University School of Chemical Technology

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY

Sector-16C, Dwarka, New Delhi-78

Date: 29.11.2021

MINUTES OF BOS MEETING

Board of Studies (BOS), USCT meeting was held on 29th November 2021 at 11.00am in online mode to discuss the New Proposed Scheme and Syllabus of M.Tech. (Chemical Engineering) and (Biochemical Engineering) and B.Tech. (Chemical Engineering) and (Biochemical Engineering).

Following members were present:

1.	Prof. A.K. Jain	Dean, USCT, Chairman
2.	Prof. Rajesh Khanna, IIT Delhi	External Member
3.	Prof. T.R. Sreekrishnan, IIT Delhi,	External Member
4.	Prof. Ajay Bansal, NIT, Jalandhar,	External Member
5.	Prof. S.K. Jana, NIT, Jaipur,	External Member
6.	Prof. U.K. Mandal	Member
7.	Prof. Tapan Sarkar	Member
8.	Prof. S.K. Sharma	Member
9.	Prof.Biswajit Sarkar	Member
10.	Prof. Aradhana Srivastava	Member
11.	Prof. Neeru Anand	Member
12.	Dr. Rakesh Angira	Member
13.	Dr. Sanigdha Acharya	Member
14.	Mr. Azad Singh	Member
15.	Dr. Dinesh Kumar	Member
16.	Dr. Vinita Khandegar	Special Invitee

Prof. A.K. Shrivastava, External Member could not attend the meeting due to his prior commitments.

The agenda items were circulated to the BOS members in advance of the meeting. The agenda items were discussed and deliberated upon one by one. The following decisions were made during the meeting:

1. **Scheme and Syllabus of B.Tech/M.Tech. (Chemical Engineering) dual degree:**

   Scheme and syllabus of B.Tech/M.Tech. (Chemical Engineering) dual degree was discussed and approved. The scheme and syllabus is enclosed as A-1 & A-2. These will be implemented from Academic session 2021-22. The M.Tech (Chemical Engineering) Scheme and syllabus as discussed above shall also be applicable for students admitted in academic year for B.Tech/M.Tech (Chemical Engineering) dual degree programme in 2017-18.

2. **Scheme and Syllabus of B.Tech/M.Tech. (Biochemical Engineering) dual degree:**

Scheme and syllabus of B.Tech/M.Tech. (Biochemical Engineering) dual degree was discussed and approved. The scheme and syllabus is enclosed as A-3 & A-4. These will be implemented from Academic session 2021-22. The M.Tech (Biochemical Engineering) Scheme and syllabus as discussed above shall also be applicable for students admitted in academic year for B.Tech/M.Tech (Biochemical Engineering) dual degree programme in 2017-18.

3. **M.Tech. (Chemical Engineering) Regular**

The scheme and Syllabus for M.Tech. (Chemical Engineering), Regular Students shall be same as in agenda item no. 1. This will be applicable for students admitted in the year 2021-22 and onwards.

4. **Minor Degree in Emerging Areas**

Further, Minor degrees in Emerging areas were discussed and it was decided to offer Minor degree along with Major B.Tech. degree in Chemical as well as in Biochemical Engineering. To award Minor degree in Chemical Engineering along with Major disciplines of other USS, few courses of Chemical Engineering have also been identified and approved. The details are annexed as [A-5]. The degree shall be named as B.Tech.(Chemical Engineering) with minor specialization in <name of minor specialization area>. For Biochemical Engineering students, B.Tech.(Biochemical Engineering) with minor specialization in <name of minor specialization area>.

Prof. Arinjay Kumar Jain

E-mail attached
Prof. Rajesh Khanna

Prof. T.R. Sreekrishnan

E-mail attached
Prof. Ajay Bansal

E-mail attached
Prof. S.K. Jana

Prof. U.K. Mandal

Prof. Tapan Sarkar

Prof. S.K. Sharma

Prof. Biswajit Sarkar

Prof. Aradhana Srivastava

Prof. Neeru Anand

Dr. Rakesh Angira

Dr. Sanigdha Acharya

Mr. Azad Singh

Dr. Dinesh Kumar

Dr. Vinita Khandegar

UNIVERSITY SCHOOL OF CHEMICAL TECHNOLOGY
SCHEME OF EXAMINATION
M.TECH. (BIOCHEMICAL ENGINEERING)

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY

Duration – 2 Years (Full time)

Program Scheme and Syllabus

(*9th to 12th semester Dual degree M. Tech in Biochemical Engineering*)

CHOICE BASED CREDIT SYSTEM

Effective from 2021-22

GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY
SECTOR-16C, DWARKA, NEW DELHI-110078

Entrepreneurship | Employability | Skill Development

Approved in the Board of Studies of USCT held on 29th November, 2021

Guru Gobind Singh Indraprastha University

Vision

The University will stimulate both the hearts and minds of scholars, empower them to contribute to the welfare of society at large; train them to adopt themselves to the changing needs of the economy; advocate them for cultural leadership to ensure peace, harmony and prosperity for all.

Mission

Guru Gobind Singh Indraprastha University shall strive hard to provide a market oriented professionaleducation to the student community of India in general and of Delhi in particular, with a view to servingthe cause of higher education as well as to meet the needs of the Indian industries by promoting establishment of colleges and Schools of Studies as Centres of Excellence in emerging areas of education with focus on professional education in disciplines of engineering, technology, medicine, education, pharmacy, nursing, law, etc.

Quality Policy

Guru Gobind Singh Indraprastha University is committed to providing professional education with thrust on creativity, innovation, continuous change and motivating environment for knowledge creation and dissemination through its effective quality management system.‖ Rules & Regulations University administration functions while dealing with various issues of administrative and academic significance, within the provisions of the University Act, rules and regulations (Statutes & Ordinances) framed there under.

University School of Chemical Technology

The University School of Chemical Technology recognizes the importance of chemical industry and the need for trained manpower, since establishment of the University in 1999, THE UNIVERSITY has taken the bold and visionary decision to start the University School of Chemical Technology, the only one of its kind in this part of the country after IIT, DELHI. The founding fathers concerned with education required in chemical industry showed extraordinary vision 100 years ago to recognise that education to provide trained manpower could be provided under two broad areas namely Unit Operations and Unit Processes. This framework still holds although it has evolved, expanded and continuously tuned over the last 10 decades to progressively include thermodynamics, reaction engineering, process control,

process economics, mathematical and numerical methods, computers, process engineering, separation processes, catalysis hazard and safety etc. each one advancing in its own right with extensive research work both in academia and in industry. The School was established with the twin objectives of generating effective trained professionals and to keep pace with the R & D activities of this fast-changing field ofChemical Technology. The B.Tech. and M.Tech (Chemical and Biochemical) programme being offered by the school are based on the pattern of I.I.T.'s and other national and international institutions of repute. The well-structured programmes are meant to impart comprehensive knowledge of various core chemical and biochemical engineering subjects, interdisciplinary courses in Biotechnology, Information Technology, Environment Management, Management Studies through Electives, and industrial exposure through practical training in laboratories and Industrial Units.

Vision

Achieving excellence through active teaching, skill development and research in the areas of chemical and biochemical engineering and allied areas to become a recognized centre for education and research.

Mission

To generate new knowledge by offering graduate and post graduate programmes and provide qualitymanpower with high employment potential in the present liberalised economic climate in the era of globalization.

- To generate new knowledge by offering graduate and post graduate programs.
- Impart quality teaching and train students in addressing the challenges in the Chemical and Biochemical Engineering field and allied areas.
- To provide proficient and knowledgeable manpower, through innovative teaching and hands on experience in state-of-the-art laboratories, of Chemical and Biochemical Engineering.
- Develop inclusive technologies with a focus on sustainability.
- Collaborate with biochemical, food and pharma industries and research organizations to cater community needs.

Master of Technology
(Biochemical Engineering)

The school was established since the foundation of the university in 1999 to a recognized centre for teaching and research in the modern field of Chemical Technology. Considering the dynamicity of science and engineering and very fast changes in process technology today, the school was conceived to start the post graduate course in biochemical engineering in the year of 2013 with the purpose of creating well- trained human recourses to fulfil the growing demands of biochemical industry. The course emphasized to synthesize and evolve bioprocess technology sustainable development and producing trained work force for biochemical research and development.

The school offers 2-years M Tech degree in Biochemical Engineering to our graduating students. The curriculum has been designed to provide education to the students with background of Biochemical Engineering field.

Program Educational Objectives (PEO)

PEO1	Pursue successful industrial/academic/research careers in biochemical engineering and allied fields.
PEO2	Apply the knowledge of advanced topics in biochemical engineering to meet contemporary needs of industry and R &D organizations.
PEO3	Exhibit project management skills with the multifaceted aspects of using computational and databases tools, equipment/ analytical instrument, and ability to work in collaborative environment to justify the needs of multidisciplinary area.
PEO4	To make professionals apply principles of chemical engineering in solving practical problems related to biological sciences, bioenergy, biosafety and environmentsustainability.
PEO5	Pursue self-learning to remain abreast with the latest developments for continuous technical and professional growth.

Programme Outcomes (POs)

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

PO1	Identify, formulate, and solve engineering problems in Biochemical field by applying knowledge of mathematics/biosciences/engineering.
PO2	Apply the state-of-the-art computational and simulation tools for solving problems in biochemical and allied engineering industries.
PO3	Design and conduct experiments, as well as to analyse and interpret data with meaningful results.
PO4	Communicate professionally to express views and to publish technical articles.
PO5	Function as a member of a multidisciplinary team or to lead a technical group.
PO6	Understand professional and ethical responsibility for societal development.
PO7	Work as an independent entrepreneur/consultant.
PO8	Pursue life-long learning, updating knowledge and skills for technical, professional and societal development with learning lessons.

