needofformulationandformulationdevelopmentconsiderations.Concept&testingofpreformulation &theirparameters.Tablets:compressed,granulation,coatings,pills,capsules.Parentalpreparations,herbalextracts,Oralliquids, Ointments.Analyticalmethodsandtestsforvariousdrugs,packagingtechniques-Glasscontainers,plasticcontainers,filmwrapper,bottleseals;storageandstabilityof biotechproducts.

Module-2 (8 Hours)

PHARMACOKINETICSANDPHARMACODYNAMICS:

Pharmacodynamics and Pharmacokinetics of protein based drugs. Disease target identification and selection,receptor-based approaches, agonists, antagonists, enzyme inhibitors Basic concepts, ADME definitions, Needof pharmacokinetic study; Interpretations from pharmacokinetics parameters, Examples of Pharmacodynamicparametersofvariousdrugs;EvolutionofDrugMetabolismPhaseIMetabolism(microsomaloxidation, hydroxylation,dealkylation) Phase IIMetabolism(Drugconjugationpathway) CYPFamilies-casestudy.

Module-3 (8 Hours)

PHARMACOTHERAPY:

Classification of drugs based on therapeutic actions using suitable examples Special emphasis on Vitamins,coldremedies,laxatives,analgesics,non-steroidalcontraceptives,externalantiseptics,antacids,antibiotics, biologicals, herbal products. Pharmacotherapy of migraine, cancer, TB, diabetes and male sexual dysfunction.Hormonereplacementtherapy.

Module-4 (8 Hours)

BIOTHERAPEUTICSANDSTEMCELLS:

Clinical importance of Therapeutic Proteins and Enzymes; Hormones and Growth Factors used as therapeutics(erythropoietin & insulin as examples). Interferons, Interleukins, Preservation and clinical use of blood andblood components, principles and safety guide lines for blood transfusion. Advanced Sustained Release,AdvanceddrugDeliverySystems: Liposomesand Nanoparticles,biodegradabledrugdeliverysystem (hydrogelbased).

Module-5 (8 Hours)

CLINICALRESEARCH:

The philosophy behind and organization of clinical research. Pre-clinical development to support testing inhumans:Invitroandinvivotestingofnewcompounds,Relationshipbetweenanimalandhumanpharmacology.Safetytesting–acute,subacutetoxicology,immunotoxicology,Conceptsofpharmacovigilance,Generalprinciplesandguidetodatasources,typesofepidemiologystudydesigns,ecological(correlation)studies,casereports,prevalencesurveysorcross-sectionalstudies,casecontrolstudies,Clinicaltrials-informedconsent,PlaceboResponses,ClinicalRegistries.ClinicalResearchInstitutes, DataManagement,ClinicalResearchfromPharmaceutical Industry.

Course outcomes (Course Skill Set)

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

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Biopharmaceuticals,Biochemistry andBiotechnology by GaryWalsh, WileyPub. 1998.
- Principles of MedicinalChemistry by Foye LippincottWilliams&WilkinsPublishers SixthEdition, 2008.
- IndustrialPharmaceutical Biotechnology by HeinrichKlefenz Wiley-VCHedition, 2002.

Web links and Video Lectures (e-Resources):

- https://www.coursera.org/courses?query=pharmaceutical
- https://www.cfpie.com/pharma-biotech
- https://www.classcentral.com/tag/biotechnology
- https://www.coursera.org/courses?query=clinical%20research

- https://ocr.od.nih.gov/courses/ippcr.html
- https://www.udemy.com/topic/clinical-research/
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

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

AGRICULTURAL BIOTECHNOLOGY AND CROP IMPROVEMENT			
Course Code	21BT734	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To provide a firm understanding of the principles and application of agriculture biotechnology.
- To provide opportunity to understand the current advancements and barriers in crop improvement.

