AC: 11-05-2017
Item No. 4.188

UNIVERSITY OF MUMBAI

Revised syllabus (Rev- 2016) from Academic Year 2016 -17

Biotechnology

Second Year with Effect from **AY 2017-18**
Third Year with Effect from **AY 2018-19**
Final Year with Effect from **AY 2019-20**

Under

FACULTY OF TECHNOLOGY

As per **Choice Based Credit and Grading System**
With effect from the AY 2016–17

From Coordinator's Desk

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) give freedom to affiliated Institutes to add few (PEO's) course objectives course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, developed curriculum accordingly. In addition to outcome based education, **Choice Based Credit and Grading System** is also introduced to ensure quality of engineering education.

Choice Based Credit and Grading System enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes Faculty of Technology has devised a transparent credit assignment policy adopted ten points scale to grade learner's performance. Choice Based Credit and grading based system is implemented for Second Year of B.E. in Biotechnology Engineering from the academic year 2017-2018. This system will be carried forward for Third Year of B.E. in Biotechnology Engineering in the academic year 2018-2019 and for Fourth Year B.E. in the year 2019-2020 respectively.

Dr. S. K. Ukarande
Co-ordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai

Preamble to the Revision of Syllabus in Biotechnology Engineering

The onset of nineties brought about some paradigm shifts. One was in the sphere of market economics. Suddenly the Indian manufacturing sector started jostling for a place with international competition in the arena. The presence of International products at competitive rates and quality forced some small and medium scale units to close their operations. The larger industry players realized the importance of R&D and accordingly set up separate cells to optimize production and improve quality. The second major impact was in the sphere of knowledge. With the advent of World Wide Web in the early nineties and its subsequent growth, the latest research trends have become accessible from drawing rooms across the globe. This acted as a positive feedback mechanism in increasing the pace of research in all fields including Bio-technology. This was the motivation for an in depth analysis of what is actually required for today's technology. It is also important to take advantage of the freely available software to enhance the quality and quantity of material that can be covered in the class room.

With this scenario as the backdrop, the first meeting was conducted by Board of Studies in Biotechnology at Thadomal Shahani College of Engineering Bandra on 3rd February 2017. It was attended by the various heads of departments of Biotechnology engineering as well as experts from industry. The academic scheme and exam scheme of the program was discussed along with the program objectives and outcomes. The core structure of the syllabus was formulated keeping in mind **choice based credit and grading system** curriculum to be introduced in this revised syllabus for B.E. (Biotechnology) for all semesters. A second meeting was held in Datta Meghe College of Engineering Airoli on 20th February 2017 and detailed syllabus of Semesters III and IV was finalised. Subsequently another meeting was held in Thadomal Shahani Engineering College Bandra on 11th April 2017 to finalise the detail syllabus of subjects pertaining to semester V, VI, VII and VIII.

Dr. Kalpana S. Deshmukh,
Chairman, Board of Studies in Chemical Engineering (Adhoc),
University of Mumbai, Mumbai.

General Guidelines

Tutorials

- The number of tutorial batches can be decided based on facilities available in the institution.
- Tutorials can be creative assignments in the form of models, charts, projects, etc.

Term Work

- Term work will be an evaluation of the tutorial/practical done over the entire semester.
- It is suggested that each tutorial/practical be graded immediately and an average be taken at the end.
- A minimum of eight tutorials/ten practical will form the basis for final evaluation.
- The total 25 marks for term work (except project and seminar) will be awarded as follows:
  Tutorial / Practical Journal – 20 marks
  Overall Attendance – 05
  Further, while calculating marks for attendance, the following guidelines shall be adhered to:
  75 % to 80%. – 03 marks
  81% to 90% - 04 marks
  91% onwards – 05 marks

Theory Examination

- In general all theory examinations will be of 3 hours duration.
- Question paper will comprise of total six questions, each of 20 Marks.
- Only four questions need to be solved.
- Question one will be compulsory and based on maximum part of the syllabus.

Note:
In question paper, weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus as far as possible.

Practical Examination:

- Duration for practical examination would be the same as assigned to the respective Lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Project and Seminar Guidelines

- Project Groups: Students can form groups with minimum 2 (Two) and not more than 3 (Three)

- The load for projects may be calculated proportional to the number of groups, not exceeding two hours per week.

- The load for projects may be calculated as:
  Sem VII: ½ hr for teacher per group.
  Sem VIII: 1 hr for teacher per group.

- Each teacher should have ideally a maximum of three groups and only in exceptional cases four groups can be allotted to the faculty.

- Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.

- The load for seminar will be calculated as one hour per week irrespective of the number of students

- Students should spend considerable time in applying all the concepts studied, into the project. Hence, eight hours each were allotted in Project A, B and three hours for Seminar to the students.

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
S.E. Semester III (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC301	Applied Mathematics-III	3	-	1	3	-	1	4
BTC302	Microbiology	4	-	-	4	-	-	4
BTC303	Cell Biology	3	-	1	3	-	1	4
BTC304	Biochemistry	4	-	-	4	-	-	4
BTC305	Unit Operations-I	3	-	-	3	-	-	3
BTC306	Process Calculations	3	-	1	3	-	1	4
BTL301	Microbiology Lab	-	3	-	-	1.5	-	1.5
BTL302	Biochemistry Lab	-	3	-	-	1.5	-	1.5
BTL303	Unit Operations-I Lab	-	2	-	-	1	-	1
	Total	20	8	3	20	4	3	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC301	Applied Mathematics-III	20	20	20	80	3	25	-	-	125
BTC302	Microbiology	20	20	20	80	3	-		-	100
BTC303	Cell Biology	20	20	20	80	3	25	-	-	125
BTC304	Biochemistry	20	20	20	80	3	-		-	100
BTC305	Unit Operations-I	20	20	20	80	3		-	-	100
BTC306	Process Calculations	20	20	20	80	3	25	-	-	125
BTL301	Microbiology Lab							25		25
BTL302	Biochemistry Lab							25		25
BTL303	Unit Operations-I Lab								25	25
	Total			120	480	-	75	50	25	750

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
S.E. Semester IV (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC401	Applied Mathematics-IV	3	-	1	3	-	1	4
BTC402	Molecular Genetics	3	-	1	3	-	1	4
BTC403	Fermentation Technology	4		-	4		-	4
BTC404	Analytical Methods in Biotechnology	4	-	-	4	-	-	4
BTC405	Immunology and Immunotechnology	3	-	1	3	-	1	4
BTC406	Unit Operations -II	3		-	3		-	3
BTL401	Fermentation Technology Lab	-	3	-		1.5	-	1.5
BTL402	Analytical Methods in Biotechnology Lab	-	3	-		1.5	-	1.5
BTL403	Unit Operations –II Lab	-	2	-		1	-	1
	Total	20	8	3	20	4	3	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC401	Applied Mathematics-IV	20	20	20	80	3	25	-	-	125
BTC402	Molecular Genetics	20	20	20	80	3	25	-	-	125
BTC403	Fermentation Technology	20	20	20	80	3	-		-	100
BTC404	Analytical Methods in Biotechnology	20	20	20	80	3	-	-	-	100
BTC405	Immunology and Immunotechnology	20	20	20	80	3	25	-	-	125
BTC406	Unit Operations -II	20	20	20	80	3	-	-	-	100
BTL401	Fermentation Technology Lab		-	-	-	3	-	25		25
BTL402	Analytical Methods in Biotechnology Lab	-	-	-	-	3	-	25	-	25
BTL403	Unit Operations –II Lab	-	-	-	-	-	-	-	25	25
	Total			120	480	-	75	50	25	750

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
T.E. Semester V (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC501	Bioinformatics	4	-	-	4	-	-	4
BTC502	Genetic Engineering	4	-	-	4	-	-	4
BTC503	Thermodynamics and Biochemical Engineering	3	-	1	3	-	1	4
BTC504	Bioreactor Analysis and Technology	3	-	1	3	-	1	4
BTC505	Business Communication and Ethics	2	-	2	-	-	2	2
BTE501X	Elective I	3	-	1	3	-	1	4
BTL501	Bioinformatics Lab	-	2	-	-	1	-	1
BTL502	Genetic Engineering Lab		3			1.5		1.5
BTL503	Lab I		3			1.5		1.5
	Total	17	12	3	17	6	3	26

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC501	Bioinformatics	20	20	20	80	3	-		-	100
BTC502	Genetic Engineering	20	20	20	80	3			-	100
BTC503	Thermodynamics and Biochemical Engineering	20	20	20	80	3	25	-	-	125
BTC504	Bioreactor Analysis and Technology	20	20	20	80	3	25	-	-	125
BTC505	Business Communication and Ethics	-	-	-	-	-	50	-		50
BTE501X	Department Elective I	20	20	20	80	3	25	-	-	125
BTL501	Bioinformatics Lab					2		25		25
BTL502	Genetic Engineering Lab					3		25		25
BTL503	Lab I	-	-	-	-	3		25	-	25
	Total			100	400	-	125	75	-	700

Department Elective I (Sem V)		
Engineering Stream	Advanced Science Stream	Technology Stream
1. Biosensors and Diagnosis (BTE5011)	1.Biophysics (BTE5012) 2.Biostatistics (BTE5013)	1. Pharmaceutical Technology (BTE5014)

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
T.E. Semester VI (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC601	Food Technology	3	-	1	3	-	1	4
BTC602	Cell & Tissue Culture	4	-	-	4	-	-	4
BTC603	Enzyme Engineering	4	-		4	-	-	4
BTC604	IPR, Bioethics and Bio safety	3	-	1	3	-	1	4
BTC605	Process Control & Instrumentation	3	-	1	3	-	1	4
BTE602X	Elective-II	3	-	1	3	-	1	4
BTL601	Lab-II	-	3	-	-	1.5	-	1.5
BTL602	Lab-III	-	3	-	-	1.5	-	1.5
	Total	20	6	4	20	3	4	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC601	Food Technology	20	20	20	80	3	25	-	-	125
BTC602	Cell & Tissue Culture	20	20	20	80	3	-	-	-	100
BTC603	Enzyme Engineering	20	20	20	80	3	-	-	-	100
BTC604	IPR, Bioethics and Bio safety	20	20	20	80	3	25	-	-	125
BTC605	Process Control & Instrumentation	20	20	20	80	3	25	-	-	125
BTE602X	Elective-II	20	20	20	80	3	25	-	-	125
BTL601	Lab-II	-	-	-	-	3	-	25		25
BTL602	Lab-III	-	-	-	-	3	-	25	-	25
	Total			120	480	-	100	50	--	750

Department Elective II (Sem VI)		
Engineering Stream	Advanced Science Stream	Technology Stream
1. Computational Fluid Dynamics (BTE6021)	1. Protein Engineering (BTE6022) 2. Cancer Biology(BTE6023)	1. Green technology (BTE6024)

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
B.E. Semester VII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC701	Bioseperation & Downstream Processing Technology-I	4	-	1	4	-	1	5
BTC702	Bioprocess Modelling and Simulation	4	-	1	4	-	1	5
BTC703	Agriculture Biotechnology	3	-	1	3	-	1	4
BTE703X	Department Elective III	3	-	1	3	-	1	4
ILO701X	Institute Level optional Subject I	3	-	-	3	-	-	3
BTP701	Project A	-	-	6	-	-	3	3
BTL701	Lab - IV	-	3	-	-	1.5	-	1.5
BTL702	Lab - V	-	3	-	-	1.5	-	1.5
	Total	17	6	10	17	3	7	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC701	Bioseperation & Downstream Processing Technology-I	20	20	20	80	3	25	-	-	125
BTC702	Bioprocess Modelling and Simulation	20	20	20	80	3	25	-	-	125
BTC703	Agriculture Biotechnology	20	20	20	80	3	25	-	-	125
BTE703X	Department Elective III	20	20	20	80	3	25	-	-	125
ILO701X	Institute Level optional Subject I	20	20	20	80	3	-	-	-	100
BTP701	Project A	-	-	-	-	-	100		50	150
BTL701	Lab - IV	-	-	-	-	-	-	25	-	25
BTL702	Lab - V	-	-	-	-	-	-	25	-	25
	Total			100	400	-	200	50	50	800

Department Elective III (Sem VII)		
Engineering Stream	Advanced Science Stream	Technology Stream
1. Stem Cell & Tissue Engineering (BTE7031)	1. Operation research in Biotechnology (BTE7032) 2. Project Management (BTE7033)	1. Nanotechnology (BTE7034)

Institute Level Optional Subject I (Sem VII)		
1. Product Lifecycle Management (ILO7011)	4. Design of Experiments (ILO7014)	7. Disaster Management and Mitigation Measures (ILO7017)
2. Reliability Engineering (ILO7012)	5. Operation Research (ILO7015)	8. Energy Audit and Management (ILO7018)
3. Management Information System (ILO7013)	6. Cyber Security and Laws (ILO7016)	9. Development Engineering (ILO7019)

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
B.E. Semester VIII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC801	Environmental Biotechnology	4	-	-	4	-	-	4
BTC802	Bioseperation & Downstream Processing technology-II	4	-	-	4	-	-	4
BTC803	Bioprocess Plant & Equipment design	3	-	1	3	-	1	4
BTE804X	Department Elective IV	3	-	1	3	-	1	4
ILO802X	Institute Level optional Subject II	3	-	-	3	-	-	3
BTP801	Project B	-	-	8	-	-	6	6
BTL801	Lab - VI	-	3	-	-	1.5	-	1.5
BTL802	Lab - VII	-	3	-	-	1.5	-	1.5
	Total	17	6	10	17	3	8	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC801	Environmental Biotechnology	20	20	20	80	3	-	-	-	100
BTC802	Bioseperation& Downstream Processing technology-II	20	20	20	80	3	-	-	-	100
BTC803	Bioprocess Plant & Equipment design	20	20	20	80	3	25	-	-	125
BTE804X	Department Elective IV	20	20	20	80	3	25	-		125
ILO802X	Institute Level optional Subject II	20	20	20	80	3	-	-	-	100
BTP801	Project B	-	-	-	-	-	100	-	50	150
BTL801	Lab - VI	-	-	-	-	3	-	25	-	25
BTL802	Lab - VII	-	-	-	-	3	-	25	-	25
	Total			100	400	-	150	50	50	750

Department Elective IV (Sem VIII)		
Engineering Stream	Advanced Science Stream	Technology Stream
1. Non-conventional Sources of Energy (BTE8041)	1. Total Quality Management (BTE8042) 2. Entrepreneurship (BTE8043)	1. Advanced Bioinformatics (BTE8044)

Institute Level Optional Subject II (Sem VIII)		
1. Project Management (ILO8021)	4. Human Resource Management (ILO8024)	7. IPR and Patenting (ILO8027)
2. Finance Management (ILO8022)	5. Professional Ethics and CSR (ILO8025)	8. Digital Business Management (ILO8028)
3. Entrepreneurship Development and Management (ILO8023)	6. Research Methodology (ILO8026)	9. Environmental Management (ILO8029)

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
S.E. Semester III (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC301	Applied Mathematics-III	3	-	1	3	-	1	4
BTC302	Microbiology I	4	-	-	4	-	-	4
BTC303	Cell Biology	3	-	1	3	-	1	4
BTC304	Biochemistry	4	-	-	4	-	-	4
BTC305	Unit Operations-I	3	-	-	3	-	-	3
BTC306	Process Calculations	3	-	1	3	-	1	4
BTL301	Microbiology Lab	-	3	-	-	1.5	-	1.5
BTL302	Biochemistry Lab	-	3	-	-	1.5	-	1.5
BTL303	Unit Operations-I Lab	-	2	-	-	1	-	1
	Total	20	8	3	20	4	3	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC301	Applied Mathematics-III	20	20	20	80	3	25	-	-	125
BTC302	Microbiology I	20	20	20	80	3	-	-	-	100
BTC303	Cell Biology	20	20	20	80	3	25	-	-	125
BTC304	Biochemistry	20	20	20	80	3	-	-	-	100
BTC305	Unit Operations-I	20	20	20	80	3	--	-	-	100
BTC306	Process Calculations	20	20	20	80	3	25	-	-	125
BTL301	Microbiology Lab	-	-	-	-	3	--	25	-	25
BTL302	Biochemistry Lab	-	-	-	-	3	--	25	-	25
BTL303	Unit Operations-I Lab	-	-	-	-	-	--	-	25	25
	Total			120	480	-	75	50	25	750

Course Code	Name of Subject	Credits
BTC301	Applied Mathematics III	04

Pre-requisites:

- Basics of complex numbers: modulus, argument; equation of a circle, roots of unity, Euler's formula; hyperbolic functions; matrices: symmetric, orthogonal and unitary matrices, rank, normal form, solutions of systems of linear equations; basics of LPP: graphical method; calculus: partial derivatives, Hessian, maxima/minima of functions of 1 and 2 real variables.

Course Objectives:

- To introduce students to the basic methods of Laplace transforms.
- Laplace transforms and inverse Laplace transforms of all the standard functions.
- To enable students to solve initial value ODE problems using L-transforms.
- To study eigen values and eigen spaces of matrices.
- Orthogonal and congruent reduction of quadratic forms.
- Complex analysis: C-R equations, Milne-Thomson method.
- Bilinear transformations and cross-ratios.
- Introduction to statistics.
- Lagrange multiplier method for 2 and 3 variables with no more than two constraints.
- To introduce the basics of optimization using Kuhn-Tucker conditions.

Course outcomes:

- The student will be able to solve initial value ODE problems.
- The student will have a good understanding of real and complex analysis.
- The student will have a thorough grounding in matrix algebra.
- The student will be ready for any further courses on optimization.

Module	Contents	Contact Hours
01	The Laplace transform: Definition and properties (without proofs); all standard transform methods for elementary functions including hyperbolic functions; Heaviside unit step function, Dirac delta function; the error function; evaluation of integrals using Laplace transforms; inverse Laplace transforms using partial fractions and H(t-a); convolution (no proof).	07
02	Matrices: Eigen values and eigens paces of 2x2 and 3x3 matrices; existence of a basis and finding the dimension of the eigen space (no proofs); non- diagonalisable matrices; minimal polynomial; Cayley - Hamilton theorem (no proof); quadratic forms; orthogonal and congruent reduction of a quadratic form in 2 or 3 variables; rank, index, signature; definite and indefinite forms.	07
03	Complex analysis: Cauchy-Riemann equations (only in Cartesian co- ordinates) for an analytic function (no proof); harmonic function; Laplace's equation; harmonic conjugates and orthogonal trajectories (Cartesian co- ordinates); to find f(z) when u+v or u -	07

	v are given; Milne-Thomson method; cross-ratio (no proofs); conformal mappings; images of straight lines and circles.	
04	Complex Integration Cauchy's integral formula; poles and residues; Cauchy's residue theorem; applications to evaluate real integrals of trigonometric functions; integrals in the upper half plane; the argument principle.	**06**
05	Statistics: (No theory questions expected in this module) Mean, median, variance, standard deviation; binomial, Poisson and normal distributions; correlation and regression between 2 variables.	**05**
06	Optimization (No theory). Non-linear programming: Lagrange multiplier method for 2 or 3 variables with at most 2 constraints; conditions on the Hessian matrix (no proof); Kuhn-Tucker conditions with at most 2 constraints.	**07**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Mathematical Methods in Chemical Engineering, V.G. Jenson and G.V. Jeffreys, Academic Press, 1970
2. Laplace transforms, Murray Spiegel, Schaum's Outline Series, 1974
3. Complex variables, Murray Spiegel, Schaum's Outline Series, 1964
4. Linear Algebra, Murray Spiegel, Schaum's Outline Series, 1964
5. Probability and Statistics: Murray R. Spiegel, Schaum's Outline Series, 1965
6. Advanced Engineering Mathematics by *Erwin Kreyszig*, 9TH Edition, Wiley India.

Course Code	Course/Subject Name	Credits
BTC302	Microbiology	4

Prerequisites:

Basic Knowledge of Living Cells

Course Objectives:

- The course aims to develop skills of the Students in the area of Microbiology particularly to identify microbes, their structure, their metabolism and their industrial applications.
- They will study various sterilization techniques and their effects.
- This will be a prerequisite for all courses offered in Bioprocess Technology

Course outcomes:

- Students will be able to carry out various microbiological techniques like staining and isolation very well.
- They would be able to identify microbes.
- They would have detailed knowledge of various sterilization techniques, which would be useful for other courses.

Module	Contents	Contact Hours.
1	**History and Scope of Industrial Microbiology:** • Introduction: Discovery of Microbial world • The experiments of Pasteur; The discovery of Anaerobic Life • Physiological significance of Fermentation; Pasteur and Fermentation • The Era of discovery of Antibiotics; Growth of Industrial fermentation	03
2	**Classification of Microorganisms:** • Types and general characteristics of microorganisms: 1) Bacteria- Archaebacteria, Actinomycetes, Rickettsia, Mycoplasma, Chlamydia 2) Fungi – Molds and yeasts 3) Algae 4) Protozoa 5) Viruses • The classification of bacteria Species: The unit of classification, New approaches to bacterial taxonomy, Bacterial taxonomy the problems of taxonomic arrangements, Bacterial phylogeny. • Aerobic and Anaerobic cultures **Microbial Pathogenesis:** • Epidemiology of infectious diseases, Bacterial, Fungal, Protozoal, Viral Diseases; • Bacterial invasion and colonization • Bacterial toxins- types and mode of action	08

3	**Microbial Nutrition:** • Nutritional requirements of microorganisms • Different types of media- Synthetic media, complex media Selective media, differential media, enrichment media.	**05**
4	**Microbial Growth:** • Introduction: phases of growth • Growth curve • Kinetics of growth • Measurement of growth • Continuous &batch culture • Synchrony • Chemostat & turbidostat • Effects of solutes, temperature, ion concentration, oxygen, hydrostatic pressure, heavy metal ions, and UV light on microbial growth	**05**
5	**Microbiological Techniques:** • Sterilization and disinfection techniques, • Principles and methods of sterilization. • Physical methods - autoclave, hot-air oven, pressure cooker, laminar airflow, filter sterilization. • Radiation methods – UV rays, gamma rays, ultrasonic methods. • Chemical methods - Use of alcohols, aldehydes, fumigants, phenols, halogens and hypochlorites. Phenol coefficient. • Isolation of pure culture techniques - Enrichment culturing, dilution plating, streak- plate, spread-plate and micromanipulator. • Preservation of microbial cultures - sub culturing, overlaying cultures with mineral oils, lyophilization, sand cultures, storage at low temperature.	**09**
6	**Antimicrobial Therapy:** • Antimicrobial sensitivity tests. • Agents used in treating infection: Antibacterial, antiviral, antiretroviral, antifungal, anti-protozoan & anti helminthes. • Resistance mechanism.	**07**
7	**Water & Soil Microbiology:** • Microbiological analysis of water purity-sanitary tests for coliforms (presumptive test, confirmed test, competed test), MPN test, defined substrate test, IMVIC test. • Soil microbiology- soil as a habitat for microorganisms, physico-chemical properties of soil, microbial community in soil, role of microorganisms in organic matter decomposition.	**07**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules. Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Textbook of Microbiology ;R. Ananthnarayan, C. K. J. Panicker, Orient Longman 6th Edition (2003)
2. General Microbiology, R.Y. Stanier, J.L. Ingraham, M.L.Wheelis and P.R. Painter, Macmillian
3. Microbiology VI Edition, M.J. Pelczar, E.C.S. Chan and N.R. Kreig, Tata McGraw Hill Microbiology by Prescott
4. Microbiology: An Introduction (9th Ed.) by Tortora GJ, Funke BR, and Case CL, Pearson Education, 2008.
5. Industrial Microbiology, Casida, New Age International
6. Industrial Microbiology, Prescott and Dunn, C.B.S. Publishers Principles of Microbiology, R.M. Atlas, WMC. Brown Publisher.
7. Microbiology – Fundamentals and Application, 6th Ed. – Purohit, S.S. (Agrobios)
8. Textbook of Microbiology, P.Charkborthy
9. General Microbiology Vol. II by Powar and Daginawala Himalaya Publ. House 8th edition (2004)

Course Code	Course/Subject Name	Credits
BTC303	Cell Biology	4

Prerequisites:

- Knowledge of basic terminology of cell and cell organelles
- Knowledge of structure and function of prokaryotic and eukaryotic cell
- Knowledge of different compartments of cell organelle.
- Knowledge of cell division
- Basic knowledge of cell events like photosynthesis, respiration

Course Objectives:

- In this course, Students will explore the great diversity of all cellular form and function.
- Course emphasis is placed on the molecular mechanisms of cell metabolism, growth, division, and communication.
- This course is central to the cell biology and serves as the bridge between foundational courses in the cell and advanced courses in the complexity of sorting in the cell.