Programme specific outcomes (PSOs)

PSO1	The students will be familiar with the concepts of biochemical engineering to identify, analyse and solve complex biological problems encountered in biochemical and other allied industries, by applying the principles of bioprocess engineering, using modern engineering tools such as ASPEN PLUS, MATLAB, ANSYS, DESIGN-EXPERT, etc., and using information provided in biological datasets.
PSO2	The students will acquire the ability to design and optimize the biochemical process engineering systems, biochemical industrial plants and production considering publichealth, safety and welfare, as well as global, social, environmental and economic aspects.
PSO3	The students will comprehend to play an important role in the diversified area of biochemical engineering (Industries, Academia and R&D) and professional environment, and able to carry out multidisciplinary research in the field of biochemical process engineering, environmental engineering, biocatalysts development and bioreactor design, bio nanotechnology, immunotechnology, biomaterials etc.
PSO4	The students will gain expertise in synthesising the information of recent advancementsin biochemical engineering for conducting research in theoretical development, current issues, and strategic planning.

SCHEME OF EXAMINATION

M.TECH
2-years for Dual Degree in Biochemical Engineering

Credit distribution

	Sem MTech (Biochemical Engineering)for Dual degree in Biochemical Engineering)			
	I (IX)	II (X)	III (XI)	VI (XII)
AC (Audit Course)	-	2	2	-
PC (Programme Core)	20	7	-	-
PP (Programme Practical/Minor Project)	4	4	-	-
OE (Open Electives)	-	3	-	-
PE (Programme Electives)	-	9	3	-
PD(Programme Dissertation)	-	-	12	15
Total	**24**	**25**	**17**	**15**
Sum of all semester	**81**			

Note:
Student must earn minimum 75 credits for the Award of M.Tech. Degree. However, Student has to appear in all the courses as per scheme, and can drop credits from elective courses only.

Marking Scheme of Examination

For Theory
1. Teachers Continuous Evaluation: 25 marks
2. Term end Theory Examinations: 75 marks

For Practical/Viva
1. Teachers Continuous Evaluation: 40 marks
2. End Term Practical/Viva: 60 marks

First semester (or IX Sem Dual degree)

Theory Papers						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
144505	CT-505	Advanced System Engineering	3	1	0	4
204521	CT-531	Advanced Bioreaction Engineering	3	1	0	4
204523	CT-533	Advanced Bioseparation Technology	3	1	0	4
204525	CT-535	Advanced Fermentation Technology	3	1	0	4
204527	CT-537	Advanced Enzyme Engineering	3	1	0	4
Practical/Viva Voce						
14551	CT-551	Advanced Computational Lab	0	0	3	2
204561	CT-561	Advanced Bioprocess Engineering Lab	0	0	3	2
		Total	**15**	**5**	**6**	**24**

Second semester (or X Sem Dual degree)

Theory Papers						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14502	CT-502	Statistical Analysis and Research Methodology	3	1	0	4
14504	CT-504	Analytical Techniques	3	0	0	3
	HVE-102*	Human Values & Ethics	2	0	0	2
Elective Course (opt any **three** from following**)**						
204532	CT-532	Bioinformatics	3	0	0	3
204534	CT-534	Bioprocess Instrumentation and Control	3	0	0	3
204536	CT-536	Metabolic Engineering	3	0	0	3
204538	CT-538	Advanced Environmental Engineering	3	0	0	3
204540	CT-540	Biotransformation and Bioremediation	3	0	0	3
14518	CT-518	Process Plant Utilities	3	0	0	3
14520	CT-520	Biomass for Energy and Chemicals	3	0	0	3
14522	CT-522	Chemical Process Quantitative Risk Analysis	3	0	0	3
Open Electives (opt any **one** from following)						
204542	CT-542	Bioprocess Safety and management in industries	3	0	0	3
		MOOCs (as per list provided by USCT)				
		Open elective course offered at PG level by other USS				
Practical/Viva Voce						
204552	CT-552	Minor Project	0	0	8	4
		Total	**20**	**1**	**8**	**25**

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Third semester (or XI Sem Dual degree)

Theory Papers						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
14601	CT-601*	Stress Management by Yoga	1	0	2	2
Elective Course (opt any **one** from following**)**						
204631	CT-631	Genomics and Proteomics	3	0	0	3
204633	CT-633	Food Engineering and Technology	3	0	0	3
204635	CT-635	Nanobiotechnology	3	0	0	3
204637	CT-637	Application of Membranes in bioprocessing	3	0	0	3
204639	CT-639	Immunotechnology	3	0	0	3
Practical/Viva Voce						
204651	CT-651	Dissertation Part-I	0	0	24	12
		Total	**4**	**0**	**28**	**17**

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Fourth Semester (or XII Sem Dual degree)

Practical/Viva Voce						
Paper ID	**Paper Code**	**Tile**	**L**	**T**	**P**	**Credit**
204652	CT-652	Dissertation Part- II	0	0	30	15
		Total	**0**	**0**	**30**	**15**

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CT-505 Advanced System Engineering	3 L	1 T	0 P	4 Credit

Course Objectives:

1. Introduction to various optimization techniques of linear and non-linear problems to the students.
2. Introduction to various emerging tools e.g., Neural Network in optimizing the problems in process industries.

Course Outcomes:

1. Students would be able to represent physical problem in mathematical terms.
2. Students would be able to optimize chemical process
3. Students would be able to apply neural networks in industrial applications

Course Content:

UNIT 1 **(15 Hrs)**

Introduction to process engineering and optimization, Formulation of various process optimization problems and their classification, Basic concepts of optimization – convex and concave function, necessary and sufficient conditions for stationary points, optimization of one-dimensional problems.

UNIT 2 **(15 Hrs)**

Unconstrained multi variable optimization – direct search methods, indirect first and second order methods; linear programming and its application: Simplex, Big M & Two Phase methods.

UNIT 3 **(16 Hrs)**

Constrained multi level optimization – necessary and sufficient for constrained optimum, quadratic programming (Wolfe's Method and Beale's Method), Generalized Reduced gradient method, optimization of stage and discrete processes, Dynamics Programming, Integer and Mixed Integer Programming (Gomory's algorithm and Branch & Bound technique)

UNIT 4 **(10 Hrs)**

Network: Fundamentals of Neural Network, Back Propagation Network, Simulated annealing. Use of Neural networking in industries, Genetic Algorithm: Fundamentals of genetic algorithm, Genetic Modeling.

Text and Reference Books:

[1] T.F. Edgar and D.M. Himmelblau "Optimization of Chemical Proceses", McGraw Hill International editions.
[2] Rao S S, "Engineering Optimization"
[3] Sharma JK. "Operations Research", Macmillian.
[4] Rajasekaran R. and Vijaylakshmi GA, "Neural Networks, Fuzzy systems and Genetic algorithm", Eastern Economy Edition.
[5] G.S. Beveridge and R.S. Schekhter "Optimization theory and practice, McGraw Hill New York.
[6] James A Anderson, "An Introduction to Neural Networks", Eastern Economy Edition.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	2	1	1	2	2	3
CO2	3	3	2	1	1	2	2	3
CO3	3	3	2	1	1	2	2	3

CT-531 Advanced Bioreaction Engineering	3 L	1 T	0 P	4 Credit

Course Objectives:

1. To familiarize the students with different bioreactor configurations
2. To provide the basic principles of reactor design and their use for bioprocess and biotechnology applications.
3. To enable students learn bioreaction kinetics in different modes of operation of bioreactors.

Course Outcomes: Students should be able to:

1. formulate and solve engineering problems on design and analysisof bioreactors.
2. understand the different reactor types with applications in biochemical processes
3. apply their knowledge in industrial applications
4. Get familiarity with concepts of scale-up/scale-down approaches of bioreactor

Course Content:

UNIT 1 **(15 Hrs)**

Bioreactors for microbial, animal and plant cell culture growth in batch and continuous modes. Design principles, mixing & mass transfer behavior and characterization of plug flow reactor (PFR), Air-lift reactor,tubular reactor etc. Design and applications of non-conventional bioreactors such as membrane reactor,photo-bioreactor, tower reactors.

UNIT 2 **(15 Hrs)**

Kinetic expressions; Review of Monod Growth model and its generalization; Continuous -Stirred tank bioreactor (single and multistage as CSTR in series and CSTR with PFR), continuous reactor with cell recycling, and Fed batch reactor used for bio-processing.

UNIT 3 **(12 Hrs)**

Bioreactors used for immobilized cells and enzymes- Packed bed, Fluidised bed. Specialised bioreactor configurations for waste treatment-Activated sludge treatment, Trickle bed bioreactors and Upflow anaerobic sludge blanket bioreactors

UNIT 4 **(14 Hrs)**

Bioreactor design-basic principles, Mass and Energy balance, Materials of construction for bioprocess plant, mechanical design of process equipment, Utilities for biochemical production plant. Concepts of Scale-up/ Scale-down of bioreactors and Bioprocesses from upstream to downstream with Case studies

Text and Reference Books:

[1] P.F. Stanbury and A. Whitaker; Principle of Fermentation Technology, Pergamon Press, 2005.
[2] J. Bu'lock, B. Kristiansen, Basic Biotechnology, Academic Press.
[3] J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw-Hill Book Co., New York.
[4] Bioprocess Engineering Basic Concepts. 2nd edition.. Prentice Hall, Upper Saddle River, NJ, 2002.
[5] P.M. Doran, Bioprocess Engineering Principles, Academic Press, London, 2012.
[6] T Panda, Bioreactors analysis and design, Tata McGraw Hill, New York, 2011.
[7] S. Aiba, A.E. Humprey, N.F. Millis, Biochemical Engineering, Academic Press, London, 1973.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	2	1	1	2	2	3
CO2	3	3	2	1	1	2	2	3
CO3	3	3	2	1	1	2	2	3
CO4	3	3	2	1	1	2	1	3

CT-533 Advanced Bioseparation Engineering	3 L	1 T	0 P	4 Credit

Course Objectives:

1. To familiarize the students with principlesof different bioseparation processes.
2. To provide the knowledge of purifications of biosynthesized products with industrial applications.
3. To enable students learn step by step downstream techniquesusedafter bioreactor operatrions.
4. To enable students to understand the various calculation procedures for all bioseparation operations
5. To describe overall downstream processing Technology Case studiesfor bioproducts

Course Outcomes: Students should be able to:

1. Identify, formulate and solveengineering problems on separations of bioproducts.
2. Understand the different separation processeshavingbiotechnology applications.
3. Apply their knowledge in downstream of industrial products.