Teaching-Learning Process (General Instructions)

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

Module-1 (8 Hours)

TISSUE CULTURE AND ITS RELEVANCE IN AGRICULTURE:

Definitions, terminologies and scope of Biotechnology in Agriculture. Tissue culture- History, Tissue Culture Media, callus, Totipotency, suspension cultures, cloning; Regeneration; Somatic Embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.

Module-2 (8 Hours)

PLANT PROPAGATION:

Micropropagation. Meristem culture and production of virus-free plants. anther and microspore culture. Embryo and ovary culture. Protoplast isolation. Protoplast fusion-somatic hybrids, cybrids. Somaclones. Synthetic seeds. In vitro germplasm conservation, hardening and acclimatization.

Module-3 (8 Hours)

MOLECULAR MARKERS AND BREEDING:

Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis, Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding.Marker assisted selection and molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression. DNA finger printing, gene silencing.

Module-4 (8 Hours)

GENE TRANSFER AND EXPRESSION:

Regulation of gene expression. Recombinant DNA technology-cloning vectors, restriction enzymes, gene cloning. Methods of gene transfer in plants. method of transformation, vector-mediated gene transfer, physical methods of gene transfer. Development of transgenies for biotic & abiotic stress tolerance. Ribozfore Technology microarray, terminator technology, nanotechnology in Gene transfer. Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases.

Module-5 (8 Hours)

CROP MANAGEMENT AND SEED TECHNOLOGY

Seed Technology - Seed technology and its importance; production processing and testing of seeds of crop plants; seed storage, seed certification; role of NSC in production; New seed policy and seed control order, Terminator Technology.- Impact of The High Yielding And Short Duration Varieties OnCropping Patterns; Concepts Of Multiple Cropping, Relay Cropping And Inter-Cropping and Their Importance.

Course outcomes (Course Skill Set)

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

- Demonstrate a firm understanding of the principles and application of agriculture biotechnology.
- Apply the current methodologies towards crop improvement.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Genetic Engineering and Biotechnology: Concepts, Methods and Applications by Chopra VL &Nasim A. Oxford & IBH. 1990.
- Elements of Biotechnology by Gupta PK, Rastogi Publ. 1997.
- An Introduction to Recombinant DNA Technology: Basic Experiments in Gene Manipulation by Hackett PB, Fuchs JA & Messing JW2nd Ed. Benjamin Publ. Co., 1988.
- Molecular Cloning, a Laboratory Manual by Sambrook J &Russel D.,3rd Ed. Cold Spring Harbor Lab. Press. 2001.
- Biotechnology, Expanding Horizons by Singh BD. Kalyani. 2005.
- 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):

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

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.

SYNTHETIC BIOLOGY AND TISSUE ENGINEERING			
Course Code	21BT735	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

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

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION TO SYNTHETIC BIOLOGY:

History, current, and future. Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells astherapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, numberviability,motilityandfunctions.Measurementoftissuecharacteristics,appearance,cellularcomponent,ECM component,mechanicalmeasurementsandphysicalproperties.

Module-2 (8 Hours)

APPLICATIONS OF SYNTHETIC BIOLOGY:

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

Module-3 (8 Hours)

APPLICATIONS OF GENETIC CIRCUITS :

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

Module-4 (8 Hours)

TISSUE ENGINEERING :

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

Module-5 (8 Hours)

TISSUE ARCHITECTURE AND BIOMATERIALS :

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

Course outcomes (Course Skill Set)

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

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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.

Suggested Learning Resources:

- Synthetic Biology: Tools and Applications by H. Zhao, Academic Press, 2013.
- Tissue Engineering by Clemens Van Bliterswijk, Academic Press; 2nd edition,2014.
- Tissue Engineering by Bernhard Palsson and Sangeeta Bhatia, Pearson, 2003.
- Tissue Engineering by Palsson, Hubbell, Plonsey and Bronzino, CRC Press, 2003.
- Tissue Engineering by Bernhard O.Palsson, Sangeeta N.Bhatia, Pearson Publishers 2009.