Course Outcome:

- By the end of the course students should be able to grasp the fundamentals in Understanding the molecular organization of the cells, function and structure of The different organelles including transport mechanisms for processes like; Protein sorting, cell communication and flow of information and transport across the unit membrane, cell signaling.
- Students will have good knowledge of cancer, its types and etiology. Students will be able to appreciate all basic concepts which he may encounter in future courses in biotechnology engineering.
- Students will be ready for application of these concepts in the field of research in biotechnology.

Module	Contents	Contact Hours
1	**Cytology:** • Developmental history of cytology: Origin of cell, Robert Hooke's Experiment, Cell theory, Miller's Experiment Properties & Types of cells: Prokaryotic & Eukaryotic cell • Structure and function of cells such as Viruses, Bacteria, Animal cells, Plant cells.	05
2	**Cell cycle & cell death:** • Cell cycle and its regulation: Cyclins, CDKs, Checkpoints • Cell division: Mitosis & Meiosis • Programmed cell death: Apoptosis, Extrinsic & Intrinsic pathway • Apoptosis vs. Necrosis	05
3	**Structural organization of cell and role of cell organelles in sorting and intracellular transport:**	08

	• Cell membrane: Function, Composition, Membrane proteins, Fluid Mosaic model, Electrical properties of membrane, Neurotransmission • Nucleus: Nuclear Envelop, Nuclear Pore Complex & its role in nucleocytoplasmic exchange • Overview of endomembrane system: secretory and endocytic pathway • Endoplasmic Reticulum: SER & RER, Protein synthesis on membrane bound and free ribosomes, Protein Glycosylation in ER & Golgi complex, Membrane biosynthesis in the ER • Golgi bodies: Movement of materials through the Golgi complex • Structure & function of Cell wall, Mitochondria, Lysosomes • Structure and function of cytoskeleton: (i)Microtubules – Structure & composition, MAPs, MTOCs, Dynamic properties of microtubules, Overview of motor proteins. (ii)Microfilaments – Structure, Assembly & disassembly. (iii)Intermediate filaments – Structure, Assembly & disassembly, Types and functions.	
4	**Transport across cell:** • Bulk transport: Exocytosis, Phagocytosis, Endocytosis – Pinocytosis & Receptor mediated endocytosis • Mechanism of transport of substances through membrane: (i) Active Transport – Ion pumps (ii) Passive Transport – Diffusion, Osmosis, Facilitated diffusion, Ion channels	**05**
5	**Cellular communication:** • General principles of cell communication: Types of adhesion, CAMs • Extracellular matrix: Components – Collagen, Proteoglycans, Fibronectin, Laminin • Interactions of cells with extracellular materials: Integrins, Focal Adhesions & Hemidesmosomes • Interactions of cells with other cells: Selectins, IgSF, Cadherins, Adherens junction, Desmosomes • Tight junctions • Gap junctions and plasmodesmata	**07**
6	**Cell Signaling:** • Types of intercellular signaling: Auto, Para & Endocrine • Overview of cellular signaling pathway • Various extracellular messengers and their receptors • Signal transduction by RTKs: Receptor dimerization, Protein kinase activation, Activation of downstream signaling pathways, Ending the response. Signaling by Insulin receptor	**05**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Cell and Molecular biology: Concepts and Experiments, Gerald Karp, John Wiley and sons Inc, 6th Edition (2010)
2. Molecular Cell Biology, H. Lodish et. al., W.H. Freeman & Co Ltd, 5th Edition (2003)
3. Cell and Molecular Biology, DeRobertis; Lippincott Williams & Wilkins 8th Edition (2001)
4. Molecular Biology of the Cell and the Hypercell with CDROM; Alberts, Bray; Garland Publishing 1st Edition (1999)
5. Molecular Biology of the Cell with CDROM Alberts, Bruce; Johnson, Alexander; Lewis, Julian 4th Edition (2005).

Course Code	Course/Subject Name	Credits
BTC304	Biochemistry	4

Prerequisites:

- Knowledge of organic chemistry: functional groups and their reactions
- Knowledge of living cell and its components

Course Objectives:

- The major objective is to provide complete understanding of all the chemical processes associated with living cells at the molecular level.
- To ensure students have a strong grounding in structures and reactions of biomolecules.
- To introduce them to the metabolic pathways of the major biomolecules.
- To correlate biochemical processes with biotechnological applications.

Course outcomes:

- The students will be able to understand and analyze the correlation between biomolecules, their associated pathways and various biological processes underlying the living systems.

Module	Contents	Contact Hours
1	• Introduction, aims and scope • Chemical foundations of Biology- Properties of water, acids, bases and buffers, covalent bonds, Non-covalent interactions in biological systems.	05
2	**Biomolecules:** Classification, Structure and Functions of : • Carbohydrates: • Lipids • Proteins • Nucleic acids	10
3	**Enzymes:** • Working of Enzymes • Concept of Activation energy and transition state • Factors affecting enzyme activity- pH, Temperature, Substrate & Enzyme Concentration	05
4	**Vitamins and Hormones:** • Vitamins: Classification, functions, role in metabolism, vitamins as cofactors. • Hormones: Classification, endocrine glands, function and mechanism of action of hormones.	05
5	**Metabolism:** • Carbohydrates- Glycolysis, TCA cycle • Lipids- Digestion by GI enzymes and breakdown of Triglycerides: α, β, ω oxidation of fatty acids	15

	• Amino acids- decarboxylation, deamination & transamination. Urea cycle; fate of amino acids (connection to TCA) • Electron Transport Chain • Photophosphorylation- Photosystems, reaction centers, pigments, cyclic and non-cyclic photophosphorylation, Z pathway	
6	**Bioenergetics:** • Laws of Thermodynamics • Concept of Enthalpy, Entropy • Energy rich compounds – ATP as energy currency	**05**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. Nelson, D.L. and M.M. Cox, "Lehninger's Principles of Biochemsitry", 4th Edition, W.H. Freemen & Co., 2005.
2. Murray, R.K., et al "Harper's Biochemistry", 23rd Edition, Prentice Hall International, 1993
3. Lubert Stryer. 2007. Principles of Biochemistry. Freeman.
4. Voet and Voet. 2005. Biochemistry. Wiley.
5. D. Skoog, D. West, F.Holler, S. Crouch "Fundamentals of Analytical Chemistry" 8th Edition, 2004. Thomson Brooks/ Cole
6. David T. Plummer, An Introduction to practical biochemistry, Tata McGraw Publishing Company Ltd.

Course Code	Course/Subject Name	Credits
BTC305	Unit Operations – I	3

Prerequisites:

Basic knowledge in physics, units and dimensions and thermodynamics

Course Objectives:

- To impart the basic concepts of fluid statics and dynamics
- To study the basic equations of fluid flow.
- They should be comfortable with measurement of pressure or pressure drop.
- To enable students to determine viscosity using method such as Stokes Law.
- To study the different types of size reduction equipment used in Industries.
- To study about the metering and pumping of fluids.

Course Outcomes:

- The student will have a thorough grounding on measurement of pressure drop, velocity, flow rates etc. of fluids.
- They can select pumps and would be able to calculate power requirement for pumping as well as agitation operations.
- They will be able to operate certain flow measurement devices and size reduction equipment.

Module	Content	Contact Hours
1	**Introduction:** Classification of fluids, Rheological behavior of fluids & Newton's Law of viscosity. Effect of temperature & pressure on viscosity of fluids. **Fluid statics:** Pascal's law ,Hydrostatic equilibrium, Barometric equation and pressure measurement (problems)	05
2	**Fluid Dynamics:** Continuity Equation, Equation of motion, Euler's equation of motion, Bernoulli's equation (problems), Bernoulli's equation for compressible fluids (isothermal and adiabatic process) concept of Reynold's number, Laminar flow in pipes, Turbulent flow in pipes, velocity and shear stress distribution across pipe, Boundary layer formation and separation of boundary layer.	07
3	**Flow of Incompressible fluids:** Relationship between skin friction and wall shear, Fanning friction factor, friction factor law for smooth pipes, Form friction, effect of roughness, energy relationships, pipe fittings, major and minor losses in pipe flow. (problems) **Flow measurements:** Venturimeter, Orificemeter, Pitot tube, Rotameter. (problems) **Pumping:** Reciprocating pumps, Rotary pumps, centrifugal pumps (Characteristics, NPSH, and Cavitation) and blowers.	08
4	**Particle Size distribution:** Importance of particle size in reactions, particle size, shape and mass distributions,	07

	measurement and analysis, concept of average diameter. (problems) **Screening:** Screening equipment, capacity and effectiveness of screen, effect of mesh size on capacity of screen. Particle size analysis – mean diameter, derived diameter. Sieving - cumulative method and differential method. **Transportation and storage of solids:** Studies performance and operation of different conveyor systems like Belt, Screw, Apron, Flight, pneumatic conveyor and elevators; Storage of solids and discharge pattern from storage bin.	
5	**Size Reduction:** Factors affecting size reduction, comminution laws – Kick's law, Rittinger's law and Bond's law and their limitations. Crushing efficiency & power consumption (problems) **Size reduction equipment:** Grinder – Construction and operation of Hammer mill, Ball mill (problems), Ultrafine grinder – Fluid energy mill, Cutting machines: knife cutters.	**04**
6	**Sedimentation:** Free settling and Hindered settling, Stoke's law & Newton's law regimes of settling. Clarifiers and thickeners, flocculation, batch Sedimentation (Kynch theory), rate of sedimentation.	**04**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

Text books

1. Dr. R. K. Bansal, "A Textbook of Fluid Mechanics & Hydraulic Machines", Laxmi Publications, 9th Edition, 2010.
2. R. S. Hiremath & A. Kulkarni. Mechanical Operations Vol. I.
3. McCabe, W.L, Smith J.C and Harriot, P., "Unit Operations in Chemical Engineering", McGraw Hill, Fourth Edition, 1984.
4. Narayanan C.M. & Bhattacharya B.C. "Mechanical operations for chemical engineers", Khanna.

References

1. Coulson, J.M., Richardson, J.F., "Chemical Engineering", Volume 2, Third Edition, Pergamon Press, 1977.
2. Badger and Bencharo, "Introduction to Chemical Engineering". TMH,
3. Fluid Mechanics and Hydraulics by Suresh Ukarande, Ane Books, 2012.

Course Code	Course/Subject Name	Credits
BTC306	Process Calculations	4

Prerequisites:

- Linear Algebra
- Differential Equation

Course Objectives:

- To study the laws regarding gas, liquid and vapor
- To develop understanding about material balance and energy balances
- To study the stoichiometry and thermodynamics of microbial growth and product formation

Course outcomes:

- The student will be able to understand basic application of various unit operations & unit processes to industrial &theoretical problems
- They will have a clear understanding of the various systems of units will be able to do the conversion of units of one system to another.
- They will be able to do basic calculations for biological systems & access the property data from appropriate sources.

Module	Content	Contact Hours
1	Units and dimensions: Systems of units, fundamental and derived units, unit conversions, dimensional homogeneity and dimensional analysis problems. Conversion of units Chemical arithmetic: Mole concept, atomic weight, molecular weight and equivalent weight- methods of determination. Chemical composition: Methods of expressing compositions of mixtures and solutions- mole percent, mass percent, volume percent, molarity, molality, normality etc. P-V-T behavior of pure liquids- Gas laws, real and ideal gases, equation of state, critical properties, properties of gas mixtures- Dalton's laws, Amagat's law-Average molecular weight and density problems. Biochemical stoichiometry: Limiting and excess reactants- conversion, degree of completion, selectivity, yield problems.	07
2	Fundamentals of material balances- Law of conservation of mass- Types of material balances, material balance with recycle bypass and purge streams	07
3	Material Balance for process involving chemical reaction, Calculations using Psychrometric chart; Humidity and saturation	07
4	Fundamentals of energy balances, Law of conservation of energy, Heat capacity, sensible heat, latent heat, calculation of enthalpy changes. General energy balance equation; Energy balance calculations with and without reactions, Energy	07

	balance for fermentation and downstream processing problems.	
5	Stoichiometry of microbial growth and product formation, Growth, Stoichiometry and elemental balances, respiratory quotient, degree of reduction, Yield and maintenance coefficients, Oxygen consumption in aerobic microbial cultures. Theoretical Oxygen demand- problems. Biochemical energetics: Metabolic reaction coupling, energetics of metabolic processes (respiration and biosynthesis). Transport across cell membranes, Thermodynamics of microbial growth, Heat generation in microbial cultures problems.	**07**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules.
- Weightage of marks should be proportional to number of hours assigned to each Module.

References

1. David M. Himmelblau. 1989. Basic Principles and Calculations in Chemical Engineering. Prentice Hall of India (P) Ltd.
2. Hougen, K. M. Watson and R. A. Ragatz. 1970. Chemical Process Principles, Part - I, John Wiley and Asia Publishing Co.
3. Bhat B.I and S. M. Vora, 2005. Stoichiometry. Tata McGraw Hill.
4. Richard Felder and Ronald W. Rausseau. 1986. Elementary Principles of Chemical Processes. John Wiley & Sons.
5. Doran P.M, Bioprocess Engineering Principles, Academic Press
6. Bailey G.E and Ollis D.F, Bioprocess Engineering Fundamentals McGraw Hill
7. Shuler M.L and Kargi F, Bioprocess Engineering- Basic Concepts, Pearson Education
8. Segel I.H, Biochemical Calculations, John Wiley
9. Blanch H.W and Clark D.S, Biochemical Engineering Marcel Dekker Inc.

Course Code	Course/Subject Name	Credits
BTL301	Microbiology Lab	1.5

List of Experiments Suggested:

- Study of different equipments- Bunsen burner, water bath, Autoclave, Laminar air flow, Incubator, Hot air oven, Centrifuge, and Refrigerator.
- Study of Microscope- Compound Microscope & its parts. Use of oil Immersion objective.
- Preparation of medium -nutrients broth, nutrient agar, agar slant.
- Staining: Simple, Differential staining methods, Capsule, Endospore; Study of shape and arrangement of bacterial cells
- Isolation of microorganism by Pure Culture Techniques.
- Effect of disinfectants on microbial flora
- Isolation and identification of microorganisms from different sources – soil, water and milk
- Antibiotic sensitivity assay
- Effect of different parameters on bacterial growth (pH, temperature & UV irradiation)
- Culture of aerobic &anaerobic bacteria
- Effect of TDP & TDT on bacterial growth
- Filter paper disc methods for evaluation of antiseptics
- Study of growth curve of *E. coli*
- Bacterial colony counting using Haemocytometer

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
BTL302	Biochemistry Lab	1.5

List of Experiments Suggested:

- Preparations of solutions –molar, normal, ppm, percent
- Study of pH meter and preparation of buffers
- Study of Beer and Lambert's Law and absorption maxima
- Glucose estimation by DNSA method
- Protein estimation by Biurette Test
- DNA estimation by DPA method
- RNA estimation by Orcinol method
- Estimation of Vitamin C by Iodometry
- Extraction and separation of plant pigment by paper chromatography
- TLC of Fatty acids
- Study of Enzyme Activity
- Estimation of Lipids

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
BTL303	Unit Operations - I Lab	1.0

List of Experiments Suggested:

- Viscosity by Stoke's Law
- Venturimeter
- Orificemeter
- Flow through Helical coil
- Reynold's Apparatus.
- Bernoulli's apparatus
- Sieve analysis
- Screen effectiveness
- Major and Minor losses
- Ball mill
- Hammer mill
- Sedimentation
- Centrifugal pumps

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
S.E. Semester IV (w.e.f 2017-2018)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC401	Applied Mathematics-IV	3	-	1	3	-	1	4
BTC402	Molecular Genetics	3	-	1	3	-	1	4
BTC403	Fermentation Technology	4	-	-	4	-	-	4
BTC404	Analytical Methods in Biotechnology	4	-	-	4	-	-	4
BTC405	Immunology and Immunotechnology	3	-	1	3	-	1	4
BTC406	Unit Operations-II	3	-	-	3	-	-	3
BTL401	Fermentation Technology Lab	-	3	-	-	1.5	-	1.5
BTL402	Analytical Methods in Biotechnology Lab	-	3	-	-	1.5	-	1.5
BTL403	Unit Operations-II Lab	-	2	-	-	1	-	1
	Total	20	8	3	20	4	3	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC401	Applied Mathematics-IV	20	20	20	80	3	25	-	-	125
BTC402	Molecular Genetics	20	20	20	80	3	25	-	-	125
BTC403	Fermentation Technology	20	20	20	80	3	-	-	-	100
BTC404	Analytical Methods in Biotechnology	20	20	20	80	3	-	-	-	100
BTC405	Immunology and Immunotechnology	20	20	20	80	3	25	-	-	125
BTC406	Unit Operations-II	20	20	20	80	3	--	-	-	100
BTL401	Fermentation Technology Lab	-	-	-	-	3	--	25	-	25
BTL402	Analytical Methods in Biotechnology Lab	-	-	-	-	3	--	25	-	25
BTL403	Unit Operations-II Lab	-	-	-	-	-	--	-	25	25
	Total			120	480	-	75	50	25	750

Course Code	Course/Subject Name	Credits
BTC401	Applied Mathematics IV	4

Prerequisites:

- **Vector Calculus**:- Multiple Integral, Partial differentiation, basic knowledge of vectors and their products, Knowledge of spherical and cylindrical coordinate system.
- Partial Differential Equation:- Integration, Know2ledge of partial derivatives.

Course Objectives:

- The syllabus/module aims to introduce the above topics (to the Learner) so as to equip the learner with mathematic tools to effectively model, analyze and find the solution of various problems in Chemical Engineering and Biotechnology processes.
- One can use vector formation and calculus together to describe and solve many problems in two/three dimension. The Fourier Transform and PDE module does the ground work for the techniques required to solve and find the answer for various physiochemical problems.

Course Outcomes:

- It is expected that the learner will develop the proactive approach towards the selection of methods to a solution of Chemical Engineering and Biotechnology problems coming across while studying higher level of the Course. (Example: Flow of Liquid through Pipes/Gases etc.)

Module	Contents	Contact Hours
01	**Fourier Series** Expansion of functions in any interval (a, b). Half range expansion; Complex form; Parseval's identity theorem; Orthogonal and Orthonormal functions. NO PROOFS REQUIRED.	09
02	Fourier Integrals and Fourier Transform; sine & cosine Integrals, sine & cosine transforms, complex transforms. NO PROOFS REQUIRED.	10
03	**Partial Differential Equations** Elliptic, Parabolic & Hyperbolic Equations; Laplace's equation; One dimensional Heat & Wave Equation, Two Dimensional wave equation. (ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	10
04	**Vector Integration** Green's Theorem in the plain; Conservative & Solenoidal Fields. Green's Theorem in the plain; Conservative, Gauss Divergence Theorem, Stokes' Theorem. (ONLY NUMERICAL PROBLEMS. NO PROOFS REQUIRED).	10

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules. Weightage of marks should be proportional to number of hours assigned to each Module

References

1. Advanced Engineering Mathematics by *Erwin Kreyszig*, 9TH Edition, Wiley India.
2. Schuam's outline series in Fourier series.
3. Schuam's outline series in partial differential equations.
4. Partial differential equations Vol 1 by Rutherford Aris.

Course Code	Course/Subject Name	Credits
BTC402	Molecular Genetics	4

Prerequisites:

- Knowledge of Cell and its components
- Knowledge of Biomolecules and their functions
- Knowledge of Cellular Metabolism

Course Objective:

- Understand the Central Dogma of gene expression
- Explain the foundations of Mendelian genetics and chromosomal theory and apply these, with appropriate terminology, to contemporary concepts in genetics.
- Understand the redundant and universal qualities of the genetic code and how it is used to determine the amino acid sequence of a polypeptide.
- Describe the processes of transcription and translation in both prokaryotes and eukaryotes at the molecular level.
- Describe how prokaryotes control their gene expression through positive and negative regulatory mechanisms.

Course outcome:

- Students will get knowledge of molecular biology and genetics of Prokaryotic and eukaryotic organisms.
- Students will get insight on Replication, Transcription and translation processes in prokaryotes and eukaryotes, various mutations, their Repair mechanisms. Genetic syndromes.

Module	Contents	Contact Hours
01	**Structure of Nucleic Acid:** • DNA, RNA: mRNA,tRNA, rRNA, • Denaturation and Renaturation of DNA, • Tm, GC content from Tm, • Complexity of DNA, Cot curves • Satellite DNA: Repetitive DNA, SNP, STR	04
02	**Mendelism and its extensions** • Mendel's Laws , problems based on his laws • Linkage and Crossing Over • Multiple allelism • ABO blood group inheritance	06
03	**Cytogenetics** • International System for Human Chromosome Nomenclature • Mechanisms of numerical and structural chromosomal aberrations • Chromosomal and non-chromosomal basis of sex determination • Syndromes – Down's, Turner, Cri Du Chat, Klinfelter Transposons • Fluorescence in-situ hybridization technique and applications	04

04	**DNA Replication and Repair:** • Prokaryotic and Eukaryotic DNA replication mechanism - Enzymes and accessory proteins involved in DNA replication , • DNA Mutations: Types of Mutations and Mutagens • DNA Repair Mechanism – Excision, recombinational, SOS, Photo reactivation, Mis-match repair	**06**
05	**Transcription** • Relationship between Genes and Proteins • Prokaryotic transcription • Eukaryotic transcription: Eukaryotic RNA Polymerases, Transcription of protein coding genes, Production of mature mRNAs in Eukaryotes- 5' Modification , 3' Modification , Intron splicing, RNA Editing	**05**
06	**Translation** • The nature of Genetic Code • Synthesis of aminoacyl-tRNA, Ribosomal RNA genes • Mechanism of initiation, elongation and termination of • Translation in bacteria Co-and post-translational modifications of proteins	**05**
07	**Regulation of gene expression** • Operon theory • lac Operon: Structure, Regulation of Lac genes, Positive control of Lac Operon • trp Operon: Gene organization of the tryptophan biosynthetic genes, Regulation of the trp operon, attenuation • ara operon: structure and regulation of ara operon	**05**

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks

Attendance: 05 marks

Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules. Weightage of marks should be proportional to number of hours assigned to each Module

References

1. Molecular Biology; David Freifelder, Narosa Publishing House, 2nd edition (2004).
2. Microbial Genetics; David Freifelder, Narosa Publishing House, 2nd edition (2004).
3. Principles of Gene Manipulations; S. B. Primrose, R. M. Twyman, R. W. old, Blackwell Science,6th Edition (2003)
4. Genetics: A molecular Approach, 2nd edition; Peter J Russell
5. Gene VIII; Benjamin Lewin; Oxford Univ. Press, 8th edition (2004)
6. Cell and Molecular biology: Concepts and Experiments, Gerald Karp, John Wiley and sons Inc, 6th Edition (2010)

Course Code	Course/Subject Name	Credits
BTC403	Fermentation Technology	4

Prerequisites:

- Knowledge of microbiology

Course Objectives: To gain broad knowledge on

- Role of microorganisms in fermentation
- The various fermentation technologies used
- Production of important products through fermentation

Course Outcomes:

- Appreciate the use of microorganisms for the production of value added commodities.
- Understand the working of a fermentation system.
- To describe key industrial bioprocesses, from the traditional to the recently evolved.
- Integrate biological and engineering principles involved in the production and recovery of commercial products.
- Develop critical thinking skills and learn to employ a quantitative, scientific approach towards conversion of biological materials to value added products.

Module	Contents	Contact Hours
01	**Introduction to fermentation** History and development of fermentation, general requirements of the fermentation, range of fermentation processes, parts of a fermentation process- upstream and downstream processing, aerobic and anaerobic fermentation, solid state and submerged fermentation.	04
02	**Introduction to Microbial Growth Kinetics** Batch culture (Quantifying cell concentration, Growth patterns and Kinetics), Continuous culture, Comparison of batch and continuous cultures in industrial processes, Fed batch culture, Examples of use of fed batch cultures.	05
03	**Isolation, preservation and improvement of industrial microorganisms** • Isolation methods utilizing selection of the desired characteristics • Isolation methods not utilizing selection of the desired characteristics • The preservation of industrially important microorganisms • Improvement of industrial microorganisms	07
	• The selection of induced mutants synthesizing improved levels of products • The use of rDNA techniques	
04	**Regulatory Mechanisms controlling the catabolic and**	03

	anabolic pathways of microbes Induction, carbon catabolite repression, crab tree effect, feedback inhibition and repression	
05	**Media for industrial fermentations & sterilization** Introduction, Typical media, Energy sources, Carbon sources, Nitrogen sources, Buffers, Oxygen requirements, Antifoams, Medium optimization, Medium sterilization: The design of batch sterilization processes, The design of continuous sterilization processes, Sterilization of the fermenter, feeds and air, Filter sterilization	**06**
06	**The development of inocula for industrial fermentations** The development of inocula for yeast , bacterial and fungal processes, The aseptic inoculation of plant fermenters	**04**
07	**Aeration and agitation** The oxygen requirements and supply of industrial fermentations, Determination of KLa, Factors affecting KLa values, The balance between oxygen supply and demand	**04**
08	**Design of fermenter** Basic function of a fermenter for microbial or animal cell culture, body construction, various parts of a fermenter	**04**
09	**Important products through Fermentation** Organic acids: citric and acetic acid; enzymes : amylase, protease, lipase; antibiotics: penicillin; vitamins: vitB12; aminoacids: lysine, Glutamic acid ; organic solvents: ethanol, acetone butanol; alcoholic breverages: wine, beer; biomass : bakers yeast; biofertilizers; biopesticides; biosurfactant; steroid transformation; biopolymers	**08**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules. Weightage of marks should be proportional to number of hours assigned to each Module

References

1. Principles of Fermentation Technology – Stanbury P.F., Whitaker A, Hall S. J.
2. Bioprocess Engineering: Basic concepts – Shuler M.L., Kargi F. (PHI)
3. Bioprocess Engineering Principles – Doran Pauline M. (Elsevier Pub.)
4. Biotechnology: A textbook of Industrial Microbiology- Cruger, W. and A. Cruger
5. Introduction to Biochemical Engineering - DG Rao, 2005, Tata McGraw-Hill, New Delhi

Course Code	Course/Subject Name	Credits
BTC404	Analytical Methods In Biotechnology	4

Pre-requisites:

- Basic knowledge of Physical and Analytical Chemistry
- Knowledge of various types of spectra
- Knowledge of Biomolecules and their properties

Course Objective:

- To study the various analytical techniques used in Biotechnology.