Course Content:

UNIT 1 **(8 Hrs)**

An overview of Industrial biochemical Processes, products produced and their bioseparation, Characteristics of bioseparations, An idealised downstream process. Removal of Insolubles, Thermodynamics of Separation Operations: Phase Equilibria, Liquid Activity-Coefficient Models, Thermodynamic Activity of Biological Species.

UNIT 2 **(15 Hrs)**

Enhanced distillation and supercritical extraction: Use of Triangular Graphs, Extractive distillation, Salt distillation, Pressure –swing distillation, Homogeneous Azeoptropic distillation, Heterogeneous Azeoptropic distillation, Supercritical-fluid extraction.

UNIT 3 **(18 Hrs)**

Solid Phase separation Process: Industrial examples, Sorbents, equilibrium considerations, kinetics and transport considerations, solid phase separation techniques, slurry and fixed bed adsorption system, continuous and counter-current adsorption systems, chromatographic separation, electrophoresis and Isoelectric focussing.

UNIT 4 **(15 Hrs)**

Mechanical separation of phases: Separation-device selection, Industrial particle-separator devices, design of particle separator, design of solid –liquid cake filtration devices based on pressure gradients, centrifuge devices for solid-l iquid separations, wash cycle, mechanical separations in biotechnology.

Case studies on complete downstream Technology for bioproducts such as protein, antibiotic, ethanol etc.,

Text and Reference Books:

[1] P.A. Belter, E.L. Cussler, W.S. Hu, Bioseparations-Downstream processing for biotechnology, Wiley, India, 1988.
[2] Seader J.D. and Henley J.E., Separation Process Principles: Chemical and Biochemical Operation, John Wiley & Sons, 2010.
[3] Douglas M, Ruthven, Principles of adsorption and adsorption process, John Wiley & Sons, 1984,
[4] Juan A. Asenjo, Separation Process in Biotechnology, CRC Press, 1990
[5] Mark McHugh, Val Krukonis, Supercrical fluid extraction: Principles and practice, Elsevier, 2013.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	2	1	1	2	2	3
CO2	3	2	2	1	1	2	2	3
CO3	3	3	2	1	1	2	2	3

CT-535 Advanced Fermentation Technology	3 L	1 T	0 P	4 Credit

Course Objectives:

1. To familiarize the students with production process of different bioproducts.
2. To provide the basic knowledge of purifications of biosynthesized products with industrial applications applications.
3. To enable students learn step by step operation of process for various bioproduct.
4. To enable students to understand the various calculation procedures for production and analysis
5. To describe overall bioprocessing technology case studies

Course Outcomes: Students should be able to:

1. Learn problems on production of bioproducts ia fermentation.
2. Students would be able to understand the different fermentation processes for products having societaluse.
3. Students would be able to apply their knowledge in downstream of industrial products.

Course Content:

UNIT 1 **(10 Hrs)**

Selection of industrially important cultures; Isolation of pure culture & genetic manipulation/improvement of industrial microorganisms with applications, Culture propagation and maintenance.

UNIT 2 **(10 Hrs)**

Process technology for the production of primary metabolites, Baker's yeast, Single Cell Protein, Alcohol, organic acids.

UNIT 3 **(12 Hrs)**

Biosynthesis and fermentative production of antibiotics – penicillin, semi-synthetic penicillin, streptomycin, tetracyclines, chloramphenicol; Microbial production of antifungal antibiotics.

Metabolic regulations in industrial fermentation of bioproducts.

Microbial production of amino acids-lysine, glutamic acid etc.; Microbial transformation of steroids; Microbial production of vitamin-β-carotene, vitamin B12, vitamin B6.

UNIT 4 **(24 Hrs)**

Recombinant DNA Technology for production of protein (insulin), vaccine (hepatitis), monoclonal antibodies (Herceptine).

Bioassay techniques for estimation of antibiotics and vitamins. Application of antibiotics in animal nutrition and food preservation, mycotoxins and microbial insecticides.

Use of microbes in mineral beneficiation; Production of biodegradable polymers, biofertilizers, microbial exopolysaccharides – xanthan gum, gelatine etc.

Text and Reference Books:

[1] Biotechnology, A Text book of Industrial Microbiology, W. Crueger and A. Crueger, Sinauer Association.
[2] Principles of Fermentation Technology, Stanbury, Whitaker and Hall, Aditya Text Pvt. Ltd.
[3] Bioprocess Engineering: basic concepts, Michael L. Shuler and FikretKargi
[4] Bioprocess Engineering, B. K. Lydersen , K.L. Nelson B.K. Lydersen and N.D'Elia, John Wiley and sons Inc.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	2	2	1	1	3	2	3
CO2	3	2	2	1	1	3	2	3
CO3	3	2	2	1	1	3	2	3

CT-537 Advanced Enzyme Engineering	3 L	1 T	0 P	4 Credit

Course Objectives:

1. To familiarize the students with production processes of different bioproducts.
2. To provide knowledge of purifications of biosynthesized enzymes with industrial applications.
3. To get understanding of free and immobilised enzyme kinetics, their mechanism of action and stability.
4. To learn process design and operation strategies for immobilized enzyme reactors and their applications
5. To learn various industrial applications of enzymes.

Course Outcomes: Students would be able to:

1. Students would be able to learn problems on enzyme kinetics.
2. Students would be able to understand the different reactions and their regulation in microbes
3. Students would be able to apply their knowledge in developing industrial productions by enzymes.

Course Content:

UNIT 1 **(6 Hrs)**

Review to "Introduction to Enzyme Engineering and Scope". Regulations, and control of enzyme in microorganisms.

UNIT 2 **(12 Hrs)**

Review to Enzyme kinetics -Single and double substrate systems, Enzyme kinetics -multiple substrate systems, Inhibition kinetics - substrate, product and inhibitors, effect of pH, temperature, Allosteric regulation of enzymes, Deactivation of enzyme kinetics.

UNIT 3 **(18 Hrs)**

Large scale production and purification of enzyme; Cofactors and their role in enzyme activity; Immobilization of enzyme and whole cells, External and diffusional mass transfer limitation, Effectiveness factor and modulus.

UNIT 4 **(20 Hrs)**

Process design and operation strategies for immobilized enzyme reactors; Stabilization of enzyme, synzymes, Immobilization of multiple enzyme system; Application of enzyme - Industrial, Analytical and Medical.

Text and Reference Books:

[1] M.F. Chaplin and C. Bucke, Enzyme Technology, Cambridge University Press.
[2] Enzyme Biochemistry, Biotechnology, Clinical Chemistry, Trevor Palmer.
[3] I.H. Segel, Enzyme Kinetics: Behavior and analysis of rapid Equilibrium and steady state Enzyme Systems, Wiley-Interscience.
[4] R.A. Copeland, Enzyme: A Practical Introduction to structure, Mechanism and data analysis, John Wiley & Sons Inc.
[5] 5.R.C.B. Currell, V.D. Mieras, Biotechnological Innovations in Chemical Synthesis, Biotol Partners staff, Butterworth Heinemann

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	1	1	2	2	3
CO2	3	3	3	1	1	2	2	3
CO3	3	3	3	1	1	2	2	3

CT-551 Advanced Computational Lab	0 L	0 T	3 P	2 Credit

Laboratory Objectives:

To solve problems involving in fluid flow operations, reaction engineering, thermodynamics, mechanicaloperations, heat and mass transfer operation using commercially available software.

Laboratory Outcomes:

1. To solve problem on linear algebraic equation and nonlinear algebraic equation using MATLAB.
2. To solve problem on ordinary differential equation and partial differential equation using MATLAB.

List of problems to be solved:

1. To understand various features, commands, functions, codes etc. used in MATLAB.
2. To solve single variable and multivariable linear algebraic equation, nonlinear algebraic equation usingMATLAB.
3. To solve ordinary differential equation (initial value and boundary value problems) and simultaneous differential equation using MATLAB.
4. To solve partial differential equation using MATLAB.
5. To solve advance problems in chemical indusries involving fluid flow operations, reaction engineering, t hermodynamics, mechanical operations, heat and mass transfer operation etc. using MATLAB.

CT-561 Advanced Bioprocess Engineering Lab	0 L	0 T	3 P	2 Credit

Laboratory Objectives:
To solve problems of bioreactor operations & bioreaction engineering, and bioseparations using the adsorbents and membranes.

Laboratory Outcomes: Students should be able to:

1. Learn the different bioprocesses to produce bioproducts, bioseparations by chromatographic, membranes and adsobents
2. Study the deactivation kinetics of microbes
3. Compute the maximum specific growth rate, growth yield, generation time and maintenance coefficient during fermentation process

List of experiments:

1. Study on protein separation by iron oxide nanoparticles.
2. Study on antibacterial activities of iron oxide nanoparticles against *Escherichia coli*.
3. Study on in-vitro drug release kinetics using cystamine coated of iron oxide nanoparticles.
4. Determination the fermentation profile of a supplied microorganism. Computation of maximum specific growth rate, growth yield, generation time and maintenance coefficient.
5. Determination of thermal death point and Thermal death time of microorganism for design of an autoclave.
6. Comparative studies of ethanol production using different substrates in batch and Continuous culture/ fed batch culture.
7. Determination of MWCO of membrane and estimation of membrane permeability of different MWCO membrane.
8. Separation of protein from aqueous solution using ultrafiltration and prediction of permeate flux.
9. Separation of polysaccharides from aqueous solution using ultrafiltration and prediction of permeate flux. 10. To separate and identify the amino acids in a mixture by thin layer chromatography
11. Adsorption of methylene blue on biomass.
12. Identify and separate the components of a given mixture of carbohydrates by paper chromatography and calculate the RF value for each component. Learning

CT-502 Statistical Analysis and Research Methodology	3 L	1 T	0 P	4 Credit

Course Objective:

To develop an understanding of various experimental designs techniques and research methodologies.