- Fundamentals of Tissue Engineering and Regenerative Medicine by Meyer, U, Meyer, Th. Handschel, J. Wiesmann, H.P. 2009.
- Stem cell transplantation, tissue engineering, and cancer applications by Bernard N. Kennedy (editor).Nova Science Publishers, 2008.
- Stem cell-based tissue repair by Raphael Gorodetsky, Richard Schäfer. RSC Publishing, 2011.
- Handbook of Stem Cells, R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, Two- Volume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells, Academic Press, 2004.
- Essential of Stem Cell Biology, R. Lanza, J. Gearhart etal (Eds), Elsevier Academic press,2006.
- Translational Approaches In Tissue Engineering & Regenrative Medicine by J. J. Mao, G. Vunjak-Novakovic et al (Eds), Artech House, INC Publications, 2008.
- Stem Cell Repair and Regeneration by Naggy N. Habib, M.Y. Levicar, , L. G. Jiao,.and N. Fisk,volume-2, Imperial College Press,2007.

Web links and Video Lectures (e-Resources):

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

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

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

OPEN ELECTIVE COURSE - II

BIOMATERIALS AND MEDICAL IMPLANTS			
Course Code	21BT741	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To Provide graduate-level foundation on biomaterial principles.
- To Discuss the concepts of surfaces & interfaces in biomaterial interactions.
- To Discuss cellular and molecular aspects of host responses to biomaterials.
- To understand the concepts related to Design and development of biomedical implants.

Teaching-Learning Process (General Instructions)

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

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

Module-1 (8 Hours)

INTRODUCTION TO BIOMATERIALS:

Historical developments, definition and classification of biomaterials, impact of biomaterials, mechanical properties, wound healing process, tissue response to implants, safety and efficiency testing, bio-compatibility. Metallic and Ceramic Biomaterials: Stainless steel, cobalt chromium alloys, titanium based alloys, nitinol, metallic corrosion, medical applications, biological tolerance of implant metals. Case studies.

Module-2 (8 Hours)

SYNTHETIC POLYMERS:

Relatively bioinert bioceramics, biodegradable ceramics, surface reactive or bioactive ceramics, composites, analysis of ceramic surfaces, deterioration of ceramics, medical applications, Nano-composites. Synthetic and Biopolymers: Polymers in biomedical use, biodegradable synthetic polymers, silicone rubber, plasma polymerization, microorganism in polymeric implants, bio polymers, polymer sterilization. Case studies.

Module-3 (8 Hours)

BIOCOMPATIBILITY:

Wound healing process-bone healing, tendon healing. Material response: Function and Degradation of materials in vivo. Host response: Tissue response to biomaterials, Testing of bone implants: Methods of test for biological performance- In vitro implant tests, Qualification of implant materials. Case studies.

Module-4 (8 Hours)

CARDIOVASCULAR BIOMATERIALS:

Tissue properties of blood vessels, Treatments of atherosclerosis; Biomechanical design issues pertaining to stents, balloon angioplasty, and pacemakers. Soft Tissue Reconstruction; Natural and Synthetic. Wound healing. Tissue ingrowths: Stability; Biofixation, Foreign Body response, Soft implants. Case Studies. Tissue Engineering: Current issues and Future Directions. Case studies.

Module-5 (8 Hours)

IMPLANTABLE DEVICES:

Implantable Cardiovascular Assist Devices, Artificial RBC Substitutes, Orthopedic Applications, Dental Implants, Adhesives and Sealants, Ophthalmological Applications (Various types of contact lenses, Intra Ocular Lens Implant), Cochlear Prostheses. Case studies.