Course outcomes:

- The students will be capable of handling different instruments in the laboratory.
- They would be able to compare different separation techniques and use them effectively in research work

Module	Contents	Contact Hours
01	**Centrifugation:** □ General principle- sedimentation velocity, sedimentation equilibrium □ Types of centrifuges, preparative and analytical centrifugation, differential centrifugation, density gradient methods □ Applications	08
02	**Chromatographic Techniques:** □ Introduction to chromatography, General principles □ Planar Chromatography: Thin layer chromatography, paper chromatography □ Column chromatography–columns, stationary phases. Packing of columns, application of sample, column development, fraction collection and analysis. □ Partition chromatography, Adsorption chromatography Affinity Chromatography, Ion Exchange Chromatography, Chromato focussing, Size exclusion chromatography. □ Gas Chromatography, HPLC: Principle & Components: pumping systems, detectors systems □ Applications	12
03	**Electro kinetic methods of separation:** □ Electrophoresis: General principle and application, factors affecting electrophoresis – voltage, current, resistance, buffer, composition, concentration, pH. □ Agarose Gel electrophoresis □ SDS-PAGE – Native and denaturing gels, gradient gels, discontinuous buffer system □ Two dimensional gel electrophoresis □ Isoelectric focusing □ Capillary electrophoresis	09

	Immuno electrophoresis	
04	**Spectroscopy:** Spectroscopic Techniques; Beers Lamberts law, molar and extinction coefficient, limitations of Beers Lamberts law Visible and UV Spectrophotometry; Principles, Instrumentation and applications	**08**
05	**Radio isotopic techniques:** Use of radioisotopes in life sciences, radioactive labelling, principle and application of tracer techniques Detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger-Muller and Scintillation counters, Autoradiography Applications	**08**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules. Weightage of marks should be proportional to number of hours assigned to each Module

References

1. Wilson K and Goulding K.H., A biologist's guide to Principles and Techniques of Practical Biochemistry.
2. Willard and Merrit, Instrumental Methods and Analysis
3. Ewing GW, Instrumental Methods of Chemical analysis.
4. Robert. M. Silverstein et al, Spectrometric identification of Organic Compounds, 7th Edition, 1981.
5. Vogel's, Text Book of Quantitative Chemical Analysis, 6th Edition, 2004.
6. John A. Adamovic, Chromatographic Analysis of Pharmaceuticals, 2nd Edition.
7. Raymond P. W. Scott, Techniques and Practice of Chromatography –Vol. 70.
8. Sethi P.D, Dilip Charegaonkar, Chromatography –2nd Edition.
9. Niessen W. M. A., Van Der Greef J, Liquid Chromatography– Mass Spectrometry, Vol. 58.
10. Kalsi. P.K, Spectroscopy of Organic Compounds.
11. Hanes, Gel Electrophoresis of Proteins- A Practical Approach,
12. Hamilton R. J. and Sewell P. A, Introduction to High Performance Liquid Chromatography
13. Gordon M. Message, Practical aspects of Gas Chromatography and Mass Spectrometry, John Wiley and Sons, New York. 1984
14. Chapman J.M and G. Ayrey, The use of radioactive isotopes in the life sciences, George Allen and Unwin Ltd., London.
15. Biophysical chemistry by Upadhyay, Upadhyay and Nath, Himalaya publication house.

Course Code	Course/Subject Name	Credits
BTC405	Immunology and Immunotechnology	4

Prerequisites:

- Knowledge of anatomy and physiology of human body
- Knowledge of blood components and blood cells
- Knowledge of lymphatic system
- Knowledge of principle of immune response and vaccine
- Knowledge of history and basic terminology in immunology

Objectives

- To learn about various basic terminology in immunology
- To have knowledge of immune system in detail
- To describe the interaction of antigens and antibodies in antibody mediated and cell-mediated immune responses.
- To make familiar with the techniques involved in antigen and antibody reactions
- To understand the concepts and principle of immunoassay techniques in routine diagnosis, research
- To learn principle and types of vaccines

Outcomes:

- Student can define innate and adaptive immunity
- Student can define the characteristics of antigens
- Student can define the characteristics of antibodies
- Student can describe cellular cooperation in antibody and cell mediated immune responses
- Student can define antigen antibody interaction
- Student can describe Production of Monoclonal Antibodies and Recombinant Vaccines.

Module	Contents	Contact Hours
01	**Introduction to immune system**	06
	Innate and adaptive immunity	
	Cells and organs of the immune system	
	Primary and secondary immune responses;	
	Cell mediated and humoral response	
02	**Antigens & Antibodies**	04
	Antigens	
	Antibodies and T cell receptors: Antigens, Structure and function of immunoglobulin,	
	B and T cell receptors	
03	**Generation and regulation of immune responses**	08
	Antigen processing and presentation	
	MHC-restriction; Cytokines	
	T Cell Maturation, activation and Differentiation B Cell	
	Generation, activation and differentiation	

	Clonal selection and immunological memory	
	Complement system, classical, alternative and MBL pathway	
	Cell mediated cytotoxic responses	
	Regulation of immune responses; Immunological tolerance	
04	**Antigen-antibody Reactions**	**07**
	Strength of Antigen-Antibody Reactions	
	In Vivo Antigen-Antibody Reactions, In Vitro Antigen-Antibody Reactions	
	Precipitation (In Fluid and In Gel Immuno electrophoresis),	
	Agglutination (Heamagglutination, Bacterial agglutination, Passive agglutination and Agglutination Inhibition).	
	Radio immuno Assay (RIA)	
	Enzyme Linked Immunosorbant Assay (ELISA),	
	Western Blot	
	• Immune Fluorescence Immunoprecipitation	
05	**Disorders of Human Immune System**	**06**
	Primary and secondary immunodeficiency; Autoimmune disorders; Hypersensitive reactions; Cytokine related diseases	
06	**Production of Monoclonal Antibodies and Recombinant Vaccines.**	**05**
	Monoclonal antibody, polyclonal antibody. Production of	
	Monoclonal antibodies - Definition, production, applications.	
	Vaccines - Definition, recombinant vector vaccines, DNA vaccines ,Multivalent subunit vaccines, minicell vaccines, conjugate vaccines	

Term work

Term work shall consist of minimum **eight** tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 marks
Attendance: 05 marks
Total: 25 marks

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.

- Remaining questions will be randomly selected from all the modules. Weightage of marks should be proportional to number of hours assigned to each Module

References

1. Essential Immunology: Ivan Roitt.
2. Kuby Immunology: Golds by, Kindt and Osborne.
3. Immunology: Roitt, Brostoff, Mole.
4. Introductory Immunology : Huw Davies

Course Code	Course/Subject Name	Credits
BTC406	Unit Operation - II	3

Pre-requisites:

- An understanding of differential equations and basic physical concepts, units and dimensions

Course Objectives:

- To study the basics of Heat and Mass Transfer
- To develop understanding about the application of Heat and Mass transfer in Bio processing.
- To calculate the size of heat transfer equipments, for a known quantity of raw material.
- To apply energy balance.
- To understand the role of diffusion, drying &distillation in the processes. To apply material balance.
- To design equipments in which heat &mass transfer occurs.

Course outcomes:

- The student will be able to understand basic application of various unit operations &unit processes to industrial &theoretical problems
- They will have a clear understanding of the theories of Heat and Mass transfer which are used for modeling.
- They will be able to do design the fermenter and Bioreactors using the models developed.

Module	Contents	Contact Hours
01	Introduction: Various modes of heat transfer Viz. Conduction, Convection and Radiation.	07
	Conduction: Fouriers law, Steady state unidirectional heat flow through single and multiple layer slabs, Cylinders and spheres for constant and variable thermal conductivity.	
	Insulation: Properties of insulation materials, Types of insulation, Critical and Optimum thickness of insulation	
	Extended Surfaces: Fins – Types of fins, Derivation of fin efficiency for longitudinal fins, Fin effectiveness. Elementary treatment of unsteady state heat conduction. Problems	
02	Convection: Individual and overall heat transfer coefficient, LMTD, LMTD correction factor.	08
	Dimensionless numbers, - Dimensional analysis, Empirical correlation for forced and natural convection.	
	Analogy between momentum and heat transfer – Reynolds, Coulburn and Prandtl analogies. Problems	
	Heat Transfer with Phase Change: Boiling phenomena, Nucleate and film boiling, Condensation – Film and Drop wise condensation, Nusselts equations.	
03	Radiation: Properties and definitions, Absorptivity, Reflectivity, Emissive power and intensity of radiation, Black body radiation,	08

	Gray body radiation,	
	Stefen – Boltzmann law, Wien's displacement law, Kirchoffs law, View factors, Radiation between surfaces- different shapes, Radiation involving gases and vapours, Radiation shields.	
	Heat Transfer Equipment: Double pipe heat exchangers, Shell and tube heat exchangers – Types of shell and tube heat exchangers, Condenser – types of condensers. Design of heat exchanger.	
	Evaporators: Types of evaporators, performance of tubular evaporator – Evaporator capacity, Evaporator economy, Multiple effect evaporator	
04	Diffusion: Molecular diffusion in fluids, Diffusion coefficient, Flick's Law of diffusion, Dependence of diffusion coefficient on temperature, pressure and composition, Diffusion in multi-component gas mixtures. Diffusion in solids: Molecular, Knudsen &surface diffusion Inter- phase mass transfer, Mass transfer coefficients ,Diffusion between phases , Equilibrium solubility of gases in liquids, Mass Transfer theories, Mass transfer in fluidized beds , flow past solids and boundary layers, Simultaneous heat and mass transfer.	**07**
05	Mass Transfer in Bioprocess Operations: Role of Diffusion in Bio processing, Oxygen Uptake in Cell Culture, Factors affecting cellular oxygen demand, oxygen transfer from gas bubble to cell, oxygen transfer in fermenters, sparging stirring and medium properties, anti foaming agents, temperature, gas pressure and oxygen partial pressure, presence of cells, measuring dissolved oxygen concentration, estimating oxygen solubility, effect of oxygen partial pressure, effect of temperature, effect of solutes, mass transfer correlations, measurement of kLa, oxygen balance method, dynamic method, sulphite oxidation method, oxygen transfer in large vessels.	**05**

Assessment

Internal:

- Assessment consists of average of two tests which should be conducted at proper interval.

End Semester Theory Examination:

- Question paper will comprise of 6 questions, each carrying 20 marks.
- Total 4 questions need to be solved.
- Question No.1 will be compulsory and based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules. Weightage of marks should be proportional to number of hours assigned to each Module

References

1. Robert E Treybal, Mass Transfer Operations, McGraw Hill Third Edition
2. Diffusion: Mass Transfer in Fluid System (Cambridge series in Chemical Engineering) by E.L.Cussler"

3. McCabe & Smith, Unit Operations in Chemical Engineering, 6th Edition, McGraw Hall, 2001.
4. Coulson and Richardson, Chemical Engineering Vol I, 4th Edition, Pergmon
5. Press, 1998.
6. Badger & Banchero, Introduction to Chemical Engineering, TMH 6th Reprint, 1998.
7. Doran P.M, Bioprocess Engineering Principles, Academic Press
8. Bailey G.E and Ollis D.F, Bioprocess Engineering Fundamentals McGraw Hill
9. Shuler M.L and Kargi F, Bioprocess Engineering- Basic Concepts, Pearson Education
10. Blanch H.W and Clark D.S, Biochemical Engineering Marcel Dekker Inc.

Course Code	Course/Subject Name	Credits
BTL401	Fermentation Technology Lab	1.5

List of Experiments Suggested:

- Alcohol production by baker's yeast
- Isolation and preservation of microorganism of commercial importance
- Cell immobilization technique by immobilizing yeast cells in calcium alginate beads.
- Production of citric acid by A.niger
- Hydrolysis of sucrose by immobilized yeast cells
- Determination of cell mass by different methods (dry weight method, density method and haemocytometer method)
- Estimation of carbohydrates from fermentation media.
- Production of amylase
- Isolation of auxotrophic mutants of industrially important microorganisms
- Study of substrate utilization kinetics of the organism
- Study the set up of various types of bioreactors
- Introduction to fermentor.

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
BTL402	Analytical Methods In Biotechnology Lab	1.5

List of Experiments Suggested:

- Chromatography of amino acids and sugars
- Agarose gel electrophoresis
- SDS-PAGE, Native PAGE
- Iso-electric Focussing
- Centrifugation
- Density gradient Centrifugation
- Affinity chromatography
- Ion exchange chromatography
- Gel filtration chromatography
- UV-Visible spectrophotometer
- Thin Layer Chromatography
- Paper Chromatography

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

Course Code	Course/Subject Name	Credits
BTL403	Unit Operations - II Lab	1

List of Experiments Suggested:

- Plate type H.E
- Natural convection
- Forced convection
- Critical Heat flux
- Emissivity
- Heat transfer through composite wall
- Shell & Tube H.E
- k of insulating material
- Vapor-liquid equilibrium
- Diffusivity of a liquid
- Diffusion through porous solids
- Determination of Mass transfer coefficients in Gas Liquid sysytem by evaporation
- Determination of Mass transfer coefficients in Liquid Liquid system.

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
T.E. Semester V (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC501	Bioinformatics	4	-	-	4	-	-	4
BTC502	Genetic Engineering	4	-	-	4	-	-	4
BTC503	Thermodynamics and Biochemical Engineering	3	-	1	3	-	1	4
BTC504	Bioreactor Analysis and Technology	3	-	1	3	-	1	4
BTC505	Business Communication and Ethics	2	-	2	-	-	2	2
BTE501X	Elective I	3	-	1	3	-	1	4
BTL501	Bioinformatics Lab	-	2	-	-	1	-	1
BTL502	Genetic Engineering Lab		3			1.5		1.5
BTL503	Lab I		3			1.5		1.5
	Total	17	12	3	17	6	3	26

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC501	Bioinformatics	20	20	20	80	3	-		-	100
BTC502	Genetic Engineering	20	20	20	80	3			-	100
BTC503	Thermodynamics and Biochemical Engineering	20	20	20	80	3	25	-	-	125
BTC504	Bioreactor Analysis and Technology	20	20	20	80	3	25	-	-	125
BTC505	Business Communication and Ethics	-	-	-	-	-	50	-		50
BTE501X	Department Elective I	20	20	20	80	3	25	-	-	125
BTL501	Bioinformatics Lab					2		25		25
BTL502	Genetic Engineering Lab					3		25		25
BTL503	Lab I	-	-	-	-	3		25	-	25
	Total			100	400	-	125	75	-	700

Department Elective I (Sem V)		
Engineering Stream	Advanced Science Stream	Technology Stream
1. Biosensors and Diagnosis (BTE5011)	1.Biophysics (BTE5012) 2.Biostatistics (BTE5013)	1. Pharmaceutical Technology (BTE5014)

Course Code	Course/Subject Name	Credits
BTC501	Bioinformatics	4

Pre-requisites:

- Basic knowledge of computers, Biochemistry: Structures of DNA, RNA & Proteins.

Course Objectives:

- To develop skills of the Students in the area of Bioinformatics particularly to make them to learn all the techniques used with biological data.
- To study various databases of DNA & Proteins along with current bioinformatics concepts & their implementation.
- To help students easily handle proteins by studying in detail about protein structure.
- To become knowledgeable about the storage, retrieval, sharing and use of biological data, information, and tools.

Course outcomes:

By learning this course the students will be able to :

- Cast a molecular biology problem as a bioinformatics problem.
- Select relevant tools, optimize their settings and build pipelines to solve the set problem.
- Easily extract the required data from a given set of data & similarly be able to store it.
- Use conventional softwares and web-based applications.
- Analyze processed data with the support of analytical and visualization tools.

Module	Contents	Contact Hours
01	Introduction to bioinformatics: Types of biological data, Sequencing Methods: DNA (Maxim Gilbert Method, Sangers Method) & Protein (MS-MSAnalysis), Genomic Sequencing, ESTs and SNPs, Applications of bioinformatics.	06
02	Types of databases: Based on storage techniques(Flat, Relational, Object Oriented); Based on data (Primary, Secondary , Specialized) Search engines: Entrez& SRS Sequence databases: NCBI, EMBL, DDBJ Structural Databases: PDB Protein Databases: PIR, SWISS PROT Other Databases: KEGG, TrEMBL, EBI.	08
03	Alignment: Global Alignment, Local Alignment Pair Wise Sequence Alignment: Dot Matrix Alignment. Dynamic programming Methods: Needleman Wunch Algorithm, Smith Waterman Algorithm. Heuristic Method: BLAST, FASTA Amino Acid Substitution Matrices: PAM, BLOSSUM Multiple Alignment: CLUSTAL WPhylogenetic Analysis	10
04	Visualization: Methods for representing biological data, Rasmol, Swiss PDB, 3D Structure Viewers.	04
05	Proteins: Structure, Classification, Classification databases. Protein Structure prediction: Primary Structure Prediction,	07

	Secondary Structure Prediction, Tertiary Structure Prediction, Homology Modelling, Chao-Fasman Algorithm, Neural Networks, Ab-Initio Modelling, Fold recognition (Threading)	
06	Interactions: Protein ligand interactions, Torsionangle, Ramchandran plot, Protein folding & Chaperones. Cartesian coordinates	**10**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Oreilly , Developing bioinformatics computer skills, Shroff publishers, 1st Indian edition
2. David mount, Bioinformatics sequence and genome analysis, CBS publishers, 2nd edition
3. N. Gautam , Bioinformatics databases & algorithm, Narosa publication
4. S. Ignacimuthu S.J, Basic bioinformatics, Narosa publications
5. T. K. Attwood, Introduction to bioinformatics, Pearson education, 8th reprint
6. S. C. Rastogi, Bioinformatics concepts, skills & applications, CBS publishers, 1st edition

Course Code	Course/Subject Name	Credits
BTC502	Genetic Engineering	4

Pre-requisites:

- Knowledge of Biochemistry, Microbiology, Molecular Biology, Genetics.

Course Objectives:

- Give insight into the functioning of Recombinant DNA molecules, their constructions, analysis and fine tuning.
- To engineer such molecules for making of difficult bio-molecules.
- This course also gives various ideas and approaches by different schools of thoughts.

Course outcomes:

By learning this course the students will be able to:

- Understand how recombinant molecules are created analysed with respect to DNA, RNA, and Protein.
- They also will be familiar with the problems they could encounter and how to trouble shoot them.
- They will be able to monitor both in-vitro and in-vivo activity.
- They will be able to suggest more rational approach to solve problem of a living system at a molecular level.

Module	Contents	Contact Hours
01	Basics of genetic material: DNA structure, topology, Super helical and relaxed molecules. Plasmids- Basic features classification, size and copy number, conjugation & compatibility. Total cell DNA preparation, different methods of plasmid DNA preparation.	06
02	Enzymes for Recombinant Technology: Cutting enzymes- Restriction Endonucleases (Classification, blunt end, sticky end, mode of action).Introduction to other enzymes-DNA polymerases, Reverse Transcriptase, Polynucleotide Kinase, Terminal Transferase, Alkaline Phosphatase,S1-Nuclease, Bal-31, DNA Ligase.	07
03	Cloning vectors: Vectors used for Gene-cloning: Plasmids (e.g pUC type, conjugative, Ti etc.), Phages (Lambda and M13 type), Cosmids and Phagemids.	07
04	Library construction and recombinant gene expression: Library construction (Genomic and C-DNA type) and Screening for the clone. Foreign gene expression in E. coli, Fusion proteins	06
05	DNA transfer in to cells: Transformation and Transfection, Membrane Fusion and Electroporation, Gene-Gun and Micro-injection	05

06	DNA and Protein Analysis: DNA: Southern and Northern Hybridization. PCR Amplification, DNA Sequence Analysis (e.g Sangers Method), Automated Sequencing, RFLP and RAPD. Protein: Western Blotting, ELISA and its variations	**08**
07	Antisense and RNA interference Technology and their applications. R-DNA in medicine, e.g. Insulin and Blood clotting factor VIII.	**06**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Molecular Biology of the Cell: Alberts et al.5th. Ed. Garland Publications.
2. Genes VIII: Benjamin Levine, Oxford University Press.
3. Principle of Gene Manipulations (2004): S.B. Primrose, R.M. Twyman & R. W. Old. Sixth edition. Blackwell Science.
4. Gene Cloning and DNA analysis: An Introduction.(2006).T. A. Brown. Blackwell Publishing.

Course Code	Course/Subject Name	Credits
BTC503	Thermodynamics and Biochemical Engineering	4

Pre-requisites:

- Knowledge of phase rule, knowledge of differentiation & Integration

Course Objectives:

- To study the basic concepts of the energy flow in and out of the system.
- To apply the thermodynamic principles to the biochemical reactions.
- To check the feasibility of the reaction.

Course outcomes:

- The student will be able to check the feasibility of a reaction.

Module	Contents	Contact Hours
01	Basic Concepts: System, Surrounding & Processes, Closed and Open systems, State and Properties, Intensive &Extensive Properties, State and Path functions, Equilibrium state and Phase rule, Zeroth law of Thermodynamics, Heat reservoir and Heat engines, Reversible and Irreversible processes.	02
02	Laws of Thermodynamics: General statement of First law of Thermodynamics, First law for Cyclic Process, Non-Flow Process, Flow process, Heat capacity. General statements of the second law, Concept of entropy, The Carnot principle, Calculation of entropy changes, Clausius inequality, Entropy and Irreversibility. Third law of Thermodynamics.	05
03	PVT Behaviour: PVT behaviour of pure fluids, equations of state and ideal gas law, Processes involving ideal gas law: Constant volume, constant pressure, constant temperature, adiabatic and polytrophic processes. Equations of state for real gases: Van-der Waals equation, Redlich- Kwong equation, Peng-Robinson equation, virial equation.	04
04	Biochemical Energetics: Coupled reactions and energy rich compounds, Reaction Stoichiometry, criteria of biochemical reaction equilibrium, equilibrium constant and standard free energy change, effect of temperature, pressure onfree energy change, effect of temperature, pressure on equilibrium constants and other factors affecting equilibrium conversion. Le Chateliers principle, liquid phase reactions, heterogeneous bioreaction equilibria, phase rule for reacting systems.	05
05	Properties of Pure Fluids: Principles of corresponding states, Generalized compressibility charts. Reference properties, energy	06

	properties, Derived properties, Helmholtz free energy, Gibbs free energy, Relationships among thermodynamic Properties: Exact differential equations, fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy heat capacity relations, modified equations for internal energy (U)&enthalpy(H),Effect of temperature on U, H & Entropy(S), Relationships between Cp & Cv, Gibbs-Helmholtz equation.	
06	Fugacity and Activity: Fugacity: Fugacity, Fugacity coefficient, effect of temperature and pressure on fugacity, Determination of fugacity of pure gases, Fugacities of solids and liquids, Activity: Effect of temperature and pressure on activity. Departure functions and generalized charts, thermodynamic diagram types of diagrams and construction of thermodynamic diagrams.	**04**
07	Properties of Solutions: Partial molar properties- Partial molar properties of solutions, determination of partial molar properties, chemical potential effect of temperature and pressure, Lewis randall rule, Raoults law for ideal solutions, Henry's law and dilute solutions ideal behavior of real solutions and Henrys law, Activity in solutions, Activity coefficients effect of temperature and pressure, Gibbs - Duhem equation, Property changes of mixing, excess properties, excess Gibbs free energy.	**06**
08	Phase Equilibria: Criteria of phase Equilibria, criterion of stability, Duhem's theorem, Vapour-Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions -azeotropes, VLE at low pressures activity coefficient equation, bubble point and dew point equilibria, Consistency test for VLE data using slope of lncurves, using partial pressure data, calculation of activity coefficients using Gibbs-Duhem equation, Liquid-Liquid Equilibrium diagrams binary liquid Equilibrium diagrams.	**04**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub

questions can be asked.

- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Smith, J.M., Van Ness, H.C., and Abbott, M.M. Introduction to Chemical Engineering Thermodynamics, McGraw Hill, Inc..
2. Kyle, B.G., Chemical and Process Thermodynamics, Prentice Hall, Inc.
3. Hougen, O.A., Watson, K.M., and Ragatz, R.A., Chemical Process Principles Part II, John Wiley & Sons, (CBS Publishers & Distributors, New Delhi).
4. YVC Rao, "An Introduction to Thermodynamics", University Press, Second Edition.
5. K V Narayanan, "Textbook of Chemical Engineering Thermodynamics", PHI Learning Second Edition.

Course Code	Course/Subject Name	Credits
BTC504	Bioreactor Analysis and Technology	04

Pre-requisites:

- Knowledge of chemical reaction kinetics, Knowledge of differentiation and integration

Course Objectives:

- To understand the basic concepts of Bioreactor design.
- To select the relevant principles and data for practical process engineering purposes.

Course outcomes:

- Student will be able to understand the different types of ideal and non- ideal reactors.
- Student will be able to design the reactors required for a particular processes.

Module	Contents	Contact Hours
01	Basic Reaction Kinetics: Reaction thermodynamics, order and molecularity of reaction, homogeneous and heterogeneous reactions, elementary and non-elementary reactions, reaction yield, reaction rate, calculation of reaction rates from experimental data, general reaction kinetics for biological system, production kinetics in cell culture, kinetics of substrate uptake in cell culture, growth kinetics with plasmid instability	06
02	Ideal Reactors: Constant volume and variable reactors, batch operation of a well-mixed enzyme and cell culture reactor, fed batch operation ofa well-mixed enzyme and cell culture reactor, continuous operation of well mixed enzyme and cell culture reactor, continuous operation of plug flow enzyme and cell culture reactor, autocatalytic reactions, recycle reactors-plug flow reactor and continuous stirred tank reactor, comparison between major modes of reactor operation.	07
03	Multiple Reactors and Reaction Systems: Continuous stirred tank reactors of equal size in series, continuous stirred tank reactors of unequal size in series, finding conversion in given system, determining the best system for a given conversion, plug flow reactors in series and parallel, reactors of different types in series. Simple reactions, step wise reactions, parallel reactions, series reactions, maximizing R in batch reactor, plug flow reactor and continuous stirred tank reactor, reactor choice for series reactions and series parallel reactions, concepts of reversible reactions.	07
04	Heterogeneous Reactions:	06

	Heterogeneous reactions in Bioprocessing, Concentration gradients and reaction rates in solid catalysts, Internal mass transfer and reactions, steady state mass balance (spherical geometry), Concentration profile for first order kinetics, Concentration profile for zero order kinetics, Concentration profile for Michaelis- Menten kinetics, Effectiveness factor and Thiele Modulus, External mass transfer	
05	Deviations from ideal reactors: Concept of nonideality, reasons of non ideality, RTD studies, F curve, C curve, E curve, diagnosis of ills of flow reactors, modelling of nonideal behaviour-dispersion model, tanks in series model.	**05**
06	Working principle of unconventional reactors: Selection criterion for bioreactors, Bubble column, Airlift reactor, Fluidizedbed reactor, perfusion reactors, membrane reactors	**04**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. D.G. Rao, Introduction to Biochemical Engg, Tata McGraw Hill Edu. Pvt. Ltd., Second edition.
2. P.M. Doran, Bioprocesses Engg. Principles, Academic Press, London, Second edition.
3. E.H. Perry 7 D.W. Green, Perrys Chemical Engineering Handbook, Seventh edition.
4. Octave Levenspiel, Chemical Reaction Engineering, John Wiley Publication, Third Edn
5. H Scott Fogler "Elements of Chemical Reaction engineering" Prentice Hall, 2006

Course Code	Course/Subject Name	Credits
BTC505	Business Communication and Ethics	2

Prerequisites:

- Students should have basic knowledge of English and general engineering.

Course Objectives

- To inculcate in students professional and ethical attitude, effective communication skills, teamwork, multidisciplinary approach, and an ability to understand Engineers' social responsibilities
- To provide students with an academic environment where they will be aware of the excellence, leadership and lifelong learning needed for a successful professional career
- To inculcate professional ethics and codes of professional practice
- To prepare students for successful careers that meets the global Industrial and Corporate requirement

Course Outcomes:

- Students will be able to
- Communicate effectively in both oral and written form and equip to demonstrate knowledge of professional and ethical responsibilities.
- participate and succeed in campus placements and competitive examinations like GATE, TOFEL
- Possess entrepreneurial approach and ability for life-long learning
- Have education necessary for understanding the impact of engineering solutions on Society, and demonstrate awareness of contemporary issues Detailed Syllabus.
- Design a technical document using precise language, suitable vocabulary and apt style.
- Develop the life skills/ interpersonal skills to progress professionally by building stronger relationships.
- Demonstrate awareness of contemporary issues knowledge of professional and ethical responsibilities.
- Apply the traits of a suitable candidate for a job/higher education, upon being trained in the techniques of holding a group discussion, facing interviews and writing resume/SOP.
- Deliver formal presentations effectively implementing the verbal and non-verbal skills.

Module	Contents	Contact Hours
1	Report Writing Objectives of Report Writing Language and Style in a report Types : Informative and Interpretative (Analytical, Survey and Feasibility) and Formats of reports (Memo, Letter, Short and Long Report)	05
2	Technical Writing Technical Paper Writing (IEEE Format) Proposal Writing	03

3	Introduction to Interpersonal Skills Emotional Intelligence Leadership and Motivation Team Building Assertiveness Conflict Resolution and Negotiation Skills Time Management Decision Making	**09**
4	Meetings and Documentation Strategies for conducting effective meetings Notice, Agenda and Minutes of a meeting Business meeting etiquettes	**02**
5	Introduction to Corporate Ethics Professional and work ethics (responsible use of social media - Facebook, WA, Twitter etc.) Introduction to Intellectual Property Rights Ethical codes of conduct in business and corporate activities(Personal ethics, conflicting values, choosing a moral response and making ethical decisions)	**02**
6	Employment Skills Group Discussion Resume Writing Interview Skills Presentation Skills Statement of Purpose	**07**

Term Work

The term work shall be comprised of the neatly written Journal comprising below mentioned assignments.

Assignment 1- Interpersonal Skills (Group activity Role play)

Assignment 2- Interpersonal Skills (Documentation in the form of soft copy or hard copy)

Assignment 3- Cover Letter Resume

Assignment 4- Report Writing

Assignment 5- Technical Proposal (document of the proposal)

Assignment 6- Technical Paper Writing

Assignment7 -Meetings Documentation (Notice, Agenda, Minutes of Mock Meetings)

Assignment 6- Corporate Ethics (Case study, Role play)

Assignment 8- Printout of the PowerPoint presentation

Term-work Marks: 50 Marks

The marks of term-work shall be judiciously awarded depending upon the quality of the term work including that of the report on experiments assignments. The final certification acceptance of Term work warrants the satisfactory the appropriate completion of the assignments, presentation, book report, group discussion and internal oral the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work.

Attendance : 05 Marks
Assignments : 20 Marks
Internal Oral: 25 Marks comprising of:
Presentation of the Project Report: 10 Marks
Book Report (one copy per group): 05 Marks
Group discussion: 10 Marks

References

1. Fred Luthans, "Organizational Behavior", McGraw Hill, edition
2. Lesiker and Petit, "Report Writing for Business", McGraw Hill, edition
3. Huckin and Olsen, "Technical Writing and Professional Communication", McGraw Hill
4. Wallace and Masters, "Personal Development for Life and Work", Thomson Learning, 12th edition
5. Heta Murphy, "Effective Business Communication", McGraw Hill, edition
6. Sharma R.C. and Krishna Mohan, "Business Correspondence and Report Writing", Tata McGraw-Hill Education
7. Ghosh,B. N.,"Managing Soft Skills for Personality Development", Tata McGraw Hill. Lehman,
8. Dufrene, Sinha, "BCOM", Cengage Learning, 2ndedition
9. Bell, Smith, "Management Communication" Wiley India Edition,3rdedition.
10. Dr. Alex, K.,"Soft Skills", S Chand and Company
11Subramaniam,R., "Professional Ethics" Oxford University Press.
12. Robbins Stephens P., "Organizational Behavior", Pearson Education
13. https://grad.ucla.edu/asis/agep/advsopstem.pdf

Course Code	Course/Subject Name	Credits
BTE5011	Department Elective I – Biosensors and Diagnostics	4

Pre-requisites:

- Biochemistry, Analytical methods in Biotechnology, Principles of basic instruments used in a Biotechnology laboratory.

Course Objectives:

The objectives of this course is that the students will be able to:

- Explain the role of biological macromolecules as recognition elements & biosensors.
- Describe the biomedical aspects of these sensors.
- Analyse the interplay between materials, components and systems in the field of bio sensing.
- Design an advanced biosensor for medical applications, using the current state of the art of biosensors.
- Describe what challenges are shared among and what challenges are unique to the major biosensor application areas.

Course outcomes:

By learning this course the students will be able to :

- Apply the principles of engineering to the development ofbioanalytical devices and the design of biosensors
- Explain the principles of linking cell components and biological pathways with energy transduction, sensing and detection.
- Differentiate among various biosensor systems.
- Design a biosensor in response to agricultural, bioenvironmental, food safety, and biosecurity applications.
- Apply engineering and biological approaches to solve problems in diagnosis of diseases, such as diabetes, cancer or detection of other analytes/ biomarkers.

Module	Contents	Contact Hours
01	Biosensors: Principles, Characteristics of Ideal Biosensors, Basic measuring procedure, Components of biosensors, Advantages & Limitations	08
02	Bio catalysis based biosensors, Bioaffnity based biosensors &Microorganisms based biosensors, Biologically active material and analyte. Types of membranes used in biosensor constructions.	09
03	Various types of transducers, Principles and applications Calorimetric, Optical, Potentiometric/ Amperometric, Conductrometric/ resistormetric.	05
04	Piezoelectric, Semiconductor, Impedimetric, Mechanical and molecular electronics based transducers, Chemiluminiscene-based biosensors.	05
05	Biosensors in clinical chemistry, Medicine and health care, Biosensors for veterinary, Agriculture and food, Low cost biosensor for industrial processes for online monitoring,	08

	Biosensors for environmental monitoring.	

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References:

1. Roger, K.R. and Gerlach, C.L. 199. Update on environmental for biosensors. Env. Sci. Techno! 33 500A - 506A.
2. Bilitewski, U. Turner, A.P.F. 2000 Biosensors for environmental monitoring Harwood, Amsterdam.
3. Moses, V and Cape, R.E. 1991, Biotechnology the science and business, Harwood, Academic Publisher London
4. Rogers, K.R. and Mascini, M. 2001. Biosensors for analytical monitoring EPA biosensors group.
5. Aboul - Enein, H. V., Stefan, R. and Van Staden, (1999) Chemiluminiscence - based biosensors - An overview crit Rev. Anal. Chem. 29, 323-331.
6. Pearson, J.E. Gill, A., and Vadgama, P. (2000) Analytical aspects of biosensors, Ann Clin Biochem 37, 119-145.
7. Biosensors: Fundamentals and applications, Oxford, U.K: Oxford University Press by Turner, A.P.F., Karube, I. & Wilson, GS.

Course Code	Course/Subject Name	Credits
BTE5012	Department Elective I – Biophysics	4

Pre-requisites:

- Knowledge of Chemistry, Physics, Atomic physics, Biochemistry, Molecular Biology.

Course Objectives:

- The objective of this course is to give insight into the structure of various macro-molecules, their constructions, analysis and interactions.

Course outcomes:

By learning this course the students will be able to:

- Understand how molecules are created and studied.
- They will be able to monitor both in-vitro and in-vivo activity and interactions.

Module	Contents	Contact Hours
01	Introduction to Biophysical Techniques: Electron Microscopy, Atomic Force Microscopy, X ray Crystallography, NMR Spectroscopy, Infrared Spectroscopy, Circular Dichroism	10
02	Nucleic Acid interactions: Carrier RNA, Interactions between DNA & protein, Zinc finger proteins, various nucleic acid binding proteins, Nuclear transport.	06
03	Membrane Structure & Properties: The principles governing the structures of biological membrane, Two-dimensional fluids, Assembly of membrane components.	06
04	Protein Structural study: Intra and inter-molecular forces, helix-coil transitions and protein folding in a thermodynamical context, Secondary Motifs, Tertiary Architecture and Quaternary Organization, crystallization, diffraction theory.	07
05	Lipids & their Interaction: Details of Lipid Structures, Lipoproteins and Glycolipids. High density (HDL) and low density (LDL) lipoprotein. Disorder caused by saturated fat and cholesterol, Arteriosclerosis.	06

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Cantor R, Samual P. R. (1985). Biophysical Chemistry. W. H. Freeman & Co.
2. Vasantha Pattabhi, N. Gautham. Biophysics. Narosa Publishing House Ltd.
3. Van Holde Johnson and Ho. (2006) Principles of Physical Biochemistry. Second Edition, Pearson Prentice Hall.
4. Igor N. Serdyuk, Nathan R. Zaccai, & Joseph Zac. Methods in Molecular Biophysics: Structure, dynamics and Function. Cambridge University Press.
5. Physical Biochemistry: Principles and applications by David Sheehan, Jon Wiley & Sons.

Course Code	Course/Subject Name	Credits
BTE5013	Department Elective I – Biostatistics	4

Pre-requisites:

- Knowledge of basic statistical methods

Course Objectives:

- To understand statistics - basic theory, philosophy and application of statistics
- To Understand why biologists need a background in statistics in conducting research
- To help students know the role of statistics as a tool for scientists

Course outcomes:

By learning this course the students will be able to:

- Identify and implement statistical techniques and models for analysis of biological data.
- To enable them interpret research.

Module	Contents	Contact Hours
01	Descriptive statistics and Probability: Frequency distribution, Measures of Central tendancy, Measures of Dispersion, Basic probability and Bayes theorem.	03
02	Probability and sampling distributions; Discrete probability distributions; Continuous probability distributions- Binomial, Poisson and normal distributions; Sampling Distributions- sample mean, difference between two sample means, Sample proportions, difference between two sample proportions.	08
03	Estimation; t-distribution; Confidence intervals for- population mean, difference between two population means, population proportion, difference between two population proportions, Variance of normally distributed population, ratio of variances of two normally distributed populations. Determination of sample size for estimating mean and proportions.	05
04	Hypothesis Testing: Hypothesis testing for - population mean, difference between two population means, population proportion, difference between two population proportions, population variance, ratio of two population variances, Type I and II error and Power of test	05
05	Analysis of Variance: Completely randomized design, Randomized complete block design, repeated measures design, factorial experiment. Regression and Correlation: Simple linear regression, correlation model, correlation coefficient, multiple regression, multiple correlation	09
06	Chi square distribution and analysis of frequency, Chi-square distribution properties, Test of goodness of fit, independence and homogeneity	05

List of Tutorials:

- Descriptive statistics and probability
- Discrete probability distributions
- Continuous probability distributions
- Sampling distributions
- Estimation
- Hypothesis testing
- Analysis of Variance
- Regression and correlation
- Chi square distribution and analysis of frequency

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Textbooks

1. Biostatistics - A foundation for analysis in health sciences by Wayne W. Daniel, Seventh edition, Wiley India
2. Fundamentals of Mathematical statistics by S.C.Gupta and V.K. Kapoor, second edition, Sultan Chand Publishers
3. Probability and statistics for engineers by J. Ravichandran, Wiley India
4. Biostatistics- How it works by Steve Selvin, Pearson Education
5. An introduction to Biostatistics by Sunder Rao and J. Richard, third edition, Prentice Hall of India
6. Probability and Statistics by Schaum's series

Course Code	Course/Subject Name	Credits
BTE5014	Department Elective I – Pharmaceutical Technology	4

Pre-requisites:

- Knowledge about biochemistry and biochemical pathways in biological systems.
- Knowledge about cell biology and metabolism

Course Objectives:

- To understand the basic aspects of pharmacokinetics and pharmacodynamics.
- To give an insight about the pre-clinical and clinical trials and different classes of drugs.

Course outcomes:

- Students will be able to tell factors affecting the bioavailability and stability of dosage form. They also know the parameters for the disposition, absorption and Michaelis-Menton constants for non-linear kinetics.
- Students will know the fabrication, design, evaluation and application of drug delivery systems.

Module	Contents	Contact Hours
01	Introduction To Pharmaceuticals: History & Definition of Drugs. Sources of Drugs - Plant, Animals, Microbes and Minerals. Drug targets, Intermolecular bonding forces. Classification of Drugs. Naming of Drugs and medicines	04
02	Pharmacodynamics and Pharmaco kinetics: Molecules acting as drug targets: Enzymes, Receptors, Nucleic acid Drug Absorption, Distribution, Metabolism and Excretion (ADME). Modes of drug administration Drug dosing (half-life, steady state concentration, drug tolerance, Bioavailability). Drug delivery system	08
03	Finalstages of drug development-trials: Preclinical and clinical trials, Patenting and regulatory affairs	04
04	Medicinal Chemistry: Antibacterial, Anticancer, Antiviral drugs, Opioid analgesics	12
05	Biopharmaceuticals: Production of Therapeutic Proteins, Hormones, Nucleic acids, Role of Biopharmaceuticals in treatment of various health disorders	06

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Biopharmaceuticals: Biochemistry & Biotechnology, Gary Walsh (1998), John Wiley &Sons Ltd.
2. Medicinal Chemistry by Graham L. Patrick, Oxford University Press
3. Remingtons Pharmaceutical sciences, (Mark Publications & Company eston PA) 1980.
4. Medicinal Chemistry: an introduction by Gareth Thomas, Wiley Publications
5. Theory & Practice of Industrial Pharmacy, (3rd ed.)Leon Lachman, Lea & Febiger (1986)

Course Code	Course/Subject Name	Credits
BTL501	Bioinformatics Lab	1

Concept of Experiments:

Ten experiments must be performed

- Access & use of different databases using NCBI metadatabase.
- To study use of ORF finder to find the correct reading frame.
- To study the characteristics of protein using PROT SCALE.
- To study prediction of coding sequence (CDS) of a gene using NCBI & Genemark and compare the results for percentage accuracy.
- To access & use different online gene & protein alignment softwares.
- Protein structure visualization using 'RASMOL' graphical user interface.
- Protein structure visualization using 'RASMOL' command line interface.
- Secondary structure prediction for amino acid sequences of a given protein.
- Homology modelling of protein using SWISS-PDB modeller.
- To study chemical structure of drugs using Chemsketch & Marvinsketch.
- To find & study phylogenetic relationships among different given species using CLUSTAL OMEGA.
- To study multiple sequence alignment (MSA) tools & compare the results.
- To study BLOCKS using Interpro.
- To study EXPASY tool for protein structure analysis.
- To find and study gene using MAP-VIEWER.

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments

Course Code	Course/Subject Name	Credits
BTL502	Genetic Engineering Lab	1.5

Concept of Experiments:

Ten experiments must be performed

- Isolation of Genomic DNA
- Purification and quantification of isolated DNA.
- Separation of DNA by Agarose gel electrophoresis.
- PCR analysis of DNA fragments by agarose gel electrophoresis
- Making the bacterial cells competent
- Transformation of E.coli.
- Isolation of plasmid DNA by boiling lysis method.
- Isolation plasmid DNA by Alkaline lysis method.
- Southern blotting
- Southern Hybridization
- In vitro DNA ligation
- RFLP technique
- Protein Analysis by SDS-PAGE
- Bacterial conjugation
- Bacterial survival against UV irradiation and mutagenesis
- Isolation of mutants, e.g.auxotrophs, by chemical mutagenesis. (Acridineorange/Ethydium bromide)
- β-galactosidase activity of lac+ & lac- mutant of E.coli.
- Primary screening of antibiotic producers from soil

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments

Course Code	Course/Subject Name	Credits
BTL503	Lab I	1.5

Concept of Experiments:

Ten experiments must be performed

- Physical method of microbial control.
- Chemical method of microbial control.
- Isolation of bioluminescent organisms.
- Diauxic growth curve of E.Coli.
- Biochemical characterization of microbes (IMVIC test, Catalase, Oxidase test).
- Detection of Amino acid producer from soil.
- Acid fast staining for mycobacteria.
- Study of air microflora& determination of sedimentation rate.
- Blood film preparation and identification of cells.
- Antibiotic susceptibility test.
- E Test
- Blood group typing using haemagglutination tests.
- To detect the antigen/antibody using Enzyme Linked Immuno Sorbent Assay (ELISA)
- To test the pattern of antigen-antibody interaction through Ouchterlony double diffusion assay
- RID
- Lymphoid organs and their microscopic organization
- Separation of mononuclear cells by Ficoll-Hypaque
- VDRL test (Demonstration)
- Immunodiagnostics (demonstration using commercial kits)
- Determination of MIC of antibacterial drugs.
- Identification of AgAb complex by Slide agglutination test

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
T.E. Semester VI (w.e.f 2018-2019)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC601	Food Technology	3	-	1	3	-	1	4
BTC602	Cell & Tissue Culture	4	-	-	4	-	-	4
BTC603	Enzyme Engineering	4	-		4	-	-	4
BTC604	IPR, Bioethics and Bio safety	3	-	1	3	-	1	4
BTC605	Process Control & Instrumentation	3	-	1	3	-	1	4
BTE602X	Elective-II	3	-	1	3	-	1	4
BTL601	Lab-II	-	3	-	-	1.5	-	1.5
BTL602	Lab-III	-	3	-	-	1.5	-	1.5
	Total	20	6	4	20	3	4	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC601	Food Technology	20	20	20	80	3	25	-	-	125
BTC602	Cell & Tissue Culture	20	20	20	80	3	-	-	-	100
BTC603	Enzyme Engineering	20	20	20	80	3	-	-	-	100
BTC604	IPR, Bioethics and Bio safety	20	20	20	80	3	25	-	-	125
BTC605	Process Control & Instrumentation	20	20	20	80	3	25	-	-	125
BTE602X	Elective-II	20	20	20	80	3	25	-	-	125
BTL601	Lab-II	-	-	-	-	3	-	25		25
BTL602	Lab-III	-	-	-	-	3	-	25	-	25
	Total			120	480	-	100	50	--	750

Department Elective II (Sem VI)		
Engineering Stream	Advanced Science Stream	Technology Stream
1. Computational Fluid Dynamics (BTE6021)	1.Protein Engineering (BTE6022) 2. Cancer Biology (BTE6023)	1. Green technology (BTE6024)

Course Code	Course/Subject Name	Credits
BTC601	Food Technology	4

Pre-requisites:

- Basic concepts of Microbiology and Fermentation Technology

Course Objectives:

- To impart knowledge of various areas related to Food science and technology
- To enable the students to understand food composition and its physiochemical, nutritional and microbiological aspects
- To familiarize the students about the processing and preservation techniques of Food products

Course outcomes:

- Students will know the principles of preservation.
- Students will understand the principles of food processing techniques and will be able to apply these principles to specific food commodities.

Module	Contents	Contact Hours
01	Introduction to food technology, Constituents of food, contribution to texture, flavour and organoleptic properties of food; food additives coloring agents, emulsifiers, preservatives, flavours, vitamins, organic acids and their functions; enzymes in food processing	06
02	Sources and activity of microorganisms associated with food; Factors affecting the growth and survival of micro-organisms in foods-intrinsic and extrinsic; Food borne diseases, infections and intoxications, food spoil agecauses. Microbial food- yeasts, bacteria and production of new protein foods - SCP, mushroom, algal proteins	07
03	Microbial fermentation and production of food and beverages using microorganisms. Pickling, Sauerkraut, vinegar, bread. Dairyproduct-Yogurt, cheese production by microbial and enzymatic (proteases) method. Alcoholic beverages-Beer (deoxygenating and desugaring by glucose oxidase of beer, beer mashing and chill proofing), Wine (red, white, sparkling)	07
04	Fermentation methods for preserving foods, Preparation of various food additives like coloring agents, emulsifiers, vitamins, flavours and organic acids	05
05	Post Harvest technology for food crops. Food preservation-high temperature methods, low temperature methods, irradiation, high pressure method and chemical preservatives. Production of Fruit juices and types of Fruit juices	05
06	Food Packaging methods: Materials used for food packaging of various food products like cheese, eggs, bread, alcoholic beverages, milk and juices	05

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which

are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Frazier, Food Microbiology, Tl-IM Publications.
2. Heller, Genetic Engineering of Food: Detection of Genetic Modifications- Wiley Publictions.
3. Le.A. et.al., Microorganism & Fermentations- N.Y. Chemical
4. Rehm, Biotechnology Set Wiley Publications
5. M. R. Adams and M. O. Moss, Food Microbiology, Royal society of chemistry
6. James M. Jay, Modern food microbiology, An Aspen Publications
7. Prescott and Dunn, Industrial Microbiology, CBS Publications.