Course outcomes:

At the end of the course, students should be able to:

1. List the different types of formal experimental design techniques.
2. Describe the six factors affecting significance, "p-values" and ANOVA.
3. Understand research problem formulation, literature review and research ethics.

Course content:

UNIT 1 **(15 Hrs)**

Introduction to Statistics: Statistical concept, Statistical Inference, Statistical Hypotheses, Statistical Estimation, Point Estimates, Interval Estimates, Quantitative Data Graphs.

Qualitative Data Graphs, Graphical Depiction of Two-Variable. Numerical Data: Scatter Plots

Graphical methods of model selection from experimental data. Two variable empirical equations. Liner, logarithmic and semi logarithmic plots. Modified linear, logarithmic and semilogarithmic plots. Reciprocal plots. **UNIT 2 (15 Hrs)** Equations for lumped data. Elongated "s" curves. Three variables empirical equations. Sterns methods. Multivariable empirical equations. Dimensionless numbers. Nomography: Introduction. Logarithmic charts. Equations oft he form F1(x)+F2(y)=F3(z), F1(x)+F2(y)=F3(z), 1/ F1(x)+1/F2(y)=1/F3(z) and line coordinate charts.

UNIT 3 **(15 Hrs)**

Statistical Analysis: Tests for Fluctuations in process variables. Test for deviation of the variables from standard conditions. Selection of theoretical model to fit the data.

Descriptive Statistics: Measures of Central Tendency- mean, median and mode, Measures of Variability- Data range, variance and standard deviation, Measures of shape of distribution of data, Tests and estimates on statistical variance.

UNIT 4 **(6 Hrs)**

Design of experiments: Factorial design of experiments. Detection of significant variables in the absence of and in the presence experimental errors. 2k factorial design. Fractional factorial design. Box-Wilson method. Estimation of quantitative significance of the variables. Response surface analysis: Interpretation of results. Reduction of equations to canonic form. Steepest ascent along response surface.

UNIT 5 **(5 Hrs)**

Research Ethics: Research honesty and integrity, Authorship, Acknowledgement and citation, Funding agencies and sponsorship, Sources of data, sensitive materials and safety, Patents and copyright, Confidentiality and privacy, Human rights, Environmental laws, Fabrication of data and misrepresentation,Plagiarism.

Text and Reference Books:

[1] Mokhtar S. Bazara& C.M.Shetty; Non linear Programming, Theory & Algorithums; John Wiley & Sons. 2. Stephan G.N., Ariela Sofer; Linear & nonlinear programming, McGraw Hill.

[2] T.F. Edgar and D.M.Himmelblan " Optimization of Chemical Processes", McGraw Hill International Ed.

[3] G.S.Beveridge and R.S.Schekhter " Optimization theory and practice, McGraw Hill, New York.

[4] G.V. Rekhlaitis, A.Ravindran and K.M. Ragidell "Engineering Optimization Methods & applications, John Wiley, New York.

[5] Stuart Melville and Wayne Goddard, "Research Methodology: an introduction for science & engineering students'".

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	1	1	2	3
CO2	3	3	3	2	1	1	2	3
CO3	3	3	3	2	1	1	2	2

CT-504 Analytical Techniques	3 L	0 T	0 P	3 Credit

Course Objective:
To develop the skills to understand the theory and practice of analytical techniques
To provide scientific understanding of analytical techniques and detail interpretation of results.

Course Outcomes:
Student will understand the fundamentals of various useful analytical techniques.
Students will acquire the basic knowledge/strategies for evaluation/quantification of material properties using those techniques.

Course Content:

UNIT 1 (15 Hrs)
Spectroscopic techniques: Fundamentals of UV-Vis, Atomic Absorption Spectroscopy (AAS) and Fourier- transform Infrared Spectroscopy (FTIR); methods for quantification of various target compounds using these techniques.

UNIT 2 (12 Hrs)
Chromatographic techniques: Fundamentals of Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC); methods for identification of the target compound(s) and/or separation of the target compound from a mixture using chromatographic techniques. GC analysis of liquids and gases

UNIT 3 (15 Hrs)
Surface and particle characterization techniques: Fundamentals of and working principles of Goniometric methods for contact angle measurement and surface characterization; Dynamic Light Scattering (DLS) techniques for particle size and surface charge measurement, and Atomic Force Microscopy (AFM) for surface morphology. BET analysis for surface area and pore diameter, acidity of catalysts and TPR/TPD studies

Text and Reference Books:

[1] Handbook of Spectroscopy, edited by Gunter Gauglitz, Tuan Vo-D, John Wiley, 2003.
[2] Analytical Techniques, edited by T.P. Mommsen, Peter W. Hochachka, Elsavier, 1994
[3] Chromatography: Fundamentals and applications of chromatography and related different migration methods, edited by E. Heftmann, Elsavier, 1994.
[4] Chemical Reaction and Reactor Design edited by J J Carberry & A. Verma; Marcel Dekker Inc, New York and Base.
[5]

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	1	2	2	2	3
CO2	3	3	3	1	2	2	2	3
CO3	3	3	3	1	2	2	2	3
CO4	3	3	3	1	2	2	2	3

HVE-102 Human Values and Ethics*	2 L	0 T	0 P	2 Credit

Course Objective:

1. To develop a universal approach towards human values.
2. To be able to strike a balance between aspirations and happiness.
3. To understand that humans are a part of nature and how being close to nature bring in joy and satisfaction
4. Select classical short stories from Indian context will expose the students.
5. to diverse and multifaceted subsections in Indian society.

Course Outcomes:

1. The students will get sensitized about the role of value education and learn to balance ambition & happiness.
2. The students will be able to understand the importance of living in harmony with nature.
3. The students will be able to see the relevance of Professional behavior and ethics
4. They will draw inspiration from the classical Indian literature narrated to them in the form of select short stories.

Course Contents

UNIT 1 **(6 Hrs)**

The Problem and Paradox of Happiness: Twin goals: happiness and just order; role of value education. Concept of good life-quality of life and subjective well-being; happiness, life satisfaction and positive affect; studying quality of life through surveys; and findings of quality-of-life surveys. Moral and Institutional approaches; and the inherent conflict between the two. Man, and Society.

UNIT 2 **(6 Hrs)**

Happiness and Nature: Biophilia hypothesis- connections with nature and co-existence with other forms of life, Deep Ecology, Importance of meaningful contact with the natural world, solutions for a healthier, greener t omorrow, Indigenous and traditional knowledge system and its intellectual roots.

UNIT 3 **(6 Hrs)**

Basics of Professional Ethics, Ethical Human Conduct: Human Conduct- based on acceptance of basics Human Values, Humanistic Constitution and Universal Human Order-skills, sincerity and fidelity. To identify t he scope and characteristics of people-friendly and eco-friendly production systems.

UNIT 4 **(6 Hrs)**

Encompassing Different Stories/ narratives on Human Values from Indian Context.

Text and Reference Books:

[1] Gaur, R.R., Sangal, S.and Bagaria, G., "A Foundation Course in Human Values and Professional Ethics", New Delhi: Excel Books, 2010.

[2] Mike, W. Martin, "Paradoxes of Happiness", Journal of Happiness Studies, 2008, pp. 171-184.

[3] Giddens, Anthony, "Sociology", 5th edition, Cambridge: Polity Press, 2006.

[4] Ambedkar, B.R., Buddha and his dhamma, http://www.scrubd.com/doc/16634512/Buddha-and-His- Dhamma-by-B-R-Ambedkar-Full [accessed on 21 October, 2010]

[5] Beteille Andre, "Antinomies of Society: Essays on Ideologies & Institutions", New Delhi: Oxford University Press, 2000.

[6] Fikret Berkes, "Sacred Ecology", Second Edition Routledge Taylor & Francis Group, 2008.

[7] Richard Louv, "Last Child in the Woods", Algonquin Books, 2008.

[8] Ramakrishnan, E.V., "Indian Short Stories": (18700-200). Sahitya Akademi, 2012.

[9] Davidar, David., "Cluch of Indian Masterpieces", Aleph Book Company, 2016.

[10] "Contemporary Indian Short Stories", Sahitya Akademi, 2014.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	1	1	2	3	3	3	3	3
CO2	1	1	2	3	3	3	3	3
CO3	1	1	2	3	3	3	3	3

CO4	1	1	2	3	3	3	3	3

CT-534 Bioprocess Instrumentation and Control	**3 L**	**0 T**	**0 P**	**3 Credit**

Course Objective:

1. To develop an understanding of different biosensors and their applications
2. To understand the instrumentation needed for control of physico chemical parameters in bioreactor

Course outcomes: At the end of the course, students should be able to:

1. Understand the operations of biosensors and their applications.
2. Make students learn about digital process control with bioinstrumentation
3. Understand data interpretation and Control in biological process.
4. Learn fundamentals of digital process control and use of computers in controlling and optimization of microbial fermentation processes

Course content:

UNIT 1 **(10 Hrs)**

Biochemical process variables and their measurements; Control principles and their application in bioreactors. On-line, in-line and off-line sensors in Bioreactor.