Course outcomes (Course Skill Set)

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

- Express a range of potential biomaterial and implants as specific treatments options.
- Outline all parameters needed to optimize the design of implants and devices.
- Identify the advantages and disadvantages of materials in terms of its compatibilities, biological responses, and degradation.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- An Introduction to Biomaterials byJ. B. Park and R. S. Lakes, Springer, 2007.
- Biological Performance of materials byJ. Black, Taylor &Francis, 2005.
- Biomaterials Science: An Introduction to Materials in Medicine by Buddy D. Ratner et al. Elsevier, 2004.
- Essential Biomaterials: Cambridge Texts in Biomedical Engineering by David Williams 2014, 1st edition.
- Polymeric Biomaterials by Piskin and A S Hoffmann, MartinusNijhoff Springer, 1986.
- Wearable And Implantable Medical Devices by Dey Nilanjan, Acad Press, 2019
- Biopolymers for Medical Applications, By Juan M. Ruso and Paula V. Messina, CRC Pressm 2017
- Biointegration of Medical Implant Materials: Science and Design by Chandra P. Sharma, Elsevier, 2019

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
- https://www.edx.org/course/biofabrication
- https://ocw.mit.edu/courses/20-441j-biomaterials-tissue-interactions-fall-2009/
- https://engineering.purdue.edu/online/courses/introduction-biomaterials
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

- Journal of Applied Biomaterials & Functional Materials
- https://www.journals.elsevier.com/biomaterials
- Journal of Biotechnology & Biomaterials
- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via Newspapers/Journal articles, on topics covered
- Group discussions on recent advancements and case studies.

BIOSENSORS AND APPLICATIONS			
Course Code	21BT742	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To learn about different classes of biosensors, their functioning principles and real-life applications.
- To Understand the principles and concepts of transducers and their application in biosensor design.
- To Understand the fundamentals of diagnostic devices and biomarker testing.
- To Understand the technical and societal factors involved in point-of-care diagnostics and wearable sensors.

Teaching-Learning Process (General Instructions)

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

Module-1 (8 Hours)

INTRODUCTIONTOBIOSENSORS: Conceptsandapplications.Biosensor classificationtheir transducing elements and biological recognition elements. Electrochemicalsensors,Thermometric Biosensors, Chemicalfibrosensors,Ion-selectiveFETs, Optical Biosensors,Conductometric, Amperometric, Impedimetric, Piezoelectric Biosensors, Whole Cell Biosensors, Immuno-Biosensors. Overview of biosensor applications in medicine, food, agriculture, water and environment, with relevant case studies.

Module-2 (8 Hours)

BIOMOLECULES IN BIOSENSORS:
DNA, enzyme, antibody, antigen, protein, peptide, aptamer. Case studies and examples of each. Amplification Techniques (PCR), ELISA (enzyme-linked immunosorbent assay). Biomarker testing and detection sensor. Surface plasmon resonance biosensors (Biacore), Catalytic biosensors (glucosensor), Antibodies based biosensors, DNA based biosensors, Nanomaterial in biosensor technology.

Module-3 (8 Hours)

ELEMENTS IN BIOSENSORS :
Biomolecule Immobilization Techniques, Enzyme Kinetics. Optimization of desired characteristics of biosensors: sensitivity, selectivity, stability, detection limit, reliability, response time, reproducibility, range and linearity, safety, simplicity, cost, and parameters like operating conditions, calibration, positive and negative controls. Bio Affinity: Labelled and Label free, whole cell sensing – bacteria, yeast, mammalian cell.

Module-4 (8 Hours)

BASICS OF DETECTION METHODS:

Fluorescence Spectroscopy, UV-Vis Absorption and Emission, Surface Plasmon Resonance, Magnetic labelling, Electrochemical Detection, redox processes, and electron transfer. Electrochemical cells for measurements, processes at electrode surface, and mass transport of material to the electrode surface. Active DC electrochemical techniques: voltammetry and amperometry, immobilized enzyme-electrodes. Impedance Spectroscopy. Potentiometry for small molecule and ion detection. Fluorescence and colorimetric biosensors.