Course Code	Course/Subject Name	Credits
BTC602	Cell and Tissue Culture	4

Pre-requisites:

- Basic knowledge of Cell Biology, Microbiology and Plant and Animal Physiology

Course Objectives:

- To examine and analyse practical and theoretical principles of cell culture
- To explain the conditions under which cells can be cultured outside the body.
- To explain the advantages and limitations of cell culture in biomedical research and applications.

Course outcomes:

By learning this course the students will be able to:

- Plan experiments using cultured cells.
- Carry out cell culture, and associated laboratory techniques.
- Carry out the most common analysis techniques associated with cell culture.
- Perform adequate statistical processing of data generated by cell culture.
- Present and analyse literature which covers cell culture.

Module	Contents	Contact Hours
01	Plant tissue culture Introduction: Internal organization of plant, Plant Tissue Culture Media, Plant growth hormones, Concept of Totipotency, Study of various types of Organ Culture, Organogenesis, Micropropagation	08
02	Plant Cell Culture And its Applications: Plant Cell Suspension Culture, Single Cell Culture, Somatic Embryogenesis,ArtificialSeeds,ProtoplastCulture&SomaticHybridization, Scale-up and Automation of Plant Cell Culture	08
03	Transformation of Plants: Agrobacterium mediated Gene transfer, Chemical Methods, Virus Mediated Gene Transfer, Transgenic Plants, Applications of Plant Biotechnology for Production of Quality Oil, Industrial Enzymes and Plantibodies	06
04	Introduction to Animal Cell Culture: Advantages and limitations of Animal Tissue Culture, Laboratory Design & Layout of ATC laboratory, Equipments and Materials of a Tissue Culture Laboratory, Media Preparation and Sterilization techniques,	08
05	Primary and secondary cell Culture: Establishment and maintenance of primary cell cultures of adherent and non-adherent cell lines, Establishment and maintenance of seconary and continuous cell cultures.	05
06	Characterization of cell lines: Cell morphology, Chromosome preparation and analysis, karyotyping, chromosome banding, Chromosome painting, Spectral karyotyping (SKY). DNA analysis- DNA	05

	hybridization, DNA fingerprinting	
07	Application of cell culture: Vaccine production, Antibody Engineering and large scale production of pharmaceutical products, Production of cytokines and therapeutic recombinant glycoproteins.	**05**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Plant Tissue Culture: Theory and Practice :Theory and Practice By S.S. Bhojwani, M.K. Razdan; Elsevier Publishers
2. Plant Tissue Culture by Kalyan Kumar De; Published by New Central Book Agency, 1997
3. Plant Tissue and Cell Culture; Volume11 of Botanical monographs, by Herbert Edward Street; Publisher: University of California Press, 1973
4. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications By R. Ian Freshney; Wiley Publishers
5. Animal Cell Culture (Introduction to Biotechniques): Sara j.Morgan, David C. Darling; Published by BIOS Scientific Publishers Ltd., 1993
6. Principles and Practice of Animal Tissue Culture – Sudha Gangal.
7. Basic Cell Culture Vol. 290 Protocols by Cheryl D Helgason, Cindy L Miller. Humanan Press.2005.
8. Basic Cell Culture 2nd Edition by JM Davis Oxford University Press.2002.
9. Biotechnology by B. D. Singh: Expanding horizons. Kalyani Publishing. 2008.
10. Animal Cell Culture & Technology by M. Butler, Published by Taylor & Francis publishers.

Course Code	Course/Subject Name	Credits
BTC603	Enzyme Engineering	4

Pre-requisites:

- Knowledge of Biochemistry, Microbiology &Molecular Biology.

Course Objectives:

The objectives of this course are to:

- Give insight into the functioning of Enzyme molecules (Biological Catalyst), their constructions, Structure, interactions with other cellular molecules, and the process of catalysis.
- Students will learn to use such molecules for making of difficult bio-molecules.
- They will also be able to understand Industrial uses and applications of Enzymes.

Course outcomes:

By learning this course the students will be able to:

- Understand how Enzymes are created as functional bio-catalysts, analysed with respect to their effciencies, their lability, and ways to make them durable.
- They also will be familiar with the problems they could encounter and how to trouble shoot them.
- They will be able to monitor both in-vitro and in-vivo activity.

Module	Contents	Contact Hours
01	Enzymes as Biological Catalysts, Chemical nature & Structure of Enzymes, Properties of enzymes, Enzyme Units, Nomenclature & Classification, Catalytic and Allosteric site, Models of Enzyme-substrate interactions, Activation Energy and catalysis, Effect of pH, Temperature and Salts on Enzyme activity	08
02	Enzyme Kinetics: Henri & Michaelis-Menten Equation & its significance, Briggs Haldane modification, Line weaver-Burke, Eadie-Hofstee & Hanes plot, Problems. Enzyme Inhibition: Irreversible & Reversible (Competitive, Uncompetitive, Noncompetitive, Mixed, Partial), Substrate Inhibition, Allosteric Inhibition.	11
03	Enzyme Assay: Kinetic determination of catalytic activity, Coupled kinetic assay, Radioimmunoassay. Instrumental techniques for Enzymatic Analysis: Manometry, Spectrophotometry, Spectrofluorimetry, Electrochemical methods (Potentiometric & Conductometry) Enthalpimetry, Radiochemical methods, Dry reagent techniques.	06
04	Working with Enzyme: Isolation & Extraction of Enzymes from various sources and locations in cell. Purification of Enzymes: Preliminary purification, further purification using chromatography & electrophoresis Criteria of Purity: Specific Activity, Electrophoresis, And	08

	Ultracentrifugation. Immobilization of Enzyme for repeat use.	
05	Solid-liquid reactors for enzymes: Types of heterogeneous reactors and its design criteria (CSTR, PFR, PBR, FBR etc.), Operational problems, Decline and loss of enzyme efficiency, Remedies.	**07**
06	Application of Enzyme in Industries: Food, Leather, Beverage, Detergents, Pharmaceuticals and Medicines, Analytical/ Diagnostics and Biosensors, Therapeutics.	**05**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Enzymes-Palmer; T, (Affliated East West Press Pvt. Ltd.), 2004.
2. Biochemistry- Stryer, Berg, 6thEdition, (W.H. Freeman and Co.), 2007.
3. Biochemistry-Metzler; DE, 2nd Edn., (Academic press) 2001.
4. Lehninger Principles of biochemistry-Nesson, Cox, 4th Edn., (W.H. Freeman and Co.), 2005.
5. Biochemistry Voet & Voet; J, 3rd Edn. (John Wiley and sons Inc.), 2004.
6. Outlines of Biochemistry-Conn; E,Stumpf, 5thEdn.(Tata-McGraw Hill), 1988.
7. Enzyme Biotechnology- Tripathi; G, (ABD Publishers), 2003.
8. Enzyme Technology, M.F. Chaplin and C. Bucke. Cambridge University Press
9. Industrial Enzymes & their applications, H. Uhlig, (John Wiley and Sons Inc.)

Course Code	Course/Subject Name	Credits
BTC604	IPR, Bioethics and Biosafety	4

Pre-requisites:

- Knowledge of materials to be classified as biohazard, knowledge about current scenario of biotechnological issues.

Course Objectives:

- Tounderstandthelawsgoverningbiotechnologyandrelatedfieldatnationalandinternational level.
- To gain knowledge about safety precautions necessary during biotechnological work.
- To understand the ethical perspective of handling biomaterials

Course outcomes:

- To be aware of rules and regulations setup at international level for various biotechnology related work so that any further research can be formulated accordingly.
- Toknowthesocialandlegalstateofthesocietywithrespecttogeneticallyengineeredproducts or other outcomes of biotechnology.
- Work according to the safety precautions set up by international bodies while handling bio hazardous material.

Module	Contents	Contact Hours
01	Introduction to Intellectual Property: Concept of Intellectual Property, Kinds of Intellectual Property: Patents, Copyrights, Designs, Trademarks, Geographical Indication. Infringement of IPR, its protection and remedies. Licensing and its types.	10
02	International Scenario: Introduction to the leading international instruments concerning intellectual property rights: The Berne Convention, GATT, WTO, Indian Patent Act, Universal Copyright Convention, The Paris Convention, TRIPS, The World Intellectual Property Rights Organization (WIPO), Budapest treaty	05
03	Patents: Requirement of patentable novelty, inventive step, prior art Classifying products as patentable and non-patentable Procedure for applying for patent, Patent Infringement and related case studies, Biological Patentability.	06
04	IPR and Biotechnology: Biopiracy and Bioprospecting, Farmers Rights and Plant breeders rights, Biodiversity, CBD	04
05	Biosafety: Good Lab Practices, Introduction to Biological Safety Cabinets, Primary Containment for Biohazards, Biosafety Levels, GMOs, LMOs and their environmental impact, Roles of Institutional Bio safety Committees: RCGM, GEAC etc. for GMO applications in food and agriculture, Risk analysis,	06

	assessment and management.	
06	Bioethics: Bioethical issues related to Healthcare & medicine, Food& agriculture, Genetic engineering. The Human Genome Project and Genetic Testing, Environmental problems.	**04**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. IPR, Bio safety and Bioethics by Deepa Goel and Shomini Parasha
2. Intellectual property rights by Dr. Reddy

Course Code	Course/Subject Name	Credits
BTC605	Process Control and Instrumentation	4

Pre-requisites:

- Knowledge of Laplace Transforms, Knowledge of differentiation and Integration

Course Objectives:

- To understand the basic concepts of process parameter control
- To understand the closed loop and open loop control system
- To carry out the stability analysis for a given process

Course outcomes:

- Student will be able to design the process control of a parameter.
- Student will be able to carry out the stability analysis for a process.

Module	Contents	Contact Hours
01	Instrumentation: Instrumentation principles, Introduction to temperature and liquid level measurements, measurement of important physico-chemical and biochemical parameters, methods of on-line and off-line biomass estimation, flow injection analysis for measurement of substrates, products and other metabolites.	05
02	First order systems: Process characteristics, Laplace transforms, first order systems examples, mercury in glass thermometer, liquid level system, linearization, response of first order system for step, pulse, impulse and sinusoidal changes in input, conceptual numericals.	05
03	Firs torder systems in series: Interacting and non-interacting systems and their dynamic response to step, pulse and impulse inputs; conceptual numericals.	04
04	Second order systems: Second order systems with transfer functions (spring-damper, control valve, U-tube manometer), response of second order system to step, pulse/ impulse and sinusoidal input Overdamped, underdamped and critically damped condition of second order system, transportation lag.	05
05	Controllers and final control elements: Actuators, Positioners, Valve body, Valve plugs, Characteristics of final control elements, controllers two position control, proportional control, derivative control, integral control, P-I (proportional- integral) control, P-D(proportional-derivative) control, P-I-D (proportional-integral- derivative) control, conceptual numericals.	05
06	Closed loop control systems: Block diagrams for servo and regulatory problems. Transient response of first and second order processes for set point	04

	changes and load changes with proportional and PI controllers, conceptual numericals.	
07	Controller design ands tability: Criteria for stability, Routhtest; Root locus analysis, Introduction to frequency response, Qualitative discussion about Bode criteria and Nyquist criteria, Controller tuning- Gain & Phase margin; Conceptual numerical on Routh test, Root locus and Bode plot.	**05**
08	Bioprocesses dynamics and control: Dynamics and control of bioreactors & sterilizers. On-line data analysis for state and parameter estimation, techniques for biochemical processes, Complex control strategies such as feed forward, cascade, adapter, supervisory, multivariable controls and their application for optimum controls.	**03**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Coughnanowr, Process Systems Analysis and Control.
2. Stephanopoulos, G., Chemical Process Control, Prentice Hall of India., 1990.
3. Richardson, J. F., Peacock, D. G., Coulson & Richardson's Chemical Engineering, Vo. 3., ed. 3., Asian Books Pvt. Ltd, New Delhi, 1994.
4. William L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill International Edition. 1990.
5. B.Wayne Bequette Process Control Modeling, Design and Simulation, Prentice Hall of India Pvt. Ltd.

Course Code	Course/Subject Name	Credits
BTE6021	Department Elective II- Computational Fluid Dynamics	4

Pre-requisites:

- Linear Algebra
- Partial Differential Equations
- Scilab or Python

Course Objectives:

- To understand the formulation of CFD problems
- To discretize the problems
- To solve the set of equations in simple cases using Scilab routines.
- To understand and use software in CFD

Course Outcomes:

- The student will be able to obtain flow profiles for some simple applications using Scilab.
- The student will be able to use appropriate software for solving realistic problems.

Module	Contents	Contact Hours
1	Module: Introduction Contents: Advantages of Computational Fluid Dynamics Typical Practical Applications Equation Structure Overview of CFD	02
2	Module: Preliminary Computational Techniques Contents: Discretisation Approximation to Derivatives Accuracy of the Discretisation Process Wave Representation Finite Difference Method	04
3	Module: Theoretical Background Contents: Convergence Consistency Stability Solution Accuracy Computational Efficiency	06
4	Module: Weighted Residual Methods Contents: General Formulation Least Squares, Galerkin and Subdomain Formulations. Weak form of Galerkin Method	08
5	Module: Finite Element Method Contents: Piece-wise Continuous Trial Functions One Dimensional Linear and Quadratic Elements	08

	One Dimensional Heat Transfer Tri-diagonal Matrix Algorithm	
6	Module: Two Dimensional Elements Quadrilateral Elements Steady State Heat Transfer in Two Dimensions Alternating Direction Implicit Method Potential Flow in Two Dimensions	**08**
7	Module: Finite Volume Method One Dimensional Diffusion Two Dimensional Diffusion Diffusion With Convection and The Upwind Scheme	**06**
8	Module: Pressure Velocity Coupling in Steady Flows The Staggered Grid The Momentum Equation The Simple Algorithm	**06**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. C.A.J. Fletcher; Computational Techniques for Fluid Dynamics 1; Springer-Verlag Berlin Heidelberg GmbH
2. P. Seshu; Textbook of Finite Element Analysis; PHI Learning Private Limited, New Delhi
3. H.K. Versteeg and W. Malalasekera; An Introduction To Computational Fluid Dynamics; Longman Scientific & Technical

References

1. John D. Anderson; Computational Fluid Dynamics; McGraw Hill Education Private Limited

Course Code	Course/Subject Name	Credits
BTE6022	Department Elective II- Protein Engineering	4

Pre-requisites:

- Knowledge of Biochemistry, Recombinant DNA Technology and Enzyme Engineering

Course Objectives:

- Imparting knowledge about structure function relationships of proteins
- Studying the problem of protein folding and methods of characterization folded proteins
- Aspects of Protein Engineering in the industry

Course outcomes:

- At the end the student would have learned:
- Structure and Function relationship in proteins and its application in designing proteins
- Process of engineering proteins to increase its value by assisting folding, purification
- Protein engineering of therapeutic proteins, industrially important enzymes and antibodies.

Module	Contents	Contact Hours
01	Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Bonds that stabilize a protein molecule, Ramchandran Plot. Protein folding pathways and Energy Status of a Protein Molecule, Protein Degradation in the cell	06
02	Techniques involved in studying protein structure: Methods of protein crystallization. Methods to study the quaternary structures of proteins: X-ray Crystallography, NMR Spectroscopy. MALDI-TOF, ESI-MS	07
03	Structure Function Relationships in Proteins: Helix-turn-Helix motif in DNA binding and homeo domain protein, Zinc fingers, Leucine zippers. Membrane proteins: General characteristics, Transmembrane segments, bacteriorhodopsin and Photosynthetic reaction center	06
04	Concepts of designing a new Protein Molecule: Chemical synthesis of peptides. Target molecules for Protein Engineering. The protein cycle and steps involved in Engineering a new Protein. De novo protein design	06
05	Applications of Protein Engineering: Protein Engineering to enhance the solubility and assist	10

	folding of expressed proteins. Protein Engineering to assist purification of expressed proteins. Role in Vaccine Development. Engineering blood clotting factors:f actor VIII. Engineering enzymes: tyrosyl- t RNA synthase. Engineering therapuetic hormones: insulin. Engineering humanized antibodies	

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Lilia Arbenghina; Protein Engineering in Industrial Biotechnology; Harwood Academic Publishers
2. Creghton TE; Proteins Function, A Practical Approach; Freeman WH, Second Ed, 1993
3. Branden C. And Tooze J.; Introduction to Protein Structure; Second Edition, Garland Publishing, NY, USA, 1999
4. Moody PCE, and A.J. Wilkinson; Protein Engineering; IRL Press, Oxford, 1990
5. Walsh.G; Protein Biotechnology and Biochemistry; 2nd ed.; Wiley Publications
6. Klaus Demobowsky, Novel Therapeutic Proteins; Wiley Publications
7. Voet D. and Voet G.; Biochemistry' Third Edn. John Wiley and Sons, 2001

Course Code	Course/Subject Name	Credits
BTE6023	Elective II- Cancer Biology	4

Pre-requisites:

- Knowledge of Biochemistry, Cell biology, Immunology, Molecular biology, Genetic Engineering

Course Objectives:

- Studying cellular and molecular mechanisms that are deregulated in cancerous cells.
- Contribution of Genetic mutation in the development of cancer
- Environmental factors influencing susceptibility of cancer
- Treatment modalities i.e traditional chemotherapies and novel targeted therapeutic approaches
- Genetic Engineering technologies to understand cancer prevention, diagnosis, and treatment

Course outcomes:

- By the end of the course, students should be able to describe the:
- Process of tumorigenesis at the molecular and cellular level.
- Cell cycle regulatory mechanisms in normal and tumor cells
- Role of oncogenes and tumor suppressor genes and their genetic alterations in cancer formation.
- Importance of apoptosis in normal and tumor cells
- Tumorigenesis, angiogenesis, and metastasis.

Module	Contents	Contact Hours
01	Control of Cell proliferation, Cell Cycle and Cell Death: Process of Cell cycle, tumor suppressor genes, Cell cycle control and pRb tumor suppressor. Apoptosis and p53 tumor suppressor gene. Introduction to different forms of cancers.	06
02	Mutagens, carcinogens, and mutations: Chemical Carcinogenesis, Metabolism of Carcinogenesis, targets of Chemical Carcinogenesis, Physical carcinogens - X-Ray radiation – Mechanism of radiation Carcinogenesis. DNA repair mechanisms – DNA repair defects and their relationship to cancer. Gene mutations and deregulation in cell signal pathway	08
03	Oncogenes, growth factors, receptors and cancer: Identification of Oncogenes, Retroviruses and Oncogenes, detection of Oncogenes, Role of growth factors and receptors in carcinogenesis, RAS, NFkB, Wnt signaling in cancer.	08
04	Tumor Invasion and Metastasis: Metastatic cascade, Basement membrane disruption, Three step theory of invasion, Proteinases and tumour cell invasion. Multi-step tumorigenesis and the evolution of cancer.	07

05	Cancer treatment modalities: Different forms of therapy- Chemotherapy, Radiation Therapy, Immunotherapy, commonly used cancer diagnostic and prognostic molecular markers, Novel targeted therapeutic approaches.	**06**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. King R.J.B., "Cancer Biology", Addision Wesley Longmann Ltd, U.K., 1996.
2. Ruddon. R.W, "Cancer Biology", Oxford University Press, Oxford, 1995, 2007.
3. Robert Allan Weinberg, "The Biology of Cancer", Volume 2, Garland Science, 2007.

Course Code	Course/Subject Name	Credits
BTE6024	Department Elective II- Green Technology	4

Pre-requisites:

- Basics of physics, chemistry, biochemistry, and microbiology

Course Objectives:

- Green Technologies is a highly interdisciplinary degree program that emphasizes green systems and the environment, energy technology and efficiency, and sustainability and society. The objective of this course is to:
- Seek opportunities for alternative sourcing, conservation, efficiency and repurposing through an understanding of product life cycles from origins to recycling or inevitable disposal.
- To design products, processes and complex infrastructure systems to promote sustainable attributes of importance to the environment and the global community.
- To combine technical and scientific skills with an understanding of the environment, renewable energy management, waste utilization, resource management and land based industries who can contribute to the national and global development.

Course outcomes:

- To understand the principles of green chemistry and engineering.
- To design processes those are benign and environmentally viable.
- To design processes and products those are safe and hazard free.
- To learn to modify chemical processes making hazardous products and make them green safe and economically acceptable by using biotechnology.

Module	Contents	Contact Hours
01	Fundamentals of Green Chemistry and Technology- Principles of Green Chemistry and technology, green chemistry metrics (atom economy, atom efficiency, E-factor, and other green chemistry metrics)	05
02	Catalysis- Introduction to catalysis, Catalytic cycle, TON, TOF, bio-catalysis	03
03	Industrial Safety and Hazard analysis- Introduction to ISO standards, hazard identification, life cycle analysis, and safety aspects related to transport, handling and storage of hazardous chemicals. green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- WEHAB (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies, industrial ecology, agro ecology and other appropriate green technologies , global warming; greenhouse gas emissions, impacts, mitigation and adaptation	10
04	Green processes- Microwave assisted reactions, ultra-sonication assisted reactions, ionic liquids as solvent, water as a reaction medium, solvent free reactions, supercritical solvents, safe product and process design, case studies	04
05	Advances in separation process- Adsorption, Distillation,	04

	filtration, membrane separation, precipitation, crystallization	
06	Green Biotechnology- Green concepts in biotechnology, organic synthesis using supported microbes and enzymes in biopharmaceuticals/ bio refineries, bioreactor designs, downstream processing.	**04**
07	Green Nanotechnology - Nanomaterials for water treatment, nanotechnology for renewable energy, nanotechnology for environmental remediation and waste Management, nanotechnology products as potential substitutes for harmful chemicals, environmental concerns with nanotechnology	**05**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Green Chemistry – An introductory text - M. Lancaster, RSC
2. Industrial catalysis – optimizing catalysts and processes – R J Wijngarden Wiley - VCH
3. Safety and Reliability of Industrial Products, Systems and Structures C. Guedes Soares (Eds), CRC Press
4. Green separation processes- C. A. M. Afonso, J. G. Crespo (Ed)- Wiley VCH
5. Industrial biotechnology- sustainable growth and economic success- Wilm Soetaert Reic J Wandamme- Wiley VCH
6. Energy, Ecology and the Environment, Academic Press Inc, B. R Wilson & W J Jones, 2005

Course Code	Course/Subject Name	Credits
BTL601	Lab-II	1.5

Concept for Experiments

A minimum of TEN experiments must be performed

- Maintenance of asceptic condition in PTC Lab
- Medium Preparations
- Callus induction and Regenerations
- Callus propagation
- Organogenesis
- Haploid Culture
- Embryo Culture
- Somatic Embryogenesis
- Suspension Culture
- Anther culture for production of haploid plants
- In vitro seed germination
- Inoculate the tissue culture raised shoots on suitable medium for in vitro rooting
- Hardening and acclimatization of in vitro raised rooted shoots
- Hairy root induction by Agrobacterium tumefaciens
- seed anti-mitotic assay
- Meristem culture for obtaining Virus free plants
- Effect of plant growth regulators on callus induction : effect of hormone variation
- Encapsulate the shoot buds, seeds to demonstrate the production of synthetic seeds
- Sterilization procedures and media preparation for Animal Cell cultures
- Establishment of Primary cell culture from chick embryo
- Animal cell culture: viable cell counting by Haemocytometer

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

Course Code	Course/Subject Name	Credits
BTL602	Lab-III	1.5

Concept for Experiments

A minimum of TEN experiments must be performed

- Isolation of enzyme from a plant source
- Isolation of enzyme from an animal source
- Isolation of intracellular enzyme
- Determination of specific activity of enzyme
- Determination of the optimum pH & temperature of enzyme
- Determine the stability of enzyme
- Immobilization of enzyme
- Determination of kinetic parameters (Km and Vmax)
- Purification of enzymes
- Studies of various enzyme reactors
- Bacteriological testing of milk (MBRT)
- Estimation of Calcium by EDTA method
- Isolation and separation of chloroplast by sucrose density gradient centrifugation
- Production of Grape wine and is biochemical analysis
- Determination of starch and sugar in plant tissue
- Clarification of fruit juices
- Study of pectinase activity
- Primary screening of Amylase producing bacteria and fungi from soil

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
B.E. Semester VII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC701	Bioseperation& Downstream Processing Technology-I	4	-	1	4	-	1	5
BTC702	Bioprocess Modelling and Simulation	4	-	1	4	-	1	5
BTC703	Agriculture Biotechnology	3	-	1	3	-	1	4
BTE703X	Department Elective III	3	-	1	3	-	1	4
ILO701X	Institute Level optional Subject I	3	-	-	3	-	-	3
BTP701	Project A	-	-	6	-	-	3	3
BTL701	Lab - IV	-	3	-	-	1.5	-	1.5
BTL702	Lab - V	-	3	-	-	1.5	-	1.5
	Total	17	6	10	17	3	7	27

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC701	Bioseperation& Downstream Processing Technology-I	20	20	20	80	3	25	-	-	125
BTC702	Bioprocess Modelling and Simulation	20	20	20	80	3	25	-	-	125
BTC703	Agriculture Biotechnology	20	20	20	80	3	25	-	-	125
BTE703X	Department Elective III	20	20	20	80	3	25	-	-	125
ILO701X	Institute Level optional Subject I	20	20	20	80	3	-	-	-	100
BTP701	Project A	-	-	-	-	-	100		50	150
BTL701	Lab - IV	-	-	-	-	-	-	25	-	25
BTL702	Lab - V	-	-	-	-	-	-	25	-	25
	Total			100	400	-	200	50	50	800

Department Elective III (Sem VII)		
Engineering Stream	Advanced Science Stream	Technology Stream
1. Stem Cell & Tissue Engineering (BTE7031)	1. Operation research in Biotechnology (BTE7032) 2. Project Management (BTE7033)	1. Nanotechnology (BTE7034)

Institute Level Optional Subject I (Sem VII)		
1. Product Lifecycle Management (ILO7011)	4. Design of Experiments (ILO7014)	7. Disaster Management and Mitigation Measures (ILO7017)
2. Reliability Engineering (ILO7012)	5. Operation Research (ILO7015)	8. Energy Audit and Management (ILO7018)
3. Management Information System (ILO7013)	6. Cyber Security and Laws (ILO7016)	9. Development Engineering (ILO7019)

Course Code	Course/Subject Name	Credits
BTC701	Bio separation and Downstream Processing Technology-I	5

Pre-requisites:

- Basics of Bioprocesses and Unit Operations
- Basic knowledge of mass balance
- Concepts of molecular diffusion and diffusion coefficients

Course Objectives:

- To cover the fundamentals, and design concepts of various downstream purification steps (unit operations) involved in a biochemical process.