UNIT 2 **(10 Hrs)**

Physical and chemical parameters in bioreactors,theory of electrode processes and their applications; measurement and control of pH, temperature, dissolved oxygen, aeration and agitation, redox potential, foam, etc

UNIT 3 **(12Hrs)**

Introduction to biosensors; Transduction principles used in biosensors; Characteristics of biosensors; Biosensors based on amperometric, potentiometric, thermistor FET, fiber optics and bioluminescence, Microbial biosensors

UNIT 4 **(10 Hrs)**

Fundamentals of digital process control; Use of computer in control and optimization of microbiological processes. Computer Interfaces and peripheral devices; Data logging, Data analysis, Process control

Text and Reference Books:

[1] J. F. Van Impe, Advanced Instrumentation, Data Interpretation and Control of Biotechnological Processes, Kluwer Academic.
[2] Stanbury, Whitaker and Hall, Principles of Fermentation Technology, Aditya Text Pvt. Ltd.
[3] S. Aiba, A.E. Humphery and N.F. Millis., Biochemical Engineering.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	1	2	2	2	3
CO2	3	3	3	1	2	2	2	3
CO3	3	3	3	1	2	2	2	3
CO4	3	3	3	1	2	2	2	3

CT-632 Bioinformatics	3 L	0 T	0 P	3 Credit

Course Objectives:

To learnbioinformatics tools and their applications.

Course Outcomes:

At the end of the course, students should be able to:

1. Understand methods to locate and extract data from key biological databases and resources
2. Develop understanding of essential features of biological data and Perform sequence alignment and phylogenetic analysis
3. Analyze sequence and the structure of any biomolecule
4. Study three dimensional structure of protein using structural bioinformatics toolin order to determine the protein function from sequence.
5. Use of in silico tools for solving research problem

UNIT 1 **(8 Hrs)**

Introduction to bioinformatics and data generation What is bioinformatics and its relation with molecular biology. Examples of related tools(FASTA, BLAST, BLAT, RASMOL), databases(GENBANK, Pubmed, PDB) and software(RASMOL,Ligand Explorer). Data generation; Generation of large scale molecular biology data. (Through Genome sequencing, Protein sequencing, Gel electrophoresis, NMR Spectroscopy, X-Ray Diffraction, and microarray). Applications of Bioinformatics.

UNIT 2 **(10 Hrs)**

Biological Database and its Types Introduction to data types and Source. Population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (Primary, Composite, and Secondary). Specialized Genome databases: (SGD, TIGR, and ACeDB).
Structure databases (CATH, SCOP, and PDBsum)

UNIT 3 **(8 Hrs)**

Data storage and retrieval and Interoperability Flat files, relational, object oriented databases and controlled vocabularies. File Format (Genbank, DDBJ, FASTA, PDB, SwissProt). Introduction to Metadata and search; Indices, Boolean, Fuzzy, Neighboring search. The challenges of data exchange and integration. Ontologies, interchange languages and standardization efforts. General Introduction to XML, UMLS, CORBA, PYTHON and OMG/LIFESCIENCE.

UNIT 4 **(16 Hrs)**

Sequence Alignments and Visualization Introduction to Sequences, alignments and Dynamic Programming; Local alignment and Global alignment (algorithm and example), Pairwise alignment (BLAST and FASTA Algorithm) and multiple sequence alignment (Clustal W algorithm). Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVISTA), 3D structure viewers (Rasmol, SPDBv, Chime, Cn3D, PyMol), Anatomical visualization.
Gene Expression and and Representation of patterns and relationship General introduction to Gene expression in prokaryotes and eukaryotes, transcription factors binding sites. SNP, EST, STS. Introduction to Regular Expression, Hierarchies, and Graphical models (including Marcov chain and Bayes notes).
Genetic variability and connections to clinical data.

Text and Reference Books

[1] Bioinformatics Sequence and Genome analysis. David W. Mount, Cold spring Harbour laboratory press.
[2] Structural Bioinformatics Edited ByPhilip E. Bourne Helge Weissig, A John Wiley & Sons Publication

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	1	1	2	3
CO2	3	3	3	2	1	1	2	3
CO3	3	3	3	2	1	1	2	3
CO4	3	3	3	2	1	1	2	3

CO5	3	3	3	2	1	1	2	3

CT-536 Metabolic Engineering	**3 L**	**0 T**	**0 P**	**3 Credit**

Course Objective:
To develop an understanding of metabolic networks and metabolic engineering

Course outcomes:
At the end of the course, students should be able to:

1. Understand the cellular metabolism, different models for cellular reactions, metabolic regulatory networks, and metabolic flux analysis.
2. Learn the techniques used for determination of metabolic fluxes involving isotopes labelling
3. Understand the metabolic control analysis using programming tools
4. Learn through case studies of microbial bioproducts like ethanol and amino acids
5. Understand the synthesis and design of metabolic networks for microbes

Course content:

UNIT 1 **(8 Hrs)**
Overview of molecular biology and cellular metabolism, different models for cellular reactions, Metabolic regulation network at enzyme level and whole cell level. Basic concepts of Metabolic Engineering.

UNIT 2 **(10 Hrs)**
Modeling of metabolic networks- stoichiometry, kinetics, mass balance for steady state, mass balance for transient case.

UNIT 3 **(6 Hrs)**
Metabolic flux analysis- linear programming, cell capability analysis, Genome Scale Flux analysis. Methods for experimental determination of metabolic fluxes- isotope labeling.

UNIT 4 **(18 Hrs)**
Metabolic control analysis- nonlinear programming.
Synthesis and design of metabolic networks - integer programming, mixed-integer nonlinear programming. Case studies – ethanol production, amino acid biosynthesis, other metabolisms in bacteria and yeast.

Text and Reference Books:

[1] Metabolic Engineering: Principles and Methodologies. Edited by G. Stephanopoulos, A.A. Aristidou, J. Neilson (1988) Academic Press, San Diego, CA.
[2] Metabolic Engineering Edited by S.Y. Lee & E.T. Papoutsakis (1999) Marcel Dekker, New York, pp.423.
[3] Biochemistry by J.M. Berg, J.L. Tymockzo and LubertStryer (2002) Fifth edition, W.H. Freeman, New York.
[4] Understanding the control of Metabolism by David Fell (1997) Portland Press.
[5] Metabolism at a Glance by J.G. Salway (1994) Blackwell Scientific Publications, Oxford.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	1	1	1	2	3
CO2	3	2	3	1	1	1	2	3
CO3	3	3	3	1	1	1	2	3
CO4	3	3	2	1	1	1	3	3
CO5	3	3	3	1	1	1	3	3

CT-538 Advanced Environmental Engineering	3 L	0 T	0 P	3 Credit

Course Objectives:
To study the Industrial Pollution and the solid waste management

Course outcomes: Students should be able to
1. Learn about pollution caused by industries and how to save environment from water, air, and solid waste pollution.
2. familiarize with waste management and global issues.

Course Content:

UNIT 1 **(5 Hrs)**
Introduction to Water Treatment: National & International Scenario; World-wide Water resources Management; Water quality standards – Drinking water standards; Industrial effluent standards

UNIT 2 **(15 Hrs)**
Physico-Chemical Treatment Technology: Aeration, Ion-exchange, Ozone treatment, adsorption. Chemicalcoagulation-precipitation, settling, flocculation theorems, Chlorination, advanced scheme for municipal water treatment.
Biological Treatment: Basics of biological water treatment, relevant kinetics, biological reactorconfigurations, Activated sludge process, trickling filtration, lagoon treatment, submerged aerators, upward flow sludge blanket reactor, rotating disc biological contactors, advances in biological treatment.

UNIT 3 **(11 Hrs).**
Air Pollution: Environmental threats, Role of Atmosphere in dispersion, Plume behavior, Dispersion problems and Stack Design, Control devices –Cyclone Separators, ESP, Venturi scrubber, gravityseparator, filters, Design Problems, Abatement of gaseous pollutants & VOCs,

UNIT 4 **(11 Hrs)**
Solid Waste analysis and characterization, Hazardous waste Characterization, Environmental legislation for solid and hazardous waste disposal and transport, Risk Assessment, Waste minimization and resource recovery, Waste stabilization, techniques, Chemical, physical and biological treatment Landfill, Sanitary and Hazardous Wastes, Incineration.

Text and Reference Books:
[1] Wastewater Engineering: Treatment And Reuse, Metcalf & Eddy, Inc., George Tchobanoglous, 2017.
[2] Basics of Solid and Hazardous Waste Mgmt. Tech., Kanti L.Shah Prentice Hal, 1999.
[3] Solid and Hazardous Waste Management, S.C. Bhatia Atlantic Publishers & Dist., 2007.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	1	1	2	1	3	2	3
CO2	3	1	1	2	1	3	2	3

CT-540 Biotransformation and Bioremediation	3 L	0 T	0 P	3 Credit

Course Objectives:
To provide a detailed study of Bioremediation/biotransformation

Course outcomes: Students should be able to

1. Understand the operations of biosensors and their applications.
2. Make students learn about digital process control with bioinstrumentation
3. Understand data interpretation and Control in biological process.
4. Learn fundamentals of digital process control and use of computers in controlling and optimization of microbial fermentation processes

Course Content:

UNIT 1 **(5 Hrs)**
Bioremediation/ Biotransformation processes and their developments, Current remediation processes in practices, Benefits of bioremediation

UNIT 2 **(10 Hrs)**
The soil environment, Fate and Transport of contaminants in soils and water bodies

UNIT 3 **(16 Hrs)**
Chemical Transformations, Microbial Ecology and Metabolism, Bioremediation of common chemical compounds, *In-situ* bioremediation process strategies.