Module-5 (8 Hours)

BIOSENSORS IN DIAGNOSTICS :

Point-of-care sensing: microfluidics and paper-based diagnostics, Point-of-care sensing: yarn and textile-based sensing. Mobile Biosensors for detection of viruses and bacteria. MicrofabricatedSensorsandtheCommercialDevelopmentof wearable Biosensors for health monitoring. Biosensor market and its growth potential. Innovative and Novel developments.

Course outcomes (Course Skill Set)

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

- Elaborate the principles and concepts of biology, electrochemistry, electronics and engineering involved in the design of biosensors
- Recognize different types of transducers, and their application in biosensor design
- 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.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks. Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Biomedical Transducers and Instruments by Tatsuo Togawa, Toshiyo Tamura, P. AKE Oberg, CRC Press 1997.
- Biosensors by A.E.GGass, IRL Press, 1990.
- Introduction to Bioanalytical Sensor by Alice Cunningham, John Wiley and Sons, 1998.
- Introduction to Biosensors by Jeong-Yeol Yoon; Publisher: Springer-Verlag New York Ed.1 2. Recognition Receptors in Biosens.by Mohammed Zourob; Publisher: Springer-Verlag New York Ed.1 3.
- Novel Approaches in Biosensors and Rapid Diagnostic Assays by Zvi Liron; Publisher: Springer US Ed.1
- Smart Sensors by Paul W. Chapman, ISA Press
- Understanding Smart Sensors by Randy Frank, 2nd Edition, ArtechHouse Publications, 2000.

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-with-diagram/10240
- https://www.youtube.com/watch?v=kQ6CY1qpGjY
- VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

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

- https://www.mdpi.com/journal/biosensors/sections/biosensors_healthcare
- https://www.mdpi.com/journal/biosensors/special_issues/med_implant
- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via Newspapers/Journal articles, on topics covered
- Group discussions on recent advancements and case studies.

BIOREMEDIATION TECHNIQUES			
Course Code	21BT743	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To Demonstrate an understanding of the nature and importance of bioremediationfor real world applications.
- To Understand the influence of site characteristics: hydraulic conductivity, soil type, microbial presence, and groundwater properties.
- To Understand the influence of contaminant characteristics to bioremediation (e.g. chemical structure, toxicity, and solubility).

Teaching-Learning Process (General Instructions)

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

Module-1 (8 Hours)

INTRODUCTION:

Process of bioremediation; Bioremediation of synthetic compounds, petrochemicals, inorganic wastes; Bioremediation strategies, Bioremediation techniques in situ, Bioremediation techniques ex situ, Phytoremediation and Phyto-technology, bioremediation of Metals, Gaseous bioremediation.

Module-2 (8 Hours)

BIOREMEDIATION:

Advantages of Bioremediation, types of bioremediation. Monitoring the efficacy of Bioremediation. Bioaugmentation, biomagnifications and Biotransformation. Bioventing. Bioremediation for controlling oil spills.

Module-3 (8 Hours)

BIOSORPTION:

Use of bacteria and fungi, Bioreaction for biosorption. Problems associated with disposal of xenobiotic compounds, Hazardous wastes. Biodegradation of xenobiotics: Persistent compounds, Degradation mechanisms, naphthalene, benzene, phenol, PCB's, propanil (Herbicide), urea. Biodegradation of petrochemical effluents.

Module-4 (8 Hours)

BIOTECHNOLOGICAL METHODS TO CONTROL POLLUTION:

Biofilters, Bioremediation, Biotransformation Biodegradation and Phytoremediation: In situ and Ex situ bioremediation; Evaluating Bioremediation; Bioremediation of VOCs. Factors affecting process of biodegradation; Biotechnological solutions for Global environment problems like Greenhouse effect, Ozone depletion, UV radiation, Acid rain.

Module-5 (8 Hours)

METHODS IN DETERMINING BIODEGRADABILITY:

Contaminant availability for biodegradation; Use of microbes (bacteria and fungi) and plants in biodegradation and Biotransformation; Phytoremediation: Waste water treatment using aquatic plants; Root zone treatment.