Course outcomes:

- Students will be able to describe theory, principle, design, application and possible integrations of unit operations in bioprocessing.

Module	Contents	Contact Hours
01	Introduction to By-products and Bio separation: Range and characteristics of bio products, Characteristics of Fermentation Broth, Selection of unit operation with due consideration of physical, chemical and biochemical aspect of biomolecules. Stages of Downstream Processing	04
02	Product release and recovery processes: Fundamental principles of obtaining the product from cell cultures: intracellular vs. extracellular product. Cell disruption-Physical, Chemical and Enzymatic methods of cell disruption, Mechanical Cell disruption methods: High pressure Cell Homogenizer, Bead Mill, Sonication	05
03	Primary Separation: Removal of insolubles and Biomass (and particulate debris) separation techniques, Flocculation and sedimentation, Centrifugation-Ultracentrifugation, Gradient centrifugation, Filtration: Theory of Filtration, Pre-treatment of Fermentation Broth, Filter Media and Equipment, Conventional and Cross-flow Filtration, Continuous Filtration, Filter cake resistance, specific cake resistance, Washing and dewatering of filter cakes	09
04	Gas Absorption: Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, absorption factor, stripping factor, minimum gas liq ratio, Single stage gas absorption-Cross Current, Co- current, Countercurrent, Multistage Counter current Operation, Absorption with Chemical Reactions, Related problems	10
05	Liquid-Liquid Separation Process: Introduction to Liquid-Liquid Extraction, Choice of Solvent for Liquid-Liquid Extraction, Binodal solubility curve,	10

	Single Stage Operation, Equipments for liquid-liquid extraction. Types of extraction processes: Reactive extraction, Aqueous two phase systems, Reverse micellar extraction, Liquid-liquid and solid-liquid extraction, Supercritical fluid Extraction. Design of extraction equipment. Different types of extractors and designing of extractors. Distillation: Simple, Steam and Equilibrium distillation, Fractionation, Mccabe Thiele method, azotropes, numericals	
06	Leaching and Precipitation: Leaching: Representation of equilibria, single stage leaching, and multistage cross current leaching, multistage counter current leaching, equipments for leaching. Precipitation: Protein Precipitation methods: Isoelectric precipitation, Salting out, Organic solvent addition, Non-ionic polymers, Polyelectrolyte Addition, Selective denaturation of unwanted proteins, Large scale precipitation, Applications	**07**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W. L.and Smith J.C., Unit operation in chemical engineering, 5Ed., McGraw Hill New York 1993.
3. Geankoplis C.J., Transport processed and unit operations, Prentice Hall, New Delhi 1997.
4. Roger G. Harrison, Paul Todd, ScottR. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, Oxford University Press
5. B.Shivshankar, Bioseparations: Principles and Techniques, Eastern Economy

Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012
6. Bioseparation & bioprocessing (2nd Ed.) 2-Volume set, Ed SUBRAMANIAN Ganapathy, Wiley-VCH, (09-2007)
7. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley Interscience Publication, 1988.
8. J.E. Baileyand D.F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, Inc., 1986.
9. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.
10. Scopes Ak, Protein Purification, IRL Press, 1993
11. Biotechnology: Bioprocessing, Rhem and Reed, Vol. 3, 1993
12. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989
13. Asenjo J.A. and J.Hong (Eds), Separation Processes in Biotechnolgy, Taylor and Francis
14. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag

Course Code	Course/Subject Name	Credits
BTC702	Bioprocess Modelling and Simulation	5

Pre-requisites:

- Knowledge of Fundamental Laws of Physics
- Knowledge of basic Mathematics
- Knowledge of Reactors and its types
- Knowledge of production of various fermentation products

Course Objectives:

- To understand the mathematical models in Biochemical Engineering systems
- To learn about different apects of modelling in Bioprocess system
- To learn various techniques to solve and simulate various bioprocess models

Course outcomes:

- Students will be able to formulate model for biochemical System.
- Students will be able to solve Biochemical models

Module	Contents	Contact Hours
01	Basic Modelling Principles: Introduction, definetion of Modelling and simulation, different types of models, application of mathematical modelling. Fundamental laws: continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics with examples	08
02	Mathematical Models for Biochemical Engineering Systems: Batch Reactor, CSTR isothermal with cooling/heating jacket or coil, Continuous Stirred Tank Bioreactor, Fed Batch reactor, Batch distillation	08
03	Numerical Methods: Solution of linear algebraic equations by Cramer's rule, Gauss elimination, Gauss siedel iterative method. Solution of Non algebraic equations by Bisection method, Newton Raphson, Secant Method. Numerical integration: Trapezoidal rule, Simpson's1/3rule, Simpson's 3/8 rule, Euler's method, Runga Kutta method, Basic data analysis-curve fitting	10
04	Modelling approaches for Biological systems Growth kinetic Models - structured and unstructured systems; Compartment models; Deterministic and stochastic approaches for modelling structured systems. Thermal death kinetics models, Stochastic Model for thermal sterilization of medium.	10
05	Modelling for activated sludge process, Model for anaerobic digestion, Model for lactic acid fermentation, antibiotic production, Ethanol fermentation	09

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. J.E. Baileyand, D.F. Ollis, Biochemical Engg Fundamentals, 1986, McGraw Hill Book Company
2. Said S.E.H. Elnashaie, Parag Garhyan, Conservation Equations and Modeling of Chemical and Biochemical Processes, 2003, Marcel Dekker
3. B. Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, 1998, Prentice Hall
4. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts,2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002
5. Process Modelling, Simulation and Control for Chemical Engineers, by William Luyben, McGraw Hill, Second Edition.
6. Numerical Methods and Modelling for Chemical Engineers, Davis M.E. ,Wiley, New York 1984
7. Numerical Methods for Engineers, Santosh Kumar Gupta, Tata McGraw hill, 1995
8. Numerical Methods, M. K. Jain, S. R. K. Iyengar, and R. K. Jain Sixth Edition. New Age International Publishers, New Delhi, 2012
9. Introduction to Chemical Engineering Computing by Bruce A. Finlayson Wiley- International, 2005.

Course Code	Course/Subject Name	Credits
BTC703	Agriculture Biotechnology	4

Pre-requisites:

- Knowledge about plant tissue culture methods and applications.
- Knowledge aboutgeneticengineeringmethodsfore.g.genetransfertechniques,plant vectors and basics of transgenic plants.
- Knowledge about traditionally used herbicides, pesticides, its advantages and drawbacks
- Knowledgeaboutethicalandbiosafetyissuesandintellectualpropertyrulesassociated
- with plants

Course Objectives:

- To understand basic plant biology and breeding methods.
- To gain knowledge about transgenic plant analysis, principle behind generation of herbicide and pest tolerant plants.
- To understand the stress condition in plants and methods to overcome it.
- To design methods for crop improvement.
- To analyse applications based on molecular farming.

Course outcomes:

- Students will be able to:
- Apply the transgenic methods to develop better quality crops.
- Understand the advantages and drawbacks of engineered plants and modify them accordingly.
- Harness the plants for improved quality biomaterials.

Module	Contents	Contact Hours
01	Agricultural Microbiology: Microbial groups in soil, Plant and Microbe interactions. Plant pathogens, Biological nitrogen fixation, Microflora of Rhizosphere and Phyllo sphere microflora, microbes in composting, Beneficial microorganisms in Agriculture: Biofertilizer (Bacterial Cyanobacterial and Fungal), microbial insecticides, Microbial agents for control of Plant diseases	05
02	Plant Breeding: Historical milestones in plant breeding, Aims and objectives of plant breeding, Significance of plant breeding in crop development. Concepts in plant breeding – Simple versus Complex Inheritance, Mating Systems, Varieties, and Pure Lines. Methods of Plant Breeding. Plant Hormone Signal Transduction - Auxin and GA Signaling, Cytokinin and Ethylene Signaling	05
03	Transgenic Plants: Transgenic Plant Analysis: screening on selection media, PCR, Intact Transgene Integration characterization, Real time PCR, Transgene expression, western blot analysis.	05

	Regulations and Biosafety. Field Testing of Transgenic Plants- Environmental Risk Assessment (ERA) process, e.g. the case of Bt Maize, Agronomic Performance, Risk analysis. Clean-gene technology.	
04	Genetic manipulation of herbicide tolerance: The use of herbicides in modern agriculture, types of compounds used as herbicides, Strategies for engineering herbicide tolerance - Glyphosate tolerance, Phosphinothricin, Prospects for plant detoxification systems, Commercialization of herbicide-tolerant plants to date, The environmental impact of herbicide-tolerant crops, Development of Superweeds.	**03**
05	Biotic and Abioticstress: Abiotic stress: Acclimatization and crop adaptation to water stress, salinity stress, temperature stress, heat and cold, Photo oxidative stress, nutrient stress, heavy metal stress, metabolite engineering for abiotic stress tolerance Biotic stress: plant response to pathogens and herbivores, biochemical and molecular basis of host plant resistance, toxins of fungi and bacteria, systemic and induced resistance, pathogen derived resistance, genetic engineering for biotic stress resistance	**06**
06	Genetic manipulation of pest resistance: The nature and scale of insect pest damage to crops. GM strategies for insect resistance: the Bacillus thuringiensis approach. The use of Bacillus thuringiensisas a biopesticide. Bt-based genetic modification of plants. Problem of insect resistance to Bt, environmental impact of Bt crops. Copy Nature strategy	**03**
07	Improvement of crop yield and quality: Genetic manipulation of fruit ripening, softening, genetic modification of ethylene biosynthesis. Golden rice and Biofortified rice. Engineering plant protein composition for improved nutrition. The genetic manipulation of crop yield by enhancement of photosynthesis	**04**
08	Molecular farming: Farming of carbohydrates (e.g.starch, polyfructans) Metabolic engineering of Lipids (e.g. Bioplastics) Molecular farming of proteins (e.g.oleosin system:hirudinand insulin production). Medically related proteins (e.g.custom made antibodies, Edible vaccines)	**04**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Plant biotechnology-The genetic manipulations of plants by Slater, A., Scott, N. and Fowler, M., Oxford University press
2. Principles of Plant Breeding by Allard R W 1960 .Kalyani Publishers, New Delhi.
3. Plant Biotechnology and Genetics: Principles, Techniques, and Applications - Edited by C. Neal Stewart, Jr.
4. Stress biology, by U.Chakraborty, Bishwanath Chakraborty, 2005. Narosa Publishing House.
5. Agricultural Microbiology by D. J. Bagyaraj, G. Rangaswami, Prentice Hall of India Pvt Ltd.

Course Code	Course/Subject Name	Credits
BTE7031	Department Elective-III: Stem Cell & Tissue Engineering	4

Pre-requisites:

- Cell Biology, Developmental Biology, Biochemistry, Molecular Biology and Genetics.

Course Objectives:

- To understand the developmental processes in a complex living system.
- To manipulate the cells to change and perform tasks in a carefully directed fashion.
- To understand the possibilities this technology offers in a medical field

Course outcomes:

- This course gives an overview about the application of stem cells for regenerative medicine.
- It explains advantages and disadvantages of stem cells as therapeutics.
- The students obtain knowledge in medical applications of biomaterials as well as about basic concepts regarding design and mechanical properties of selected natural and synthetic biomaterials
- The Tissue Engineering and Regenerative Medicine educate students in two new, interdisciplinary fields in the biomedical sciences that aim to replace damaged tissue in the human body and to stimulate the body's own regenerative processes.
- International research and development of new therapies in these areas is currently booming

Module	Contents	Contact Hours
01	Development of multicellular organisms: Universal mechanisms of animaldevelopment, Basic anatomical features, Role of proteins and regulatory DNA in development, Approaches to understand developmental processes, Cell fate, Positional value of cell, Inductive signalling, Asymmetric cell division, Positive feedback, Morphogens and their gradients, Intrinsic programming, Patterning by sequential induction	06
02	Stem cells: Definition, Properties & Types of stem cells, Maintaining population of stem cells, Transit amplifying cells. Embryonic stem cells: Properties, Pluripotent stem cells and methods of generating them. Adult stem cells and their sources.	04
03	Epidermal renewal by stem cells: The multilayered structure of epidermis, Role of stem cells and transit amplifying cells in epidermis renewal. Renewal by multipotent stem cells: Blood cell formation, Bone marrow and Hemopoietic Stem Cells, Hematopoiesis, Contact Signals From Stromal Cells. Osteogenesis: Formation of bone & cartilage from Mesenchymal Stem Cells.	05

04	Applications of stem cells in regenerative medicine: Repairing Nervous system, Liver cell proliferation and repair, Cardiac repair, Diabetes treatment, GM stem cells and Gene therapy. Ethical issues associated with stem cells	**05**
05	Tissue Engineering: Introduction to biomaterials and tissue engineering, Elements of biomaterials, Self-assembly and growth, Mechanical concepts in biomaterials, Different protein fibers: collagen, silk, keratin. Characterization of biomaterials, Methods for the determination of biocompatibility, Biological composite materials e.g. fibers, Hierarchical design bone, wound care und suture materials, vascular implants, biomimetic and bio-inspired materials, Basic techniques to manufacture scaffolds from raw biomaterials and different prerequisites for the biomaterials	**10**
06	Tissue engineering examples: Bone & Cartilage tissue engineering, skin tissue engineering, vascular tissue engineering, heart valves tissue engineering	**05**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Molecular biology of Cell: Alberts et al.2014.(Chapter 22 and 23)
2. Gordana Vunjak- Novakovic, R. Ian Freshney (2006): Culture of Cells for Tissue Engineering, Wiley
3. Ulrich Meyer, Thomas Meyer, Jörg Handschel, Hans Peter Wiesmann (2009): Fundamentals of Tissue Engineering and Regenerative Medicine, Springer
4. Lanza RP, Langer R, Vacanti J. Principles of Tissue Engineering. Third edition. Academic Press. 2007

Course Code	Course/Subject Name	Credits
BTE7032	Department Elective-III: Operation Research in Biotechnology	4

Pre-requisites:

- Linear Algebra
- Computer Programming

Course Objectives:

- To understand Linear Programming and its applications to OR models.
- To understand and solve network models in OR.
- To understand Game theory and its applications.
- To study and design Queuing systems.

Course Outcomes:

- The student will be able to solve typical OR models using linear integer and dynamic programming techniques.
- The student will be able to model and solve network flow problems in OR.
- The student will be able to make decisions under various scenarios.
- The student will be able to design Queuing Systems

Module	Contents	Contact Hours
1	Module: Linear Programming Contents: Introduction Graphical Method of Solution Simplex Method Two-Phase Method Duality Dual Simplex Revised Simplex	10
2	Module: Transportation Models Contents: Examples of Transportation Models The Transportation Algorithm The Assignment Model The Trans shipment Model	06
3	Module: Network Models Contents: Scope and Definition of Network Models Minimal Spanning Tree Algorithm Shortest Route Problem Maximal Flow Model	06
4	Module: Integer and Dynamic Programming Contents: Branch and Bound Method Travelling Salesman Problem Introduction to Dynamic Programming Forward and Backward Recursion Selected Applications	06

5	Module: Deterministic Inventory Models Contents: Classic EOQ Model EOQ with Price Breaks Dynamic EOQ Models No-Setup Model Setup Model	**06**
6	Module: Decision Analysis and Game Theory Contents: Decision Making under Certainty Decision Making under Risk Decision Under Uncertainty Game Theory	**06**
7	Module: Queuing Systems Contents: Elements of a Queuing Model Role of Exponential Distribution Pure Birth and Death Models Generalized Poisson Queuing Model Measures of Performance	**08**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Text Books

1. Operations Research; Hamdy A. Taha; Eighth Edition; Prentice Hall India

References

1.Hillier and Lieberman; Introduction to Operations Research

Course Code	Course/Subject Name	Credits
BTE7033	Department Elective-III: Project Management	4

Pre-requisites:

- Knowledge of Fundamentals of project

Course Objectives:

- To get acquainted with various aspects of project management.
- To study different scheduling and planning techniques used in the industry.
- To study various applications of inventory and project management with respect to the Bioprocess Industry.
- To study Life-cycle of the project.
- To develop and strengthen entrepreneurial quality in students.
- To impart basic entrepreneurial skills and understandings to run a business efficiently and effectively.

Course outcomes:

At the end of the course, learners should be able to;

- Describe the fundamental concepts in Project management
- Analyse the various scheduling and planning techniques
- Understand and apply suitable strategy for any specific project
- Apply project management principles in business situations to optimize resource utilization and time.

Module	Contents	Contact Hours
01	Introduction to Project Management: Management, Definition, Goal, Lifecycles. Project Selection Methods. Project Portfolio Process, Project Formulation. Project Manager – Roles, Responsibilities and Selection, Project Teams.	08
02	Planning and Budgeting: The Planning Process – Work Break down Structure Role of Multidisciplinary teams. Budget the Project – Methods. Estimating and Improvement. Budget uncertainty and risk management.	09
03	Scheduling and Resource allocation: GANTT Chart, PERT & CPM Networks, GERT, Crashing Project Uncertainty and Risk Management – Simulation – Gantt Charts. Algorithms for solving sequencing problems – Processing of N jobs through K machines, Assignments and transportation algorithms -Expediting a project –Resource loading and leveling. Allocating scarce resources –Goldratt's Critical Chain.	09
04	Project control and conclusion: The Plan-Monitor-Control cycle – Data Collecting and reporting	09

	Project Control – Designing the control system. Project Evaluation, Auditing and Termination.	

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. John M. Nicholas, "Project management for business/Technology", Pearson
2. Uddesh Kohli, K.K Chitkara, "Project Management Handbook", Tata McGraw Hill
3. Samuel J. Mantel et al, "Project management", Wiley India
4. S. Choudhury, "Project Management", Tata McGraw Hill
5. P K Joy, "Total Project Management –The Indian context", Macmillan
6. Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2001
7. S.S. Khanka, Entrepreneurial Development, S. Chand and Company Limited

Course Code	Course/Subject Name	Credits
BTE7034	Department Elective-III: Nanotechnology	4

Pre-requisites:

- Knowledge of Biophysics, Biochemistry, Molecular Biology, Immunology and Analytical Methods in Biotechnology

Course Objectives:

- To develop the skills of the student in the area of Nanotechnology and its application.
- Tofamiliarizestudentwithdifferenttechniquesforsynthesizingandcharacterizin gof various nanoparticles.

Course outcomes:

- Students will have an in depth understanding of the components of Nanotechnology and the instruments used in Nanotechnology.
- Students will be able to apply the concepts of Nanotechnology in various fields.

Module	Contents	Contact Hours
01	Basics and Scale of Nanotechnology: Introduction, Scientific revolutions, Time and length scale in structures, Definition of a nanosystem, Dimensionality and size dependent phenomena, Surface to volume ratio-Fraction of surface atoms, surface energy and surface stress, surfaced efects, Properties at nanoscale (optical, mechanical, electronic and magnetic)	06
02	Different Classes of Nanomaterials: Classification based on dimensionality, Quantum Dots, Wells and Wires, Carbon-based nano materials (buckyballs, nanotubes, graphene), Metal based nanomaterials (nanogold, nanosilver and metal oxides), Nanocomposites, Nanopolymers, Nanoglasses, Nano ceramics, Biological nanomaterials	07
03	DNA and Protein based Nanostructures: DNA-gold particle conjugates, Polymer nanocontainers, Nanopores and nanomembranes for biochemical sensing, Micro and nanofluidic devices in biological studies, Peptide nanotubes and their applications in electronics, antibacterial agents; protein self-assembly, nanochips, nanopolymers	07
04	Nano-bioanalytics: Luminescent Quantum Dots for Biological Labeling, Nanoparticle Molecular Labels Surface Biology: Analysis of Biomolecular Structure by Atomic Force Microscopy and Molecular Pulling-Force Spectroscopy, Biofunctionalized Nanoparticles for Surface Enhanced Raman Scattering and Surface Plasmon Resonance, Bioconjugated Silica Nanoparticles for Bioanalytical Applications	06

05	Nanotechnology in Food, Medicine and Health Sciences: Nanocomposites for food packaging, nanomaterials in cosmetics, Regenerative medicine - Nanostructured collagen mimics in tissue engineering, synthesis of nanodrugs, polymeric nanoparticle for Drug and gene delivery, Micelles for drug delivery, Nanotechnology in cancer research, Preparation of nanobiomaterials-Polymeric scaffolds collagen, Elastins, Mucopolysaccharides, proteoglycans, cellulose and derivates, Dextrans, Alginates, Pectins, Chitin Toxicity and Environmental Risks of Nanomaterial	**09**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Pradeep T., A textbook of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., 2012.
2. Hari Singh Nalwa, Nanostructured Material and Nanotechnology, Academic Press, 2002
3. Niemeyer C. M., Bionanotechnology: Concepts, Application and Perspectives Wiley VCH, 2006

Course Code	Course Name	Credits
ILO7011	Institute Level Optional Subject I- Product Life Cycle Management	03

Objectives:

- To familiarize the students with the need, benefits and components of PLM
- To acquaint students with Product Data Management & PLM strategies
- To give insights into new product development program and guidelines for designing and developing a product
- To familiarize the students with Virtual Product Development

Outcomes:

Learner will be able to…

- Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
- Illustrate various approaches and techniques for designing and developing products.
- Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
- Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Module	Detailed Contents	Contact Hours
01	Introduction to Product Lifecycle Management (PLM):Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications PLM Strategies: Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM.	10
02	Product Design: Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process.	09
03	Product Data Management (PDM):Product and Product Data,	05

	PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation.	
04	Virtual Product Development Tools: For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies.	**05**
05	Integration of Environmental Aspects in Product Design: Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design.	**05**
06	Life Cycle Assessment and Life Cycle Cost Analysis: Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis.	**05**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. Saaksvuori Antti, Immonen Anselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Course Code	Course Name	Credits
ILO7012	Institute Level Optional Subject I- Reliability Engineering	03

Objectives:

- To familiarize the students with various aspects of probability theory
- To acquaint the students with reliability and its concepts
- To introduce the students to methods of estimating the system reliability of simple and complex systems
- To understand the various aspects of Maintainability, Availability and FMEA procedure

Outcomes:

Learner will be able to…

- Understand and apply the concept of Probability to engineering problems
- Apply various reliability concepts to calculate different reliability parameters
- Estimate the system reliability of simple and complex systems
- Carry out a Failure Mode Effect and Criticality Analysis

Module	Detailed Contents	Contact Hours
01	Probability theory: Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. Probability Distributions: Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. Measures of Dispersion: Mean Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	08
02	Reliability Concepts: Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. Reliability Hazard Models: Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	08
03	System Reliability: System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
04	Reliability Improvement: Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	08
05	Maintainability and Availability: System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts	05

	standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	
06	Failure Mode, Effects and Criticality Analysis: Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	**05**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. L.S. Srinath, "Reliability Engineering", Affiliated East-Wast Press (P) Ltd., 1985.
2. Charles E. Ebeling, "Reliability and Maintainability Engineering", Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980.
4. P.D.T. Conor, "Practical Reliability Engg." John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, "Reliability in Engineering Design", John Wiley & Sons.
6. Murray R. Spiegel, "Probability and Statistics", Tata McGraw-Hill Publishing Co. Ltd.