UNIT 4 **(11 Hrs)**
Solid phase bioremediation, Slurry phase bioremediation, Vapour phase bioremediation, Natural attenuationwith processes used

Text and Reference Books:

[1] Eweis, Ergas, Chang and Schroeder, Bioremediation Principles, WCB Mc Graw Hill
[2] Alexander M., 1999, Biodegradation and Bioremediation, 2nd edition, Academic Press, USA.
[3] Ajay Sing, O.P. Ward, 20204, Biodegradation and Bioremediation, 2nd edition, Academic Press, USA.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	1	3	2	1	3	3	3
CO2	3	31	3	2	1	3	3	3
CO3	3	31	3	2	1	3	3	3
CO4	3	1	3	2	1	3	3	3

CT-518 Process Plant Utilities	3 L	0 T	0 P	3 Credit

Course Objective:
This course consists of lectures, question and answer sessions designed to educate the student in the process plant utilities in chemical Enginerring.

Course Outcomes: The students will be able to:
1. Exhibit the ability to understand the application of various process plant utilities.
2. Understand the Importance of steam economy and refrigeration systems.
3. Understand the importance of insulation for the process equipment

Course Content:

UNIT 1 **(10 Hrs)**
Various process utilities, their role and importance in chemical plants.
Water sources: sources of water, their characteristics, storage and distribution of water, water for boiler use, cooling purposes, drinking and process water treatment reuse and conservation of water, water resources management.

UNIT 2 **(11 Hrs)**
Steam: Steam generation and its application in chemical process plants, distribution and utilization, design of efficient steam heating systems, steam economy, condensate utilization, steam traps, their characteristics, selection and application, waste heat utilization.
Compressors and Vacuum Pumps: Types of compressors and vacuum pumps and their performance characteristics. Methods of vacuum development and their limitations, materials handling under vacuum, piping systems, lubrication and oil removal in compressors in pumps.

UNIT 3 **(10 Hrs)**
Refrigeration Systems: Refrigeration system and their characteristics, load calculation and load calculation and humidification and de humidification equipment's, drying and cooling tower, air blending, exhaust, ventilation, cryogenics, their characteristics and production of liquid N_2 and O_2

UNIT 4 **(11 Hrs)**
Insulation: Importance of insulation for the process equipment, insulation material and their effect on various materials of equipment piping, fitting and valves, insulation for high, intermediate, low and sub zero temperatures including cryogenic insulation, determination of optimum insulation thickness.
Inert Gases: Introduction, properties of inert gases & their use, sources and methods of generation, comparison of nitro generation routes, general arrangement for inerting system, operational, maintenance and safety aspects.

Text and Reference Books:
[1] Jack Broughton; Process utility systems; Institution of Chem. Engineers U.K.
[2] Reid, Prausnitz poling; The properties of gases & liquids, IV ed. McGraw Hill international ed.
[3] S.C.Arora& S. Domkumdwar; A course in refrigeration and air conditioning; Dhanpat Rai & Co.(P) ltd.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3
CO3	3	3	3	2	2	1	2	2

CT-520 Biomass for Energy and Chemicals	3 L	0 T	0 P	3 Credit

Course Objective:
Study of utilization of biomass to meet energy demand in various sectors.

Course Outcomes:
1. Ability to have a good understanding on fundamentals for the conversion of biomass resources for harnessing and generating bioenergy.
2. Ability to understand various analytical techniques to characterize biomass and products from biomass.
3. Ability to understand the biochemical conversion technologies of biomass into various bio-products.
4. Ability to understand the applications of biomass conversions into biogas, alcohols and other products.

Course Content:

UNIT 1 **(10 Hrs)**

Introduction to biomass, Sources of biomass and Biomass and other solid wastes. Biochemical conversion of biomass into biogas, alcohols and other products

UNIT 2 **(10 Hrs)**

Biomass wastes Compositions, Characteristics, Properties, Structural Components, Production of Biomass and Biomass wastes, Photosynthesis.

UNIT 3 **(10 Hrs)**

Biomass characterization. Solid, liquid and gaseous products from biomass.

UNIT 4 **(12 Hrs)**

Overview of conversion technologies – Pre-processing techniques and separation of components for feed stocks preparation, thermo chemical conversion of biomass. Combustion, pyrolysis and gasification of biomass. Design of gasifier for biomass conversion, Electricity generation and charcoal production from biomass. Useful chemicals and energy from rice husk.

Text and Reference Books:

[1] S.Samir, R.Zaborsky, Biomass Conversion Processes for Energy and Fuels, New York, Plenum Press, 1981.
[2] Nicholas P. Cheremisinoff, Paul N. Cheremisinoff, Fred Ellerbusch, Biomass Application, Technology and Production, Marcel Dekker, inc. NY.
[3] A.V. Bridgwater and D.G.B. Boocock, Developments in Thermochemical Biomass Conversion, , Editors, Vol I &II , Blackie Academic and Professional Publisher, London, ed.1997.
[4] Samir Kumar Khana, Bioenergy and Biofuel from Biowastes and Biomass, ASCE publications, 2010.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	1	3	2	2	3	2	3
CO2	3	2	3	3	3	2	2	3
CO3	3	3	2	2	3	3	3	3
CO4	3	1	2	3	3	3	2	3

CT-522 Chemical Process Quantitative Risk Analysis	3 L	0 T	0 P	3 Credit

Course Objective:

1. To understand various techniques for identifying hazards leading to fire, explosion or toxic release
2. To determine the consequences of an accident including the rate of material release and the physical state of the material.
3. To determine the failure probabilities of components which contribute to the failure of a process usingevent and fault trees.
4. To explain the importance of pressure protection and relief design procedure,

Course Outcomes:

The students will be able to

1. Identify the potential hazards involved in the chemical process industries.
2. Perform consequence analysis of chemical process industries.
3. Determine the potential damage.
4. Determine failure frequencies of the entire system.
5. Estimate Individual risk and societal risk

Course Content:

UNIT 1 **(12 Hrs)**

Techniques of CPQRA: Scope of CPQRA Studies, Application of CPQRA and Limitations of CPQRA Consequence Analysis: Source Models, Explosion & Fires, Effect Models

UNIT 2 **(10 Hrs)**

Dispersion Models: Dispersion and the parameters required to describe dispersion, the neutrally buoyantplume and puff models

Relief Systems Relief design code requirements, Relief types and their characteristics, Relief installationpractices, Chemical Reactivity**:** Reactive Chemical Hazards, Reactive Chemicals Testing and estimating kineticparameters

UNIT 3 **(10 Hrs)**

Event Probability and Failure Frequency Analysis: - Incident Frequencies from Historical Record andFrequency Modeling Techniques including event tree and fault tree.

UNIT 4 **(10 Hrs)**

Measurement, Calculation & Presentation of Risk Estimates: - Risk Measures, Risk Presentation, Risk Calculations, Risk Uncertainty, Sensitivity & Importance.

Text and Reference Books:

[1] Daniel A Crowl, Joseph F. Lovvar, Chemical Process Safety Fundamentals with Applicat.: Prentice Hall
[2] Loss Prevention in Process Industries, Lees, F.P.
[3] Guidelines for Chemical Process Quantitative Risk Analysis, CCPS of AIChE
[4] Risk Analysis for Process Plant, Pipelines & Transport; J.R. Taylor.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3
CO3	3	3	3	2	2	1	2	2
CO4	3	3	3	2	2	1	2	3
CO5	3	3	3	2	2	1	2	2

CT-542 Bioprocess Safety and Management in Industries	3 L	0 T	0 P	3 Credit

Course Objective:

1. To understand various guidelines for process safety in bioprocess mannufacturing.
2. To develop the understanding of biosafety in microbiological and biomedical laboratories.
3. To explain the importance of idetifying bioprocess hazards and emergency response methods forprotection and overall safety awareness.

Course Outcomes: The students will be able to

1. Identify the potential hazards involved in the biochemical process industries.
2. Understand the good mannufacturing practices of biochemical process industries.
3. Develop and document a system for biosafety hazards managements

Course Content:

UNIT 1 **(6 Hrs)**

Introduction, Bioprocess Engineering Information Transfer and Management Practices, Need for Bioprocess Safety and management Systems, Bioprocessing Incidents and Releases, An Overview of BioprocessingIndustries, Historical Developments, Microbiological Advancements, Future Bioprocess Technology Developments, Good Mannufacturing Practice

UNIT 2 **(12 Hrs)**

Genetic Advancements, Food Sciece and Food Process Technology Advancements; Future bioprocess developments and their risk, Bioprocess Lifecycle, Discovery and Development Phase –laboratory and Pilo Plant for scaleup, Upstream and Downstream- Inoculation, seed and Production Biosafety, Containment and Production Risks Fermentation and Cell culture

UNIT 3 **(8 Hrs)**

Use of Biosafety cabinets, fume hoods, laminar flow equipment, Facilities Design, Equipment Design Cleaning Inactivation, maintenance and sterilization; Air and Gas Emission pattern in lab, Disinfection sterilization and decontamination of waste, Product Handling and Product Safety Information; Material Disposal and Disposable Process technology, Risk related to aerosol production.

UNIT 4 **(8 Hrs)**

Develop and Document a system to manage Biosafety hazards, Bioprocess Hazard Information Transportation and shipping of hazardous material, Incidents and Releases, Management Practices and Programs, Management safety models, Biosafety Training for Workforce, A Generic procedure for Initia Bioprocess Incidents and Response Applying Behavior based safety to Bioprocesses

UNIT 5 **(8 Hrs)**

Identifying Bioprocess Hazards, Emergency response procedures, Effects of emerging technology on Bioprocessing Risk Management, Radiation safety awareness, Understanding the reporting system and its importance.