Course outcomes (Course Skill Set)

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

- Demonstrate an understanding of the nature and importance of bioremediation for real life problems.
- Analyze the influence of site characteristics like hydraulic conductivity, soil type, microbial presence, and groundwater properties.
- Analyze the influence of contaminant characteristics to bioremediation (e.g. chemical structure, toxicity, and solubility).

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks.Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Bioremediation Principles by Eweis JB, Ergas SJ, Chang DPY, and Schroeder ED, McGraw-Hill Companies, Inc., 1998.
- Environmental Biotechnology: Principles and Applications, by B.E. Rittmann and P.L. McCarty, McGraw-Hill, Inc., New York, 2001.
- Environmental Biotechnology: Theory and Application, by G.M. Evans and J.C. Furlong, John Wiley & Sons, Ltd., Chichester, England, 2003.
- Bioremediation, by K.H. Baker and D.S. Herson, McGraw-Hill, Inc., New York, 1994.
- Bioremediation: A Desk Manual for the Environmental Professional, by D.R. Schneider and R.J. Billingsley, Cahners Publishing Company, Des Plaines, IL, 1990.
- Environmental Biotechnology for Waste Treatment, by G.S. Saylor, R. Fox and J.W. Blackburn (eds.), Plenum Press, New York, NY. 1990.
- Hydrocarbon Bioremediation by R.E. Hinchee, B.C. Alleman, R.E. Hoeppel, and R.N. Miller (eds.), Lewis Publishers, Boca Raton, FL. 1994.
- Emerging Technology for Bioremediation of Metals by J.L. Means and R.E. Hinchee (eds.), Lewis Publishers, Boca Raton, FL. 1994.
- Microbial Transformation and Degradation of Toxic Organic Chemicals, by L.Y. Young and C.E. Cerniglia (eds.), Wiley-Liss, Inc., New York, NY. 1995.

Web links and Video Lectures (e-Resources):

- https://www.mooc-list.com/tags/bioremediation
- https://onlinecourses.nptel.ac.in/noc21_bt41/preview
- http://learnbioremediation.weebly.com/course-overview.html

- https://www.classcentral.com/course/swayam-applied-environmental-microbiology-10083
- 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 via Newspapers/Journal articles, on topics covered
- Group discussions on recent advancements and case studies.

BIOFUELS AND BIOENERGY			
Course Code	21BT744	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To emphasize the fundamental biological mechanisms for harnessing and generating bioenergy derived from various sources.
- Identify potential biomass feedstocks including energy crops.
- To have an understanding of the existing and emerging biomass to energy technologies.
- To develop a critical thinking about sustainability & resilience.
- To explore potential solutions for energy needs and problems by incorporating the bioenergy technologies.

Teaching-Learning Process (General Instructions)

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

Module-1 (8 Hours)

INTRODUCTION:

Fundamental concepts in understanding biofuels and bioenergy systems, biomass production, availability and attributes for bioenergy and biofuel production. Types of biomass derived fuels and energy, Bioenergy Sources, Characteristics & Classification. Biofuel sources and properties.

Module-2 (8 Hours)

BIOFUEL PRODUCTION:

Biogas production from organic matter and animal residues. Fermentation technology in biofuel production. Thermo-chemical and biochemical conversion of biomass to fuel, effect of different parameters on pyrolysis and gasification. Environmental aspects of biofuel production

Module-3 (8 Hours)

BIOMASS, BIO-ENERGY AND BIO-REFINERY:

Basic concepts of circular economy based on organics. Biomass: Properties and types. Biomass: constituents at molecular level, at chemical level, energy properties. Biomass typologies: lignocellulosic, starchy, sugary, oilseeds, OFMSW, sewage sludge, manure. Biomass conversion: Chemical conversion, Oil trans-esterification (biodiesel production). Hydrolysis. Biomass conversion: Biochemical conversion, Anaerobic digestion (biogas production from organic waste and wastewater).