Course Code	Course Name	Credits
ILO7013	Institute Level Optional Subject I- Management Information System	03

Objectives:

- The course is blend of Management and Technical field.
- Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
- Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
- Identify the basic steps in systems development

Outcomes:

Learner will be able to…

- Explain how information systems Transform Business
- Identify the impact information systems have on an organization
- Describe IT infrastructure and its components and its current trends
- Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
- Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Module	Detailed Contents	Contact Hours
01	Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, and Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS.	4
02	Data and Knowledge Management: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	7
03	Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls	7
04	Social Computing (SC): Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
05	Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.	6
06	Information System within Organization: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. Acquiring Information Systems and Applications: Various System development life cycle models.	8

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Kelly Rainer, Brad Prince, Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007.
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

Course Code	Course Name	Credits
ILO7014	Institute Level Optional Subject I- Design of Experiments	03

Objectives:

- To understand the issues and principles of Design of Experiments (DOE)
- To list the guidelines for designing experiments
- To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes:

Learner will be able to…

- Plan data collection, to turn data into information and to make decisions that lead to appropriate action
- Apply the methods taught to real life situations
- Plan, analyze, and interpret the results of experiments

Module	Detailed Contents	Contact Hours
01	Introduction 1.1 Strategy of Experimentation 1.2 Typical Applications of Experimental Design 1.3 Guidelines for Designing Experiments 1.4 Response Surface Methodology	06
02	Fitting Regression Models 2.1 Linear Regression Models 2.2 Estimation of the Parameters in Linear Regression Models 2.3 Hypothesis Testing in Multiple Regression 2.4 Confidence Intervals in Multiple Regression 2.5 Prediction of new response observation 2.6 Regression model diagnostics 2.7 Testing for lack of fit	08
03	Two-Level Factorial Designs and Analysis 3.1 The 22 Design 3.2 The 23 Design 3.3 The General2k Design 3.4 A Single Replicate of the 2k Design 3.5 The Addition of Center Points to the 2k Design, 3.6 Blocking in the 2k Factorial Design 3.7 Split-Plot Designs	07
04	Two-Level Fractional Factorial Designs and Analysis 4.1 The One-Half Fraction of the 2k Design 4.2 The One-Quarter Fraction of the 2k Design 4.3 The General 2k-p Fractional Factorial Design 4.4 Resolution III Designs 4.5 Resolution IV and V Designs 4.6 Fractional Factorial Split-Plot Designs	07
05	Conducting Tests 5.1 Testing Logistics	07

	5.2 Statistical aspects of conducting tests 5.3 Characteristics of good and bad data sets 5.4 Example experiments 5.5 Attribute Vs Variable data sets	
06	Taguchi Approach 6.1 Crossed Array Designs and Signal-to-Noise Ratios 6.2 Analysis Methods 6.3 Robust design examples	**04**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition, John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Practical Experiment Designs for Engineers and Scientists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and D. T. Voss
6. Phillip J Ross, "Taguchi Technique for Quality Engineering," McGraw Hill
7. Madhav S Phadke, " Quality Engineering using Robust Design," Prentice Hall

Course Code	Course Name	Credits
ILO7015	Institute Level Optional Subject I- Operations Research	03

Objectives:

- Formulate a real-world problem as a mathematical programming model.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

Outcomes:

Learner will be able to…

- Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
- Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
- Solve specialized linear programming problems like the transportation and assignment problems; solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
- Understand the applications of integer programming and a queuing model and compute important performance measures

Module	Detailed Contents	Contact Hours
01	Introduction to Operations Research: Introduction, , Structure of the Mathematical Model, Limitations of Operations Research Linear Programming: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, Duality, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis Transportation Problem: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. Assignment Problem: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem Integer Programming Problem: Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to	14

	Decomposition algorithms.	
02	Queuing models: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	**05**
03	Simulation: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	**05**
04	Dynamic programming. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	**05**
05	Game Theory. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	**05**
06	Inventory Models: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	**05**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, Kedar Nath Ram Nath-Meerut.
5. Operations Research, Kanti Swarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Course Code	Course Name	Credits
ILO7016	Institute Level Optional Subject I- Cyber Security and Laws	03

Objectives:

- To understand and identify different types cybercrime and cyber law
- To recognized Indian IT Act 2008 and its latest amendments
- To learn various types of security standards compliances

Outcomes:

Learner will be able to…

- Understand the concept of cybercrime and its effect on outside world
- Interpret and apply IT law in various legal issues
- Distinguish different aspects of cyber law
- Apply Information Security Standards compliance during software design and development

Module	Detailed Contents	Contact Hours
1	Introduction to Cybercrime: Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	4
2	Cyber offenses & Cybercrime: How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	9
3	Tools and Methods Used in Cyberline Phishing, Password Cracking, Keyloggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
4	The Concept of Cyberspace E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law ,The Intellectual Property Aspect in Cyber Law , The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking, The Need for an Indian Cyber Law	8
5	Indian IT Act. Cyber Crime and Criminal Justice: Penalties, Adjudication and	6

	Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments	
6	Information Security Standard compliances SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	**6**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Nina Godbole, Sunit Belapure, Cyber Security, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, Information Systems Security, Wiley India, New Delhi
6. Kennetch J. Knapp, Cyber Security &Global Information Assurance Information Science Publishing.
7. William Stallings, Cryptography and Network Security, Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information , A Compliance Primer for IT professional : https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538

Course Code	Course Name	Credits
ILO7017	Institute Level Optional Subject I- Disaster Management and Mitigation Measures	03

Objectives:

- To understand physics and various types of disaster occurring around the world
- To identify extent and damaging capacity of a disaster
- To study and understand the means of losses and methods to overcome /minimize it.
- To understand role of individual and various organization during and after disaster
- To understand application of GIS in the field of disaster management
- To understand the emergency government response structures before, during and after disaster

Outcomes:

Learner will be able to…

- Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
- Plan of national importance structures based upon the previous history.
- Get acquainted with government policies, acts and various organizational structures associated with an emergency.
- Get to know the simple do's and don'ts in such extreme events and act accordingly.

Module	Detailed Contents	Contact Hours
01	Introduction: Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
02	Natural Disaster and Manmade disasters: Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	09
03	Disaster Management, Policy and Administration: Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with	06

	and how to proceed in due course of time, study of flowchart showing the entire process.	
04	Institutional Framework for Disaster Management in India: Importance of public awareness, Preparation and execution of emergency management programme. Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India. Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	**06**
05	Financing Relief Measures: Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. International relief aid agencies and their role in extreme events.	**09**
06	Preventive and Mitigation Measures: Pre-disaster, during disaster and post-disaster measures in some events in general structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. Do's and don'ts in case of disasters and effective implementation of relief aids.	**06**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. 'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S. Dagur, published by Centre for land warfare studies, New Delhi, 2011.

3. ‘Introduction to International Disaster Management’ by Damon Copolla, Butterworth Heinemann Elseveir Publications.
4. ‘Disaster Management Handbook’ by Jack Pinkowski, CRC Press Taylor and Francis group.
5. ‘Disaster management & rehabilitation’ by Rajdeep, Dasgupta, Mittal Publications, New Delhi.
6. ‘Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications.
8. (Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Course Code	Course Name	Credits
ILO7018	Institute Level Optional Subject I- Energy Audit and Management	03

Objectives:

- To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
- To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
- To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes:

Learner will be able to…

- To identify and describe present state of energy security and its importance.
- To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
- To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
- To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
- To analyze the data collected during performance evaluation and recommend energy saving measures

Module	Detailed Contents	Contact Hours
1	Energy Scenario: Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
2	Energy Audit Principles: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	08
3	Energy Management and Energy Conservation in Electrical System: Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings. Energy efficiency measures in lighting system, Lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers.	10

	Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	
4	Energy Management and Energy Conservation in Thermal Systems: Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	**10**
5	Energy Performance Assessment: On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	**04**
6	Energy conservation in Buildings: Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	**03**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B. Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

Course Code	Course Name	Credits
ILO7019	Institute Level Optional Subject I- Development Engineering	03

Pre-requisite:

- Interest in societal development.

Course Objective:

- To understand the characteristics of rural Society and the Scope and Nature and Constraints of rural Development.
- To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas
- The objective of the course is an exploration of human values, which go into making a 'good' human being, a 'good' professional, a 'good' society and a 'good life'. The context is the work life and the personal life of modern Indian professionals.
- To understand the Nature and Type of Human Values relevant to Planning Institutions.

Course Outcome:

- Students will be able to apply knowledge for Rural Development.
- Students will be able to apply knowledge for Management Issues.
- Students will be able to apply knowledge for Initiatives and Strategies
- Students will be able to develop acumen for higher education and research.
- Students will master the art of working in group of different nature.
- Students will develop confidence to take up rural project activities independently.

Module	Contents	Contact Hours
1	Introduction to Rural Development Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development.	04
2	Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	04
3	Post-Independence rural Development Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people's participation and Panchayati Raj; Ashok Mehta Committee - linkage between Panchayati Raj, participation and rural development.	04
4	Rural Development Initiatives in Five Year Plans Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies;	06

	Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.	
5	Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	**04**
6	Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education.	**04**
7	Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom.	**06**
8	Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	**04**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

Reference

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rdGoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District Planning, 2006, Planning Commission New Delhi
6. Planning Guide to Beginners

7. Weaver, R.C., The Urban Complex, Doubleday.
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington.
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V. , Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory and Practice, Vol. 4, No.4, pp.395 – 407

Course Code	Course Name	Credits
BTP701	Project-A	03

Guidelines:

- Project groups: Students can form groups with not more than 3 (three).
- Students should spend considerable time in applying all the concepts studied, into the Project, hence, eight hours each are allotted in project A and B to the students.
- Students are advised to take up industrial/ experimental/ simulation and/or optimization based topics for their project
- Students should report their guides weekly with their work.

Exam Guidelines

Term Work - 100 Marks:

- Presentation – 50 Marks
- Report -50 Marks

Oral – 50 Marks

Course Code	Course/Subject Name	Credits
BTL701	Lab IV	1.5

Concepts for experiments:

A minimum of 10 experiments must be performed based on the following concepts:

- Viscometer
- Cell disruption
- Conventional filtration
- Distribution coefficient in Liq-liq extraction
- Solid-liquid extraction of natural product and subsequent purification
- Leaching
- Protein precipitation by various methods and its recovery
- Separation of Plant Pigments using Column Chromatography
- Steam Distillation
- Simple Distillation
- Vacuum Filtration
- Extraction of Phytochemicals using different extraction methods

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

Course Code	Course/Subject Name	Credits
BTL702	Lab V	1.5

Concepts for experiments:

A minimum of 10 experiments must be performed based on the following:

- Material Balance without Reaction
- Material Balance with Reaction
- Energy Balance equations
- Solving Linear equations
- Solving Non-linear algebraic equations
- Parameter Estimation in kinetics
- Modelling of Batch, Fed Batch and Continuous
- Simulation of Batch Reactor
- Simulation of Continuous Reactor
- Solving Numerical integrations
- Solving Algebraic equations
- Solving Differential Equations

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

University of Mumbai
Program Structure for B.E. Biotechnology (Revised 2016)
B.E Semester VIII (w.e.f 2019-2020)

Course code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
BTC801	Environmental Biotechnology	4	-	-	4	-	-	4
BTC802	Bioseperation& Downstream Processing technology-II	4	-	-	4	-	-	4
BTC803	Bioprocess Plant & Equipment design	3	-	1	3	-	1	4
BTE804X	Department Elective IV	3	-	1	3	-	1	4
ILO802X	Institute Level optional Subject II	3	-	-	3	-	-	3
BTP801	Project B	-	-	8	-	-	6	6
BTL801	Lab - VI	-	3	-	-	1.5	-	1.5
BTL802	Lab - VII	-	3	-	-	1.5	-	1.5
	Total	17	6	10	17	3	8	28

Course code	Course Name	Examination Scheme								
		Theory					Term Work	Pract/ Oral	Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in hrs)				
		Test 1	Test 2	Avg						
BTC801	Environmental Biotechnology	20	20	20	80	3	-	-	-	100
BTC802	Bioseperation& Downstream Processing technology-II	20	20	20	80	3	-	-	-	100
BTC803	Bioprocess Plant & Equipment design	20	20	20	80	3	25	-	-	125
BTE804X	Department Elective IV	20	20	20	80	3	25	-		125
ILO802X	Institute Level optional Subject II	20	20	20	80	3	-	-	-	100
BTP801	Project B	-	-	-	-	-	100	-	50	150
BTL801	Lab - VI	-	-	-	-	3	-	25	-	25
BTL802	Lab - VII	-	-	-	-	3	-	25	-	25
	Total			100	400	-	150	50	50	750

Department Elective IV (Sem VIII)		
Engineering Stream	Advanced Science Stream	Technology Stream
1. Non-conventional Sources of Energy (BTE8041)	1. Total Quality Management (BTE8042) 2. Entrepreneurship (BTE8043)	1. Advanced Bioinformatics (BTE8044)

Institute Level Optional Subject II (Sem VIII)		
1. Project Management (ILO8021)	4. Human Resource Management (ILO8024)	7. IPR and Patenting (ILO8027)
2. Finance Management (ILO8022)	5. Professional Ethics and CSR (ILO8025)	8. Digital Business Management (ILO8028)
3. Entrepreneurship Development and Management (ILO8023)	6. Research Methodology (ILO8026)	9. Environmental Management (ILO8029)

Course Code	Course/Subject Name	Credits
BTC801	Environmental Biotechnology	4

Pre-requisites:

- Knowledge of Biotechnological aspects and molecular genetics

Course Objectives:

- The main objective of this course is to introduce to the students the current biotechnological approaches and technologies in the use of microbes and/or other organisms and their processes to improve environmental quality, clean up contaminated environment, renew resources and generate valuable products for human society.

Course outcomes:

- Apply their knowledge of environmental science and biological systems to improve the quality of life in individual context.
- Recognize key environmental problems and to apply the operating principles and biotic systems for remediation.
- Design, improve and apply biotechnological systems and processes to meet practical needs of different environmental problems.

Module	Contents	Contact Hours
1	Introduction: Environmental Degradation, types of environmental degradation, factors affecting environmental degradation, Environmental monitoring- sampling (land, air, water), analysis- physical, chemical, biological, pollution monitoring- bio indicators, biosensors, biomarkers, pollution control aspects.	03
2	Pollution control: Atmospheric stability, atmospheric dispersion- (Gausian plume model), air pollution control- Particulate and gaseous control, source correction methods, natural pathways of exchange of air pollutants from atmosphere to earth (wet precipitation- rain out, washout)	06
3	Water Pollution Control: Measurement of organic and inorganic pollutants, DO depletion, modelling of BOD reaction, problems on BOD, Methods of waste water treatment, Microbiology and design (activated sludge process, trickling process), Rotating Biological contactors, Fluidized bed reactors, anaerobic sludge digestion, Methanogenesis, methanogenic, acetogenic, fermentative bacteria- technical process and condition, waste water treatment using aquatic plants, heavy metal removal by hairy roots.	07
4	Soil Pollution Control: Bioremediation of contaminated soil, types of bioremediation, factors affecting bioremediation, phyto fremediation, role of genetic engineering	05

5	Solid waste management: Types of solid waste, sources, effects, methods of collection, disposal methods, potential methods of disposal, disposal of hazardous waste, Biological conversion process (aerobic, anaerobic, bioventing), biotechnology applications to hazardous waste management	**06**
6	Special topics in Bioremediation technology: Nanotechnology for bioremediation of heavy metals, sulphate and sulphur reducing bacteria, bioremediation of petroleum sludge using bacterial consortium and bio surfactants	**04**
7	Downstream Processing: Downstream processing in biological treatment process, effluent disposal and reuse, bio filtration of waste gas, treatment and purification of biogas	**04**
8	Effuent treatment: Need of ETP in industry, Components of ETP, general design procedure for ETP, ETP studies of industries like dairy, metal, food etc.	**05**
9	Environmental Legislations: Water Prevention and Control Pollution Act, Water pollution act, Air pollution and prevention act, The environment Protection Act, Forest Conservation Act, Municipal Solid Waste Rules, Biomedical Waste Rules, Hazardous Wastef Rules, Environmental Clearance, Environmental Legislation and Pollution Control Acts in India, Central Pollution Control Board, its functions and powers, Procedure to operate an industry	**02**
10	Environmental Standards: Need and Use of environmental standards, Agencies and Bodies setting environmental standards, classification of environmental standards, National and International Standards for waste water	**03**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Environmental Biotechnology- Allen Scragg, Oxford University Press, Second edition
2. Environmental Biotechnology, 1995 S.N. Jogdand, Himalaya Publishing

House.
3. Bioremediation, 1994 Barker, K.H. and Herson, D.S., Mcgraw Hill, Inc. New York
4. Waste water Engineering, Metcalf & Eddy, Tata McGraw Hill Publication, Fourth edition
5. Environmental Science, Richard T. Wright, PHI Pvt. Ltd., Ninth edition
6. EnvironmentalPollutionHealthandToxicology,S.V.S.Rana,NarosaPublishing House Pvt.Ltd., First edition

Course Code	Course/Subject Name	Credit
BTC802	Bioseperation and Downstream Processing technology-II	4

Pre-requisites:

- Basics of Bioprocesses and Unit Operations.
- Basic knowledge of mass balance.
- Concepts of molecular diffusion and diffusion coefficients.

Course Objectives:

- To cover the fundamentals, and design concepts of various downstream purification steps (unit operations) involved in a biochemical process.

Course outcomes:

- Students will be able to describe theory, principle, design, application and possible integrations of unit operations in bioprocessing

Module	Contents	Contact Hours
01	Adsorption and Ion Exchange: Introduction to Adsorption, Types of Adsorption, Adsorption Isotherms, Single Stage Adsorption, Multistage Cross Current Adsorption, Multistage Counter Current Adsorption, Equipments for Adsorption, Ion Exchange Equilibria, Ion Exchange Equipments Design and Construction of Chromatographic Columns for Bioseparations	10
02	Membrane Separation Techniques: Membrane separation processes: Reverse Osmosis, Ultrafiltration, Microfiltration, Nanofiltration, Dialysis, Electrodialysis, Gas Permeation, Pervaporation. Types of Membranes, Membrane Modules and design. Retention coefficient, Concentration Polarization, Membrane fouling Factors affecting membrane filtration. Advantages of membrane separation processes over conventional separation techniques, Industrial Applications	08
03	Equipments for Gas-Liquid Contacting applicable for Bioprocesses: Classification of equipments for gas-liquid contacting, Gas dispersed and liquid continuous phase-Sparged Vessels (Bubble Columns), Mechanically Agitated Vessels, Tray Towers, Spray Towers and Spray Chambers, Packed Towers Comparison of Packed Towers with Tray Towers.	06
04	Crystallization: Solubility curve, Super saturation, Method of obtaining supersaturationEffectofheatonsizeandgrowthofcrystal,RateofCrystalgrowth and Delta-L law of crystal growth, Material and energy balance for crystallizers Crystallization equipment-description	08
04	Drying: Introduction to drying, Equilibrium, Different types of moisture contents, Rate of Drying and drying curve, Batch	06

	Drying and calculation of time of drying, types of driers, Lyophilisation, Formulation Mixing and agitation: Principles of agitation, agitation equipment, Solid solid mixing equipment, Mixing effectiveness and Mixing index, Flow patterns in Agitated vessels, Impellers, Types of impellers, power consumption of impellers	
05	Case Studies of downstream processing: Baker's yeast, Ethanol, Citric acid, Penicillin, Insulin, interferon, Monoclonal antibodies, Tissue plasminogen activator, Taq polymerase	**07**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Treybal R.E., Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5Ed. McGraw Hill New York 1993.
3. Geankoplis C.J., Transport processed and unit operations, Prentice Hall, New Delhi 1997.
4. RogerG.Harrison,PaulTodd,ScottR.Rudge,DemetriP.Petrides,Bioseparations Science and Engineering, Oxford University Press
5. B. Shivshankar, Bioseparations: Priniples and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012
6. Bioseparation & bioprocessing (2nd Ed.)2-Volume set, Ed SUBRAMANIAN Ganapathy, Wiley-VCH, (09-2007)
7. P.A. Belter, E.L. Cussler and Wei-ShouHu., Bioseparations- Downstream Processing for Biotechnology, Wiley Interscience Publication, 1988.
8. J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, Inc., 1986.
9. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.
10. Scopes Ak, Protein Purification, IRL Press, 1993
11. Biotechnology: Bioprocessing, Rhem and Reed, Vol.3, 1993
12. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989
13. Asenjo J.A. and J.Hong (Eds), Separation Processes in Biotechnolgy, Taylor and Francis

14. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag
15. Nooralbettu Krishna Prasad, Downstream Process Technology, PHI Learning, Pvt. Ltd., Eastern Economy Edition.

Course Code	Course/Subject Name	Credits
BTC803	Bioprocess Plant & Equipment Design	4

Pre-requisites:

- Process Calculation
- Unit operation I and II

Course Objectives:

- To impart basic concepts of mechanical and process design of process plant.
- To impart design principles for bioreactor.

Course outcomes:

- This course makes the students to learn the methods and practices followed in the design of Bioprocess equipments.
- This course makes the students to draw the designed equipments to scale.
- Thecourseimpartsadvancedknowledgeonbioreactordesignforefficientutilizatio nof the principles in bioprocess technology

Module	Contents	Contact Hours
1	Material of construction for process and bioprocess plants. Mechanical design of process equipment. Design of cylindrical and spherical vessel under internal and external pressure. Selection and design of enclosures- flat plate, formed heads, torispherical and hemispherical heads, standard flanges and nozzles- classification of flanges, flange thickness calculation, gasket selection and design, bolt selection and calculation (Numerical problems are not needed for design of flanges, gasket and nozzles) Design of heat exchange equipments for upstream and downstream operations in bioprocessing industries: Heat exchangers process design (TEMA and IS 4503 standards) of double pipe, single pipe and multipass shell and tube heat exchangers.	06
2	Introduction to Indian Standards for storage tanks and their use in design of process vessel. Storage vessels for volatile andnon-volatile liquids including unfired pressure vessels. Design of supports- Bracket, leg, saddle and skirt support and fixed roof and open roof tanks.	06
3	Introduction to general design information for Bioprocess plants: Development of flowsheet, piping and instrumentation diagram and its description. General design consideration, optimum design	06
4	Design of Distillation column: Detailed design and drawing of perforated plate distillation column. Absorption columns: Detailed design and drawing of perforated plate and packed towers.	06
5	Design of fermenters: Design considerations for maintaining sterility of process streams and process equipments. Design of mechanically	06

	agitated fermenters and non- mechanically agitated (bubble column and air lift) fermenters.	
6	Design of various types of evaporators employed in bioprocess operation: Evaporators-Standard vertical tube evaporator, single and multiple effect evaporators and forced circulation evaporator. Thermal sterilization systems in fermentation processes: batch and continuous thermal sterilizers.	**06**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Sinnott, R.K., Coulson & Richardson's 'Chemical Engineering', Volume 6, 3rd Edn., Butterworth Heinemann, New Delhi, 1999.
2. Perry, R.H., etal., Perry's' Chemical Engineers Handbook',7th Edn., McGraw Hill, New York, 1997.
3. Joshi, M.V., and Mahajani, V.V., "Process Equipment Design", 3rd Edn., Macmillan India Limited, New Delhi, 1996.
4. Bownell, L.E., and Young, E.M., 'Process Equipment Design', Wiley Eastern, 1968.
5. Peters and Timmerhause, 'Plant Design and Economics for Chemical Engineers'
6. S.B.Thakore, B.I.Bhatt, "Introduction to Process Engineering and Design", McGraw Hill Companies
7. Michael L Schuler and Fikret Kargi, 'Bioprocess Engineering' Printice Hall of India Pvt. Ltd.
8. Pauline M Doran, 'Bioprocess Engineering Principles' Academic Press
9. Pressure vessel code-IS Code 2825, B.I.S., New Delhi, 1969
10. Heat Exchanger Design Code IS 4503, B.I.S., New Delhi, 1969
11. Process Equipment Design and Drawing by Kiran Ghadyalji, Nandu publication

Course Code	Course/Subject Name	Credits
BTE8041	Department Elective IV: Non-conventional Sources of Energy	4

Pre-requisites:

- Knowledge of conventional sources of energy and energy utilization.

Course Objectives:

- The main objective of this course is to introduce to the students the current approaches and technologies in the development of non-conventional sources of energy their processes to improve environmental quality and energy requirement, clean and abundant energy, renewable resources and generate cost efficient methods to harness energy for human society.