Text and Reference Books:

[1] Guidelines for Process safety in Bioprocess Manufacturing, By CCP S, USA.
[2] Biosafety in Microbiological and Biomedical Laboratories, 2009, 5th Edition, CDC, H H S Publications, USA
[3] Biosafety in the Laboratory: Prudent Practices for Handling and Disposal of Infectious Materials (1989), NRC, National academy press, USA

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3
CO3	3	3	3	2	2	1	2	2

Paper Code: - 552
Subject: Minor Project
For the minor project a supervisor shall be allocated by the school, in the area of interest of the student. The student has to submit a report at the end duly approved by the supervisor for evaluation.

CT-601* Stress Management by Yoga	1 L	0 T	2 P	2 Credit

Course Objective:

1. To achieve overall health of body and mind
2. To overcome stress

Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Course Content:

UNIT 1 **(9 Hrs)**

Definitions of Eight parts of yog. (Ashtanga)

UNIT 2 **(10 Hrs)**

I. Yam and Niyam.
II. Do`s and Don't's in life
III. Ahinsa, satya, astheya, bramhacharya and aparigraha
IV. Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

UNIT 3 **(9 Hrs)**

Asan and Pranayama

I. Various yog poses and their benefits for mind & body **II.** Regularization of breathing techniques and its effects **III.** Types of pranayama

Text and Reference Books:

[1] Janardan Swami Yogabhyasi Mandal, Yogic Asanas for Group Tarining-Part-I Nagpur.
[2] Swami Vivekananda, Advaita Ashrama Rajayoga or conquering the Internal Nature (Publication Department), Kolkata.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	2	2	1	2	3
CO2	3	3	3	2	2	1	2	3

CT-631 Genomics and Proteomics	3 L	0 T	0 P	3 Credit

Course Objective:

To develop a broad understanding of genomics and proteomics

Course outcomes:

At the end of the course, students should be able to:

1. understand different techniques employed in deciphering Genomes,and illustrate how these current genomic technologies can be used in the study gene function
2. make students learn tools necessary to study the proteome
3. understand how -omics approaches are advancing biochemical research and help students to design a set of experiments in order to address biological question

Course Contents

UNIT 1 **(7Hrs)**

Genome and Gene structure: Gene structure, Structural organization of prokaryotic and eukaryotic genome. Genome assembly and annotation.Genome databases. DNA Sequencing methods: Classical, automatic, next generation sequencing. Bioinformatics for the analysis of sequence data.

UNIT 2 **(7Hrs)**

Mapping genomes: Genetic mapping; DNA markers - RFLPs, SSLPs, SNPs. Physical mapping - Restriction mapping, Fluorescent in situ hybridization, Radiation hybrid mapping and Sequence tagged site mapping.Whole Genome sequence techniques and application.Functional genomics, Metagenomics. The humangenome project and the human genetic map. HapMap Project. Human disease genes. Pharmacogenomics **UNIT 3** **(7Hrs)**

Techniques used in Genomics: Restriction digestion, PCR, RT PCR, Real Time PCR, LAMP, DNAMicroarray, Introduction to Genome editing tools: CRISPER, Site directed mutagenesis.

UNIT 4 **(7 Hrs)**

Introduction to proteomics: Amino acids, peptides - Ramachandran plot. Protein structure: Primary andsecondary structural elements, super-secondary structure, domains, mechanism of protein folding. Protein engineering principles

UNIT 5 **(7 Hrs)**

Proteomics: Protein Purification strategies: Affinity Chromatography, Gel filtration, Ion exchange, HPLC/FPLC, GC. Fundamental methods used in proteomics: PAGE/SDS-PAGE, immunoblotting, Isoelectric focussing, Two-dimensional gel electrophoresis (2DGE), ITRAQ, Proteome databases.

Quantitative and Functional proteomics: Mass spectrometry.

Molecular interactions: Protein-Protein interactions, Protein-DNA interactions. Methods to predict molecular interactions: Yeast two hybrid method, Phage-Display method.

UNIT 6 **(7 Hrs)**

Making use of proteome databases of sequence and structure. Introduction to Molecular Docking and Denovo protein design process.

Text and Reference Books:

[1] Brown T. A. 2007, Genomes 3. Garland Science Publishing, New York.
[2] Dunham, I., 2003. Genome Mapping and sequencing. Horizon Scientific.
[3] Lewin B. 2003. Genes VIII. Oxford University Press. Oxford.
[4] Recombinant DNA (Second edition), James D. Watson and Mark Zoller.
[5] The Human Genome 2001, Nature Vol. 409.
[6] Primrose, S. B., and R. M. Twyman . 2006. Principles of gene manipulation and Genomics, Blackwell.
[7] R.M.Twyman, Principles of Proteomics, BIOS Scientific Publishers.
[8] P.Michael Conn, Handbook of Proteomic Method. Humana Press, Totowa, New Jersey, 2003.
[9] Liebler, Daniel Introduction to Proteomics Tools for the New Biology, Springer

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	2	3	2	-1	1	1	1	3
CO2	2	3	2	1	1	1	1	3
CO3	2	3	2	1	1	1	1	3

CT-633 Food Engineering and Technology	3 L	0 T	0 P	3 Credit

Course Objectives:

1. To educate the students to food process engineering skills in multidisciplinary field as a combination of physical and chemical sciences, microbiology, and engineering for food and related agro-industries.
2. To impart knowledge of different unit operations of food industries like size reduction, evaporation,drying, fluid flow and food freezing.
3. To introduce the concept of material and energy balance as applied to food engineering systems

Course Outcomes:Students should be able to:

1. Learnfood process engineering with the technological inputs on mechanical and chemical Engineeringin developing quality food products cost effectively and its processing.
2. Understand the fundamentals of engineeredfood products and the unit operations used in food industries.
3. apply the principles of mass, heat transfer and thermodynamics to analyze and synthesize unit operations in food processing technology, get familiarize with principles of fluid flow and basic unit operation principles of several food processing methods, get understand the basic principles and energy laws related to size reduction, develop ability to make material and energy balances on unit operations and processes, to understand the concept of humidity and usage of psychometric chart, and learn the principles of dehydration and types of dryers employed in food processing sector.

Course Contents:

UNIT 1 **(10 Hrs)**

History of Microorganisms in food, role and significance of microorganisms in foods. Intrinsic and Extrinsic Parameters of Foods that affect microbial growth. Microorganisms in fresh meats and poultry, seafood's, fermented and processed meats and fermented dairy products and other miscellaneous foods. Preservation technologies for fermented products

Starter cultures in cheeses, beer, wine and distilled spirits, SCP, medical foods, probiotics and health benefits, primary & secondary fermentation for improvements, catabolic repression, High gravity brewing, B- glucan problem, getting rid of diacetyl in Beer, wine and distilled spirits.

Detection of Food-borne Organisms. Bioassay and related Methods

UNIT 2 **(12 Hrs)**

Review of basic engineering mathematics; units and dimensions; mass and energy balance. Principles ofFluid Flow - Introduction to stress strain behaviour in materials; properties of fluid viscosity; capillary tube viscometer; power l aw equation for pseudoplastic; newtonian and dilatant fluids; flow in pipes-friction, laminar and turbulent flow equations, considerations in pumping fluid.

Review of Size Reduction-Principles, types of equipments, applications and energy laws, Screening of solids, size measurement and analysis, standard sieves, Membrane Separation Processes. Mixing objectives, equipments for solid, liquid mixing; energy requirements, mixing indices. Rheology of Food Production.

Food freezing - Properties of frozen foods; freezing point depression, general introduction to enthalpy change during freezing, Plank's equation for predicting freezing time; food freezing equipment such as air blast freezers; plate freezers and immersion freezers. Evaporation - Thermodynamics of evaporation; boiling point elevation; heat transfer during evaporation; heat transfer coefficients, design of evaporation system; retention t ime; single effect and multiple effect system; thermo-compression systems.

UNIT 3 **(8 Hrs)**

Psychrometry - Principles, air properties; application in drying of foods. Food dehydration - Basic principles of dehydration; constant rate and falling rate periods of dehydration; equilibrium moisture content; fixed bed dehydration; drum dehydration, and fluidized bed drying; spray drying of liquid foods, different types of dryer and their specific applications in food processing sector.

UNIT 4 **(12 Hrs)**

Food Preservation Using Irradiation, Characteristics of Radiations in Food Preservation and Principles for destruction of Microorganisms, food Processing by Irradiation, and its sApplication, Radappertization, Radicidation, and Radurization of Foods, Legal Status of Food Irradiation

Storage and Stability Food Preservation with Low Temperatures and High Temperatures, Preservation ofFoods by Drying, Food-borne Pathogens and identification methods.

Consumer perspective and future of food process Engineering.

Text and References Books:

[1] Modern Food Micro-Biology by James M. Jay, an Aspen Publication, Maryland, USA.
[2] Food Microbiology: Fundamentals and frontiers by M.P. Doyle, L.R. Beuchat and Thoma J. Montville, ASM press, USA.
[3] Food Science and Food Biotechnology by G.F.G. Lopez & G.V.B. Canovas, CRC Press, Florida, USA.
[4] Food Process Engineering and Technology by Berk Z. 2009. Elsevier.
[5] Food Engineering Operations by Brennan JG, Butters JR, Cowell ND & Lilly AEI. 1990 Elsevier.
[6] Unit Operations in Food Processing by Earle RL. 1985. Pergamon Press.
[7] Food Processing Technology: Principle and Practice by Fellows P. 1988. VCH Publ.
[8] Principles of Food Processing by Heldmen DR &Hartel RW. 1997, Springer
[9] Unit Operations of Chemical Engineering by McCabe WL & Smith JC. 1999, McGraw-Hill.
[10] Unit Operation of Agricultural Processing by Sahay KM & Singh KK. 1994, Vikas Publ. House.
[11] Introduction to Food Engineering by Singh RP & Heldman DR, 1993, Academic Press.
[12] Handbook of Frozen Food Processing and Packaging by Sun Da Wen. 2006,Francis and Taylor, CRC press.
[13] Fundamentals for Food process Engineering by Toledo RT, 2007, Springer.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	1	2	1	1	2	2	3
CO2	3	1	2	1	1	2	2	3
CO3	3	1	2	1	1	3	2	2

CT-635 Nanobiotechnology	3 L	0 T	0 P	3 Credit

Course Objectives:

To provide a detailed study of nanobiotechnology and its applications

Course outcomes: Students should be able to:

1. Learn fundamentals of nanotechnology and its application to biotechnology
2. Familiarize with biomaterials, types of nanomaterials and its applications
3. Understand bio nanostructures, nanotechnology used in different biomedical, clinical and medical uses

Course Content:

UNIT 1 **(7 Hrs)**

Overview and fundamental Principles of Nano biotechnology- History Perspective of Integration of biology, Chemistry, and material science. Opportunities and promises of nano biotechnology. Functional Principles of Nanobiotechnology – Structure and functional properties of Biomaterials bimolecular sensing, Molecular recognition and flexibility of biomaterial.