Module-4 (8 Hours)

Fermentation (bioethanol production) Chemical engineering tools for analysis and design of energy processes, Reaction stoichiometry, Reaction kinetics. Reaction thermodynamics. Reactors. Process analysis and design. Biomass conversion: Thermochemical conversion, Biomass storage and feeding systems. Combustion plants for heat generation: wood and

pellet burning stoves; wood, pellet and wood chips boilers; plant schemes for heat generation; control, protection and safety systems. Gasification plants. Pyrolysis plants.

Module-5 (8 Hours)

BIOFUELS:

Liquid (biodiesel, bioethanol), gaseous (syngas, biogas), solid (charcoal and biochar). Biomass conversion: Physical conversion, Dewatering, drying, size reduction, steam explosion, densification, pelleting, chipping, oil extraction, Innovative bioenergy plants: biomass to synthetic natural gas; biomass to liquid biofuels through Fisher Tropsch; absorption enhanced reforming. Hydrothermal processes: carbonization, liquefaction, gasification. Algal biofuels: Growth/harvest rates, transesterification.

Course outcomes (Course Skill Set)

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

- Realise the significance of biofuels and bioeenrgy systems in our day-to-day life.
- Apply the acquired knowledge to design biomass energy plants and to evaluate their performances.
- Analyze the different options available given the nature of the feedstock available (kind of biomass, kind of organic waste) and the technological opportunities to valorise it as bioenergy.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50) in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks.Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- G. N. Tiwari and M. K. Ghosal, by Fundamentals of Renewable Energy Sources, Narosa Publishing House, 2007.
- Renewable Energy Engineering and Technology, Principles and Practice by Kishore V V N, , The Energy and Resources Institute (TERI) , 2009.
- Biogas Technology by Nijaguna, B.T. New Age International publishers (P) Ltd., 2002.

- Bioenergy and Biofuel from Biowastes and Biomass by Samir Kumar Khana, ASCE Publications , 2010.
- Biomass for renewable energy, fuels, and chemicals. By D.L. Klass, Academic Press, 1998.

Web links and Video Lectures (e-Resources):

- https://www.edx.org/learn/biorefinery
- https://www.classcentral.com/course/swayam-bioenergy-7896
- https://www.futurelearn.com/courses/renewable-energy-achieving-sustainability-through-bioenergy
- https://www.coursera.org/lecture/synbioethics/biofuels-ai9ji
- Advanced Biofuels and Bioproducts, J. W. Lee,
- http://www.springer.com/cn/book/9781461433477
- Algae for Biofuels and Energy, M.A. Borowitzka, N.R. Moheimani,
- Application of Hydrothermal Reactions to Biomass Conversion, F. Jin, http://www.springer.com/cn/book/9783642544576
- Biogas Energy, T. Abbasi, S.M., Tauseef, S.A. Abbasi, http://www.springer.com/us/book/9781461410393
- BioH2 & BioCH4 through Anaerobic Digestion, B. Ruggeri, T. Tommasi, S. Sanfilippo, http://www.springer.com/us/book/9781447164302
- Biomass Conversion, C. Baskar, S. Baskar, R.S. Dhillon, https://link.springer.com/book/10.1007%2F978-3-642-28418-2
- Recycling of Solid Waste for Biofuels and Bio-chemicals, O.P. Karthikeyan, K. Heimann, S.S. Muthu, http://www.springer.com/cn/book/9789811001482
- 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 via Newspapers/Journal articles, on topics covered
- Group discussions on recent advancements and case studies.

BIOTERRORISM AND NATIONAL SECURITY			
Course Code	21BT745	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To Familiarize the issues related to National Security.
- To Understand thethreats facing society due to bioterrorism.
- To understand the approaches to tackle these threats effectively, to safe guard National Security.