Course outcomes:

- Apply their knowledge of energy generation and its conservation to improve the quality of life in individual context.
- Recognize key energy problems and to apply the operating principles and biotic systems for remediation.
- Design, improve and apply biotechnological systems and processes to meet practical needs of different problems of energy requirement.

Module	Contents	Contact Hours
01	Introduction: Traditional energy systems: fossil fuel, firewood, coal; Fossil fuel based systems, Impact of fossil fuel based systems; renewable and non-renewable sources of energy; global and national energy crisis, Prospects of renewable energy sources.	03
02	Solar energy: Solar radiation spectrum, radiation measurements, applications (heating, cooling, drying, distillation); flat plate collectors, concentrating collectors, Solar air heaters- types, solar driers, storage of solar energy-thermal storage, solar pond, solar water heaters, solar distillation, solar still, solar cooker, solar heating & cooling of buildings, photovoltaics - solar cells & its applications	08
03	Wind Energy: Principle of wind energy conversion; analysis of aerodynamic forces acting on wind mill blades and estimation of power output; wind patterns and wind data; types of wind mills, components of wind mill, site selection.	03
04	Geothermal energy: Estimation and nature of geothermal energy, geothermal sources and resources: hydrothermal, geo-pressured hot dry rock, magma; Advantages, disadvantages and application of geothermal energy; prospects of geothermal energy in India.	03
05	Energy from the Ocean: Ocean Thermal Electric Conversion (OTEC) systems: open cycle, closed cycle, Hybrid cycle, prospects of OTEC in	05

	India. Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy. Wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy.	
06	Energy from Biomass: Biomass conversion principle: combustion and fermentation; Biogas generation plants: classification, advantages and disadvantages, constructional details, site selection ,digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of bio gas, utilization of biogas. Biodiesel: principle, production, efficiency, scope in India.	**05**
07	Fuel cells: Introduction, Design principle, operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, and application of fuel cells. Microbial Fuel cells: Principle, construction, working, efficiency and scope in India.	**04**
08	Hydrogen energy: Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles. Nuclear energy: nuclear reactors, fission and fusion reactions; advantages and disadvantages of nuclear energy.	**04**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Non-conventional energy sources by G.D. Rai, Khanna Publishers
2. Solar Energy: Fundamentals and Applications by H.P. Garg & Jai Prakash, Tata McGraw Hill

3. Solar Engineering of Thermal Processes by Duc and Beckman, John Wiley
4. Solar Energy: Principles of Thermal Collection and Storage by S,P Sukhatme, Tata McGraw Hill
5. Non-Conventional Energy Resources, B H Khan, Tata McGraw-Hill Education, Jan-2006
6. Non-Conventional Energy Resources by S.Hasan Saeed and D.K.Sharma
7. Fuel Cells by Bockris and Srinivasan; McGraw Hill

Course Code	Course/Subject Name	Credits
BTE8042	Department Elective IV: Total Quality Management	4

Prerequisites:

- Knowledge of Basic Engineering and Science.

Course Objectives:

- To acquaint with the significance and features of TQM philosophy.
- To familiarize with various quality tools and their uses in problem solving.
- To appraise on the modern productivity improvement approaches and their interface with TQM
- To familiarize with various quality standards, quality auditing and certification methodology.
- To give and an insight into the ongoing global trends in quality approach and practices with special forms to the customer relationship

Course Outcomes:

Learner will be able to:

- Appreciate the importance of quality and its dimensions in striving for excellence
- Understand the conscious compromise between cost and quality
- Develop competency in the selection in various manufacturing and service functions
- Develop competency in the use of appropriate quality tools in various manufacturing and service functions
- Integrate quality approaches for productivity improvement.
- Acquire knowledge base and develop skills for conducting quality audits

Module	Contents	Contact Hours
1	Introduction: Definition of Quality, principles and dimensions of TQM Quality in manufacturing and service segments. Approach in implementation of TQM, barriers in implementation. Cost of quality prevention, appraisal and failure costs, hidden costs, trade-o between quality and cost.	8
2	Planning for quality and Quality improvement: Planning for quality: Need for quality policies and objective. Significance of top management commitment, strategic planning for quality. Quality improvement: Management of controllable defects, operator controllable defects, sporadic and chronic problems of operator controllable defects, sporadic and chronic problems of quality, Pareto's principle. Bench marking: Definition and significance, data collection for bench marking and its use.	8
3	Customer relations: Customers, user and consumers, product awareness, types of customers, customer perception and expectations. Quality feedback and redressal. Basic principles of reliability: quality	8

	and reliability, Product life cycle, trade-o between maintainability.	
4	Vendor relations: Vendor as a partner, vendor selection, vendor evaluation. Push Pull view of supply chain and cycle view of chain management	**8**
5	SQC Tool: Histograms, Pie charts, Scatter diagrams, Cause and diagram etc. Statistical Process Control: Process variability: Variables and process variation, measures of accuracy and centering, precision or spread, normal distribution Process Control: Control charts for variables (X-chart, R-chart, -chart) and attributes (np-charts, p-chart, c-charts, U-chart) Process capability: OC curve, acceptance sampling, single and double sampling producer's and consumer's risk.	**8**
6	Quality System: Quality standards: ISO 9001:2000 Quality management system.ˆ ISO 14001:2004 Environmental management system. ISO 27001:2005 Information security management system. Quality assurance: Nature of assurance, reports on quality, measuring performance, internal audit, surveillance audit, quality certification methodology and implications Productivity improvement Tools/ Approaches/ Techniques: Principles of Six-Sigma, approaches like JIT, Lean manufacturing zero defect concept, KANBAN, QFD, FMEA, Basics of DOE and Shining concepts of quality. Productivity improvement techniques like 5S, POKAYOKE, SMED, KAIZEN and Concurrent Engineering.	**8**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to

each module

References

1. Juran, J. M., Gryana, F. M., Quality planning and analysis, TMH.
2. Bester Fidd, D. H., et.al. Total quality management, Prentice Hall.
3. Erossbly, Pillip b., Quality is free, Mentor/New Americal Library.
4. Ishikawa, K., What is total quality control? The Japanese way, Prentice Hall
5. Fergenbaum, Armand V., Total quality control.
6. Logothetis, N., Managing for total quality, Prentice Hall
7. Aurora, K. C., Total Quality Management, S. K. Kataria and Sons
8. Haldar, U. K., Total Quality Management, Dhanpatrai and Co.

Course Code	Course/Subject Name	Credits
BTE8043	Department Elective IV: Entrepreneurship	4

Pre-requisites:

- Basic Knowledge of Engineering Science, Mathematics and Interest towards finance

Course Objectives:

- Meaning and concept of entrepreneurship
- Preparing a Business Plan
- Financing the New Venture
- Managing Growth in New Venture
- skills required to be an entrepreneur

Course outcomes:

- Students will be able to make decision in new venture
- Students will have creativity in Entrepreneurship.
- Students will develop skill for innovation and competition.
- Students learn leadership qualities.

Module	Contents	Contact Hours
1	Introduction to Entrepreneurship: Meaning and concept of entrepreneurship, the history of entrepreneurship development, role of entrepreneurship in economic development, agencies in entrepreneurship management and future of entrepreneurship.	04
2	The Entrepreneur: Meaning of entrepreneur, the skills required to be an entrepreneur, the entrepreneurial decision process, and role models, mentors and support system.	04
3	Business Opportunity Identification: Business ideas, methods of generating ideas, and opportunity recognition	05
4	Preparing a Business Plan: Meaning and significance of a business plan, components of a business plan, and feasibility study	05
5	Financing the New Venture: Importance of new venture financing, types of ownership securities, venture capital, types of debt securities, determining ideal debt-equity mix, and financial institutions and banks	05
6	Launching the New Venture: Choosing the legal form of new venture, protection of intellectual property, and marketing the new venture	04
7	Managing Growth in New Venture: Characteristics of high growth new ventures, strategies for growth, and building the new venture capital	04
8	Harvesting Rewards: Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy	04

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which

are to be given at regular intervals Batch wise.
Tutorials: 20 Marks
Attendance: 05 Marks
Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Entrepreneurship, Hisrich Peters Sphephard, Tata McGraw Hill
2. Fundamentals of entrepreneurship, S.K. Mohanty, Published by PHI Learning, 2010
3. Management and Entrepreneurship, By N. V. R. Naidu, T. Krishna Rao
4. Entrepreneurship in Theory and Practice: Paradoxes in Play by S. L. Nielsen, K. Klyver, M. Rostgaard Evald Published by Edward Elgar Publishing Ltd; 2012

Course Code	Course/Subject Name	Credits
BTE8044	Department Elective IV: Advanced Bioinformatics	4

Pre-requisites:

- Bioinformatics, Knowledge of protein structure.

Course Objectives:

- Study the development and implementation of tools that enables to efficiently access and manage various types of information.
- Study the development of new algorithms (mathematical formulas) and statistics used to assess relationships among members of large data sets. For example, methods to locate a gene within a sequence, predict protein structure and/or function, and cluster protein sequences into families of related sequences.
- The primary goal of bioinformatics is to increase the understanding of biological processes. What sets it apart from other approaches, however, is its focus on developing and applying computationally intensive techniques to achieve this goal.
- Help have a better knowledge of pharmaceutical biology & its relation with information technology.

Course outcomes:

By learning this course the students will be able to:

- Describe the contents and properties of the most important bio informatical databases, perform text-and sequence-based searches, and analyse and discuss the results in light of molecular biological knowledge
- Explain the major steps in pair wise and multiple sequence alignment, explain the principle for, and execute pair wise sequence alignment by dynamic programming
- Explain the major features of evolution of genes and proteins and explain how different methods can be used to construct phylogenetic trees.
- Explainthemajorfeaturesofmethodsformodellingproteinstructuresanduseprogramsfor visualizing and analysing such structures.
- Give examples of methods for describing and analysing genes, genomes and gene expression
- To solve any biological sequence analysis problem, with choosing & modifying suitable computational model to solve it.

Module	Contents	Contact Hours
01	Introduction to concepts of molecular modelling Methods of molecular modelling: Molecular mechanics, Abinitio Quantum mechanics, Semi empirical quantum mechanics. Energy minimization of molecules: local & global energy minima.	10
02	Overview: Machine learning, Genetic algorithms, Simulated annealing Interoperability: Introduction, Its role in bioinformatics. Interexchange Languages: XML, CORBA and UMLS.	08

	Clustering algorithms.	
03	Drug discovery, Markov chains, Hidden markov models.	**06**
04	Drug designing: Drug optimization, Identification of pharmacophore, Optimizing access to target, Prodrugs, Endogenous compounds as drugs, Quantitative structure- activity relationship (QSAR).	**05**
05	Docking: Introduction, Protein protein docking, Protein Ligand docking, Applications of docking.	**06**

Term Work

Term work shall consist of minimum eight tutorials from entire syllabus which are to be given at regular intervals Batch wise.

Tutorials: 20 Marks

Attendance: 05 Marks

Total: 25 Marks

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Cynthia Gibas & Per Jambeck, Developing Bioinformatics computer skills, third edition.
2. S.C. Rastogi, Bioinformatics concepts, skills & applications, first edition.
3. Dov Stekel, Microarray Bioinformatics.
4. David W. Mount, Bioinformatics sequence and genome analysis.
5. N.Claude Cohen, Molecular modeling in drug design.
6. Oreilly, Developing bioinformatics computer skills, Shroff publishers, 1st Indian edition.
7. Medicinal Chemistry by Graham L. Patrick, Oxford University Press

Course Code	Course Name	Credits
ILO8021	Institute Level Optional Subject II- Project Management	03

Objectives:

- To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
- To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Outcomes:

Learner will be able to…

- Apply selection criteria and select an appropriate project from different options.
- Write work break down structure for a project and develop a schedule based on it.
- Identify opportunities and threats to the project and decide an approach to deal with them strategically.
- Use Earned value technique and determine & predict status of the project.
- Capture lessons learned during project phases and document them for future reference

Module	Detailed Contents	Contact Hours
1	Project Management Foundation: Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	5
2	Initiating Projects: How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	6
3	Project Planning and Scheduling: Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS).	8
4	Planning Projects:	6

	Crashing project time, Resource loading and leveling, Goldratt's critical chain, Project Stakeholders and Communication plan. Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	
5	Executing Projects: Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. 5.2 Monitoring and Controlling Projects: Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. 5.3 Project Contracting Project procurement management, contracting and outsourcing,	**8**
6	Project Leadership and Ethics: Introduction to project leadership, ethics in projects. Multicultural and virtual projects. 6.2 Closing the Project: Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	**6**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7thEd.
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9 th Ed.

Course Code	Course Name	Credits
ILO8022	Institute Level Optional Subject II- Finance Management	03

Objectives:

- Overview of Indian financial system, instruments and market
- Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
- Knowledge about sources of finance, capital structure, dividend policy

Outcomes:

Learner will be able to…

- Understand Indian finance system and corporate finance
- Take investment, finance as well as dividend decisions

Module	Detailed Contents	Contact Hours
01	Overview of Indian Financial System: Characteristics, Components and Functions of Financial System. Financial Instruments: Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. Financial Markets: Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market Financial Institutions: Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	06
02	Concepts of Returns and Risks: Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. Time Value of Money: Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	06
03	Overview of Corporate Finance: Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. Financial Ratio Analysis: Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	09
04	Capital Budgeting: Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback	10

	Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) Working Capital Management: Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	
05	Sources of Finance: Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. Capital Structure: Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	**05**
06	Dividend Policy: Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	**03**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Course Code	Course Name	Credits
ILO8023	Institute Level Optional Subject II- Entrepreneurship Development and Management	03

Objectives:

- To acquaint with entrepreneurship and management of business
- Understand Indian environment for entrepreneurship
- Idea of EDP, MSME

Outcomes:

Learner will be able to…

- Understand the concept of business plan and ownerships
- Interpret key regulations and legal aspects of entrepreneurship in India
- Understand government policies for entrepreneurs

Module	Detailed Contents	Contact Hours
01	Overview Of Entrepreneurship: Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	04
02	Business Plans And Importance Of Capital To Entrepreneurship: Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur Entrepreneurship And Business Development: Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	09
03	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
04	Indian Environment for Entrepreneurship: key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	08
05	Effective Management of Business: Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with	08

	large industries), exercises, e-Marketing	
06	Achieving Success In The Small Business: Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	**05**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGraw Hill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. Maddhurima Lall, Shikah Sahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Course Code	Course Name	Credits
ILO8024	Institute Level Optional Subject II- Human Resource Management	03

Objectives:

- To introduce the students with basic concepts, techniques and practices of the human resource management.
- To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations.
- To familiarize the students about the latest developments, trends & different aspects of HRM.
- To acquaint the student with the importance of inter-personal & inter-group behavioural skills in an organizational setting required for future stable engineers, leaders and managers.

Outcomes:

Learner will be able to…

- Understand the concepts, aspects, techniques and practices of the human resource management.
- Understand the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective.
- Gain knowledge about the latest developments and trends in HRM.
- Apply the knowledge of behavioural skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

Module	Detailed Contents	Contact Hours
01	Introduction to HR Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions. Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues.	5
02	Organizational Behaviour (OB) Introduction to OB Origin, Nature and Scope of Organizational Behaviour, Relevance to Organizational Effectiveness and Contemporary issues Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior. Motivation: Theories of Motivation and their Applications for Behavioral Change (Maslow, Herzberg, McGregor); Group Behaviour and Group Dynamics: Work groups formal	7

	and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. Case study	
03	Organizational Structure & Design Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	**6**
04	Human resource Planning Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale. Performance Appraisal Systems: Traditional & modern methods, Performance Counselling, Career Planning. Training & Development: Identification of Training Needs, Training Methods	**5**
05	Emerging Trends in HR Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development , managing processes & transformation in HR. Organizational Change, Culture, Environment Cross Cultural Leadership and Decision Making: Cross Cultural Communication and diversity at work, Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation.	**6**
06	HR & MIS Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries Strategic HRM Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals Labor Laws & Industrial Relations Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	**10**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.

- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Stephen Robbins, Organizational Behaviour, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behaviour, Latest Ed, 2016, Pearson Publications

Course Code	Course Name	Credits
ILO8025	Institute Level Optional Subject II- Professional Ethics and Corporate Social Responsibility (CSR)	03

Objectives:

- To understand professional ethics in business
- To recognized corporate social responsibility

Outcomes:

Learner will be able to…

- Understand rights and duties of business
- Distinguish different aspects of corporate social responsibility
- Demonstrate professional ethics
- Understand legal aspects of corporate social responsibility

Module	Detailed Contents	Contact Hours
01	Professional Ethics and Business: The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
02	Professional Ethics in the Marketplace: Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy Professional Ethics and the Environment: Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
03	Professional Ethics of Consumer Protection: Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy Professional Ethics of Job Discrimination: Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
04	Introduction to Corporate Social Responsibility: Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	05
05	Corporate Social Responsibility: Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP) in India	08
06	Corporate Social Responsibility in Globalizing India: Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi.
4. Corporate Social Responsibility in India (2015) by Bidyut Chakrabarty, Routledge, New Delhi.

Course Code	Course Name	Credits
ILO8026	Institute Level Optional Subject II- Research Methodology	03

Objectives:

- To understand Research and Research Process
- To acquaint students with identifying problems for research and develop research strategies
- To familiarize students with the techniques of data collection, analysis of data and interpretation

Outcomes:

Learner will be able to…

- Prepare a preliminary research design for projects in their subject matter areas
- Accurately collect, analyze and report data
- Present complex data or situations clearly
- Review and analyze research findings

Module	Detailed Contents	Contact Hours
01	Introduction and Basic Research Concepts 1.1 Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology 1.2 Need of Research in Business and Social Sciences 1.3 Objectives of Research 1.4 Issues and Problems in Research 1.5 Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	09
02	Types of Research 2.1. Basic Research 2.2. Applied Research 2.3. Descriptive Research 2.4. Analytical Research 2.5. Empirical Research 2.6 Qualitative and Quantitative Approaches	07
03	Research Design and Sample Design 3.1 Research Design – Meaning, Types and Significance 3.2 Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	07
04	Research Methodology 4.1 Meaning of Research Methodology 4.2. Stages in Scientific Research Process: a. Identification and Selection of Research Problem b. Formulation of Research Problem c. Review of Literature d. Formulation of Hypothesis e. Formulation of research Design	08

	f. Sample Design g. Data Collection h. Data Analysis i. Hypothesis testing and Interpretation of Data j. Preparation of Research Report	
05	Formulating Research Problem 5.1 Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	**04**
06	Outcome of Research 6.1 Preparation of the report on conclusion reached 6.2 Validity Testing & Ethical Issues 6.3 Suggestions and Recommendation	**04**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R., 1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nded), Singapore, Pearson Education

Course Code	Course Name	Credits
ILO8027	Institute Level Optional Subject II- IPR and Patenting	03

Objectives:

- To understand intellectual property rights protection system
- To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
- To get acquaintance with Patent search and patent filing procedure and applications

Outcomes:

- understand Intellectual Property assets
- assist individuals and organizations in capacity building
- work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Module	Detailed Contents	Contact Hours
01	Introduction to Intellectual Property Rights (IPR): Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. Importance of IPR in Modern Global Economic Environment: Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	05
02	Enforcement of Intellectual Property Rights: Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in IPR enforcement Indian Scenario of IPR: Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	07
03	Emerging Issues in IPR: Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	05
04	Basics of Patents: Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	07
05	Patent Rules: Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	08
06	Procedure for Filing a Patent (National and International): Legislation and Salient Features, Patent Search, Drafting and	07

	Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication etc, Time frame and cost, Patent Licensing, Patent Infringement Patent databases: Important websites, Searching international databases	

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield, 2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. Lous Harns, 2012, The enforcement of Intellectual Property Rights: A Case Book, 3rd Edition, WIPO
7. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian, 2012, Intellectual Property Rights, 1st Edition, Excel Books
9. M Ashok Kumar and mohd Iqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial Publications
10. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi, IPR: Drafting, Interpretation of Patent Specifications and Claims, New India Publishing Agency
14. Vivien Irish, 2005, Intellectual Property Rights for Engineers, IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Course Code	Course Name	Credits
ILO8028	Institute Level Optional Subject II - Digital Business Management	03

Objectives:

- To familiarize with digital business concept
- To acquaint with E-commerce
- To give insights into E-business and its strategies

Outcomes:

The learner will be able to …..

- Identify drivers of digital business
- Illustrate various approaches and techniques for E-business and management
- Prepare E-business plan

Module	Detailed content	Contact Hours
1	Introduction to Digital Business- Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts. Difference between physical economy and digital economy. Drivers of digital business- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things (digitally intelligent machines/services). Opportunities and Challenges in Digital Business,	09
2	Overview of E-Commerce E-Commerce- Meaning, Retailing in e-commerce-products and services, consumer behaviour, market research and advertisement. B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals. The E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing. EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC.	06
3	Digital Business Support services: ERP as e –business backbone, knowledge Tope Apps, Information and referral system Application Development: Building Digital business Applications and Infrastructure	06
4	Managing E-Business-Managing Knowledge, Management skills for e-business, Managing Risks in e –business. Security Threats to e-business -Security Overview, Electronic commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security,	06

	Prominent Cryptographic Applications	
5	E-Business Strategy-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition(Process of Digital Transformation)	**04**
6	Materializing e-business: From Idea to Realization-Business plan preparation. Case Studies and presentations	**08**

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules
- Weightage of marks should be proportional to number of hours assigned to each module

References

1. A textbook on E-commerce, Er Arunrajan Mishra, Dr W K Sarwade, Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, Vinocenzo Morabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective - DOI:10.1787/9789264221796-en OECD Publishing

Course Code	Course Name	Credits
ILO8029	Institute Level Optional Subject II- Environmental Management	03

Objectives:

- Understand and identify environmental issues relevant to India and global concerns
- Learn concepts of ecology
- Familiarise environment related legislations

Outcomes:

Learner will be able to…

- Understand the concept of environmental management
- Understand ecosystem and interdependence, food chain etc.
- Understand and interpret environment related legislations

Module	Detailed Contents	Contact Hours
01	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities. Environmental issues relevant to India, Sustainable Development, and The Energy scenario.	10
02	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
03	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
04	Scope of Environment Management, Role & functions of Government as a planning and regulating agency. Environment Quality Management and Corporate Environmental Responsibility	10
05	Total Quality Environmental Management, ISO-14000, EMS certification.	05
06	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

Assessment

Internal

- Assessment consists of two tests which should be conducted at proper intervals.

End Semester theory examination

- Question paper will comprise of 6 questions each carrying 20 questions.
- Total 4 questions need to be solved
- Question no.1 will be compulsory based on entire syllabus wherein sub questions can be asked.
- Remaining questions will be randomly selected from all the modules

- Weightage of marks should be proportional to number of hours assigned to each module

References

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management, T V Ramachandra and Vijay Kulkarni, TERI Press
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Course Code	Course Name	Credits
BTP801	Project-B	06

Guidelines:

- Project groups: Groups of minimum two and not more than three students can be made.
- Students should spend considerable time in applying all the concepts studied, into the Project, hence, eight hours each are allotted in project A, B to the students.
- Students are advised to take up industrial/ experimental/ simulation and/or optimization based topics for their project
- Students should report their guides weekly with their work.

Exam Guidelines

Term Work - 100 Marks:

- Presentation – 50 Marks
- Report -50 Marks

Oral – 50 Marks

Course Code	Course/Subject Name	Credits
BTL801	Lab-VI	1.5

Concepts for experiments:

A minimum of 10 experiments must be performed from the following concept:

1. Physical property like pH, turbidity, conductivity, alkalinity determination of waste water
2. Determination of total phosphorus content of waste water
3. Determination of total Kjeldahl Nitrogen of waste water
4. Determination of BOD of waste water
5. Determination of COD of waste water
6. Determination of Oil and grease content of waste water
7. Determination of total solids, total suspended solids and total dissolved solids
8. Determination of MLSS and MLVSS
9. Determination of Sludge Volume Index
10. Estimation of metals like iron, copper in waste water
11. Determination of chloride content of waste water
12. Estimation of coliform bacteria in waste water
13. Determination of phytoplankton in waste water
14. Determination of Most Probable Number of waste water
15. Removal of heavy metals by chemical methods from waste water Adsorption

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.

Course Code	Course/Subject Name	Credits
BTL802	Lab-VII	1.5

Concepts for experiments:

A minimum of 10 experiments must be performed from the following Concept:

- Adsorption
- Dialysis
- Reverse Osmosis
- Batch drying
- Crystallization
- Isolation and purification of biomolecules (protein/s or enzyme) from crude source / fermentation broth
- Determination of Solar Constants
- Study of Enzyme inhibitors
- Characterization of enzymes / Determination of Molecular weight of enzymes

Practical Examination

- Duration for practical examination would be the same as assigned to the respective lab per week.
- A student becomes eligible for practical examination after completing a minimum of eight out of ten experiments.