UNIT 2 **(7 Hrs)**

Protein and DNA based Nanostructures- Protein based nanostructures building blocks and templates-Proteins are transducer and amplifiers of bimolecular recognition events – Nanobioelectronic devices and polymer nanocontainers- Microbial production of inorganic nanoparticles –Magnetosomes. DNA based nanostructure – Topographic and Electrostatic Properties of DNA and Proteins –Hybrid conjugates of Goldnanoparticles-DNA

UNIT 3 **(7 Hrs)**

Nanomaterials used in biotechnology- Nanoparticles, carbon nanotubes, Quantum dots and buckyballs interface with biological macromolecules. Biological perspectives of nano materials - impact of nanomaterials in biological processes tolerance by immune system and toxicity. Nucleic acid Engineering -Modification of DNA for nano- technological applications. Nanostructure assembly using DNA. Large scale nano particle manufacturing and its particle characterization.

UNIT 4 **(7 Hrs)**

Nanotechnology in Biomedical and pharmaceutical industry – Nanoparticles in bone substitute and dentistry and dentistry-Implants – Prosthesis- Reconstructive Intervention and surgery –Nanorobotics in surgery Photodynamic Therapy – Nano sensor in diagnosis – Protein Engineering –Drug delivery – Therapeutic applications.

(7 Hrs)

Nanotechnology in Agriculture and food technology – Insecticide developments using Nanotechnology and nano fertilizers. Nanotechnology in food Processing, food safety and bio security, toxin and contaminant detection, smart packaging. **(7 Hrs)**

Biosensing applications of nano biotechnology – Nano –biosensing –Biosensor and nanobiosensor - basics. Design and types of nano bio sensors. DNA aptamer for Nano biosensing and drug discovery.

Text and Reference Books:

[1] S S R Kumar Challa, Homes Josef, Carola Leushaer, Nanofabrication towards Biomedical Applications, Techniques, Tools, Application and impact, Wiley-VCH, 2005

[2] C M Niemeyer and C A Mirkin (Editor), Nanobitechnology: Concept, Applications and Perspectives, Wiley Press, 2004.

[3] Maheshwar Sharon and Madhuri Sharon, Bionanotechnology, CRC Press, India, 2012.

[4] Jennifer Kuzuma and Peter VerHage, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, 2006.

[5] Neelima, Hmalsch (Ed.), Biomedical Nanotechnology, CRC Press, 2005.

[6] D S Goodsell, Bionanotechnology: Lessons from nature, Wiley Press, 2004.

[7] Mark A. Ratner and Daniel Ratner, Nanotechnology: A Gentle Introduction to a next big idea, Pearson.

[8] S. Klussman, The Aptamer handbook: Functional oligonucleotides and their Applications, Wiley-VCH.

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	23	3	1	1	2	1	3
CO2	3	2	3	1	1	2	1	3
CO3	3	2	3	1	1	2	1	3

CT-637 Application of membranes in Bioprocessing	3 L	0 T	0 P	3 Credit

Course Objective:

1. To provide a general overview of membrane processes, membrane modules, transport modelling, and process engineering fundamentals.
2. To enable students to understand the application of membrane in various process industries such as protein, enzyme, fruit juice, plant extract, dairy, and alcoholic beverages, etc.

Course outcomes:

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

1. Understand the various membrane processes, principles, separation mechanisms, selection criteria and their industrial applications.
2. Understand the various transport models, different types membrane fouling and their control, and the effects of process parameters on system performance.
3. Understand the basic principles and application of affinity ultrafiltration, membrane bioreactor and electric field enhanced ultrafiltration.
4. Know the state-of-the-art and future scope of application of membranes in various processes industries.

Course content:

UNIT 1 **(11 Hrs)**

Membrane processes: Microfiltration, Ultrafiltration, Nanofiltration and Reverse osmosis; Membrane configuration, Criterion of selection of suitable membrane; Membrane fouling and its control; Membrane cleaning and compaction; Concept of integrated membrane process; Process design and energy requirement.

UNIT 2 **(10 Hrs)**

Solute and solvent transport modeling: Pore blocking model, Concentration polarization model, Resistance in series model, Gel layer model, Osmotic pressure model, Combined fouling model etc. Estimation of various fouling resistances.

UNIT 3 **(11 Hrs)**

Affinity ultrafiltration and membrane bioreactor. Electric field enhanced ultrafiltration

UNIT 4 **(10 Hrs)**

Applications: Purification and concentration of protein, enzymes etc.; Dairy processing; Sugar refining; Fruit juice processing; Treatment of plant extract; Alcoholic beverages etc.

Text and References Books:

[1] J.A. Howell, V. Sanches, R.W. Field, Membrane in Bioprocessing: Theory and Applications, Chapman & Hall Inc, London, U.K., 1993

[2] R. Rautenbach and R. Albrecht, Membrane Processes, , John Wiley & Sons Ltd., 1994

[3] Leos J. Zeman and Andrew L. Zydney, Microfiltration and Ultrafiltration; Principles and Applications, Marcel Dekker, 2016

[4] Munir Cheryan, Ultrafiltration and Microfiltration Handbook, CRC Press, 2016

[5] Marcel Mulder, Basic Principle of Membrane Technology, second Edition, Kluwer Academic Publishers, 1996

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	3	3	1	1	2	1	3
CO2	3	3	3	1	1	2	1	3
CO3	3	3	3	1	1	2	1	3
CO4	3	3	3	1	1	2	1	3

CT-639 Immunotechnology	3 L	0 T	0 P	3 Credit

Course Objective:

1. To develop a broad understanding of immune system, its protection mechanism against infections, and malfunction leading to disease.
2. To understand the development of vaccines and immunological therapeutic agents.

Course outcomes:

At the end of the course, students should be able to understand:

1. Immunological processes at cellular and molecular level
2. Components of immune system and its response to microbial infections.
3. Immunological response and regulation
4. To understand development of immunological asssays, immunological products applied in medicalindustry

Course Content:

UNIT 1 **(12 Hrs)**

Phylogeny of immune system. Innate and acquired immune system, components of immune system, Humoral and cell-mediated immunity. Cell types of immune systems.

Antibodies: Immunoglobulin classes & subclasses, antigenic Determinants (isotype, allotype, idiotype). the genetic basis of antibody diversity.

Polyclonal and Monoclonal antibodies, Catalytic antibodies.

Antigen: Structure and properties of antigens, biological aspects of antibody-antigen interaction. Identification and measurement of antibodies and antigens.

Cells and Organs of Immune System: Lymphoid cell, heterogeneity of lymphoid cells, T-Cells, primary and secondary lymphoid organs- thymus, bursa of fabricus, spleen, Lymph nodes, lymphatic system, mucosal associated lymphoid tissue (MALT)

UNIT 2 **(10 Hrs)**

Antigen processing and presentation, activation of B and T lymphocytes, MHC, Cytokines and their role in immune regulation, T cell regulation and MHC restriction, immunological tolerance.

UNIT 3 **(8 Hrs)**

Cell mediated toxicity, Hypersensitivity, Autoimmunity, Tumor immunology, Transplantation immunology,Immunotherapy and Gene therapy.

Acquired Immuno Deficiency Syndrome (AIDS).

Vaccine: Live, attenuated, killed, Subunit Vaccines, Adjuvants. DNA vaccines, Protein based vaccines, Viral vector based vaccines and other new generation vaccines.

UNIT 4 **(12 Hrs)**

Generation of monoclonal antibodies, Hybridoma Technology and its application.

Immunological Techniques: Immunoflorescence, Immuno diffusion, immuno-electrophoresis, ELISA, RIA,Fluorescence activated cell sorter (FACS).

Text and Reference Books:

[1] Immunology by J. Kubey Fence Creek Publishing (Blackwell).
[2] Immunology by Ivan Riott.
[3] Basic immunology, A.K. Abbas and A. H. Lichtman, Saunders W.B. Company.
[4] Immunology, Roitt, Mosby- Yearbook Inc.
[5] Immunology, W.L. Anderson, Fence Creek Publishing (Blackwell).

Course Outcome (CO) to Programme outcomes (PO) Mapping (Scale 1: Low; 2: Medium; 3: High)								
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	1	2	1	1	3	1	3
CO2	3	1	2	1	1	3	1	3
CO3	3	1	2	1	1	3	1	3
CO4	3	1	2	1	1	3	1	3

CT-651 Dissertation Part -I	**0 L**	**0 T**	**24 P**	**12 Credit**

The student is required to work on a research topic related to Biochemical Engineering. Candidate would prepare a detailed report and present (at least twice in a semester) the work before the Internal/external expert committee.

CT-652 Dissertation Part -II	**0 L**	**0 T**	**30 P**	**15 Credit**

The student is required to work on a research topic related to Biochemical Engineering. Candidate would prepare a detailed report and present (at least twice in a semester) the work before the Internal/external expert committee.