Teaching-Learning Process (General Instructions)

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

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

Module-1(8 Hours)

INTRODUCTION TO NATIONAL SECURITY, TERRORISM AND BIOTERRORISM:

Definition, meaning of national security, terrorism against the nation, Terrorists (Traditional Terrorists and New age Terrorists using nuclear, chemical, biological and radiological weapons). Bioterrorism and the psychology behind bioterrorism-Historical perspective. Dimensions of National security: economic security, energy security, physical security, environmental security, food security, border security, and cyber security. National security act 1980.

Module-2(8 Hours)

TOOLS, TECHNIQUES. EMPHASIS OF BIOLOGICAL AGENTS:

Microbes. Immune System Primary classes of Microbes-bacteria, virus, and other agents. Immune system (types: innate and acquired), Interaction between microbes and the immune system.

Module-3(8 Hours)

BIOTERRORISM WEAPONS AND TECHNIQUES:

Availability and characteristics of microbes, reasons for selection and use, Symptoms-Pathogenicity Epidemiology-natural and targeted release-The biological, techniques of dispersal, and case studies of Anthrax, Plague-Botulism, Smallpox, and VHF. Possibility of causing epidemic, pandemic, endemic effects.

Module-4(8 Hours)

PREVENTION AND CONTROL OF BIOTERRORISM:

Surveillance and detection. Detection equipment and sensors. Diagnosis-Treatment Vaccinations, supplies. Challenges in availability and affordability. Effectiveness, liability, public resistance. Response- first responders, infectious control, hospital, prevention, Protection-Decontamination, Biosafety measures and tools. Notification. Role of Law Enforcement. Economic impact in the nation.

Module-5(8 Hours)

BIOTERRORISM MANAGEMENT ETHICAL ISSUES:

Personal, national, the need to inform the public without creating fear, cost-benefit Rations. Information Management. Government control and industry Support. Microbial forensics, Public health security and bioterrorism preparedness and response act of 2002. India's preparedness against bioterrorism: biodefence strategies and policy measures

Course outcomes (Course Skill Set)

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

- Explain the issues related to National Security.
- Describe the threats facing society due to bioterrorism.
- Apply the knowledge to tackle these threats effectively, to safe guard National Security.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). 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 35% (18 Marks out of 50)in the semester-end examination(SEE), and a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

- First test at the end of 5th week of the semester
- Second test at the end of the 10th week of the semester
- Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

- First assignment at the end of 4th week of the semester
- Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for**20 Marks** (**duration 01 hours**)

- At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

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:

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

- The question paper will have ten questions. Each question is set for 20 marks.Marks scored shall be proportionally reduced 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. Marks scored out of 100, shall be proportionally reduced to 50 marks

Suggested Learning Resources:

- Biosecurity and Bioterrorism -Containing and Preventing Biological Threats. By Jeffrey Ryan. 2nd Edition - February 12, 2016.
- Bioterrorism: Confronting a complex threat by Andreas Wenger.Viva Publishres. 2007.
- Bioterrorism and Infectious Agents: A New Dilemma for the 21st Century (Emerging Infectious Diseases of the 21st Century), by I.W. Fong and Kenneth Alibek, Springer, 2005.
- Bioterrorism: Guidelines for Medical and Public Health Management, by Henderson, Donald, American Medical Association, 1st Edition, 2002.
- Biotechnology research in an age of terrorism: confronting the dual use dilemma, National Academies of Science, USA, 2003.

Web links and Video Lectures (e-Resources):

- https://www.futurelearn.com/courses/biosecurity-terrorism
- https://www.classcentral.com/course/biosecurity-terrorism-8078
- https://www.mooc-list.com/tags/bioterrorism
- https://online.stanford.edu/courses/publpol222-biosecurity-and-pandemic-resilience
- http://www.centerforhealthsecurity.org/
- https://emergency.cdc.gov/agent/agentlist-category.asp
- 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 via Newspapers/Journal articles, on topics covered
- Group discussions on recent advancements and case studies.