M.Tech. in 'Polymers & Bio Systems Engineering' | 2 Years

Overall Template (Interdisciplinary Program; Initiative by Dept. of Chem. Engg.)

Semester 1 (8+4+2=14 Credits)	
Core Courses	Credit
Physical Biology of Cells - I	1
Systems Biology - I	1
Concepts in Soft Matter Systems	2
Transport in Biological Systems	2
Introduction to Statistical Hypothesis Testing	2
Electives (Any 4 credits)	Credit
Inter-molecular & Surface Science	2
Advanced Fabrionics	2
Basics & Applications of AI/ML for Process Systems Engg.	2
Adsorption & Kinetics	2
English Communication (Mandatory)	1
Industrial Lectures (Mandatory)	1

Semester 2 (6+6=12 credits)	
Core Courses	Credit
Bio-macromolecular Engineering	2
Physical Biology of Cells - II	1
Systems Biology – II	1
Polymeric Biomaterials: Science & Applications	2
Electives (Any 6 credits)	Credit
Molecular Thermodynamics	2
Introduction to Microfluidics and Microreactors	2
Molecular Simulation Techniques	2
Characterization of Polymer & Bio Systems	2
Design of Experiments and data analysis	2
Polymer Processing and Rheology	2

Semester 3 & 4		
Thesis	(12+12)	24 Credits

Overall	
Core Courses	14
Electives	10
Project	24
Other Mandatory Courses	2
Total	50

GATE Papers Eligibility	B.Tech. Eligibility
Chem. Engg.	Chem. Engg.
Mech. Engg.	Mech. Engg.
Mat. Sc.	Mat. Sc.
Biotech	Biotech
Biomed	BioMed. Engg.
Poly. Sci. Eng.	Poly. Si. Engg.
From Industry & Labs (Duration can be relaxed up to 2 years; No GATE requirements) & Self-sponsored	

Faculty:

1. Lopamudra Giri, Dept. of Chemical Engg. (LG)
2. Balaji Iyer, Dept. of Chemical Engg. (BI)
3. Kishalay Mitra, Dept. of Chemical Engg. (KM)
4. Satyabrata Samavedi, Dept. of Chemical Engg. (SS)
5. Chandra Shekhar Sharma, Dept. of Chemical Engg. (CSS)
6. Debaprasad Shee, Dept. of Chemical Engg. (DS)
7. Suhanya Duraiswamy, Dept. of Chemical Engg. (SD)
8. Harish N Dixit, Dept. of Mechanical and Aerospace Engg. (HND)
9. Mudrika Khandelwal, Dept. of Materials Science and Metallurgical Engineering (MK)
10. Ashish Misra, Dept. of Biotechnology (AM)
11. Saptarshi Majumdar, Dept. of Chemical Engg. (SM)

Background:

Development of modern engineering applications in life sciences and allied sectors are increasingly driven by a strong fundamental understanding of complex systems at the interface of polymeric materials and biology. Recent advances in nanoscience and material fabrication approaches, innovations in high-end multimodal characterization tools, developments in computational/systems biology approaches and a significantly enhanced ability to mimic/probe biological responses have all been possible only through scientific collaborations that cut across disciplines. In particular, inter and multidisciplinary research in the areas of soft multifunctional materials and biological systems is expected to play an important role in the development of sustainable new technologies for the healthcare sector and pharmaceutical industries.

Objectives:

We propose an M.Tech program that combines aspects of modern soft materials and biological systems engineering to train students who can creatively and skillfully solve complex engineering problems in the emerging areas of polymer science, nano-formulation and healthcare. Specifically, the proposed M.Tech. program will enable students master key concepts in polymer science, biological soft matter, biomaterials, systems biology, statistical analysis and data science, as well as expose them to several micro and nanotechnology-based fabrication and characterization techniques. Through hands-on projects that can potentially involve collaborations with pharmaceutical industries and hospitals, the program will train students to address challenges arising in the development of new products and engineering processes. With faculty expertise that provides a strong theoretical and well-rounded practical exposure to students, such a program is expected to produce highly skilled personnel with the requisite academic, research and leadership skills to handle technological, economic and social challenges in the healthcare sector. In a nutshell, this is a humble attempt to mingle computational, theoretical, systems and engineering treatments in polymer and biological applications.

Eligibility:

- B.Tech/B.E., in one of the following disciplines: Chemical Engineering, Mechanical Engineering, Materials Science & Engineering, Polymer Science & Engineering, Biomedical Engineering, Biotechnology
- GATE qualification in one or more of the following papers: CH/ME/XE-C/XE-F/BM/BT

Intake: 5 (Regular) for August' 2020 admission.

M.Tech. in 'Polymers & Bio Systems Engineering'	Aug'20 Semester

Semester 1 (8+4+2=14 Credits)		
Number	***Core Courses***	Credit
PB5010	Physical Biology of Cells - I (AM)	1
PB5020	Systems Biology - I (LG)	1
PB5030	Concepts in Soft Matter Systems (BI)	2
PB5040	Transport in Biological Systems (HND)	2
PB5050	Introduction to Statistical Hypothesis Testing (SS)	2
	Electives (Any 4 credits)	Credit
PB5210	Inter-molecular & Surface Science (SM)	2
PB5220	Advanced Fabrionics (CSS, SD)	2
PB5230	Basics & Applications of AI/ML for Process Systems Engg. (KM)	2
PB5240	Adsorption & Kinetics (DS)	2
XXXXXX	English Communication (Mandatory)	1
PB5106	Industrial Lectures (Mandatory)	1

Curriculum:

PB5010: Physical Biology of Cell – I (Dr. Ashish Misra, BT; 1 credit)

Content:

Components of eukaryotic cells and cell function, protein expression, DNA, RNA, ion channels, transcription factors, receptors and other components of signalling pathway, structure of biopolymers.

References

1. P. Atkins and J. D. Paula, Physical Chemistry for the Life Science, second edition, Oxford University Press.
2. P. Atkins and J. D. Paula, Physical Chemistry, Eight edition, Oxford University Press.

PB5020: Systems Biology – I (Dr.Lopamudra. CHE; 1 credit)

Content

Introductory biology, differential equations and probability, system level reasoning for biomolecular pathway and networks, single cell and population-level systems biology, Population-level systems include models of pattern formation and cell-cell communication, programming in python or MATLAB.

References

1. Alon, Uri. *An Introduction to Systems Biology: Design Principles of Biological Circuits*. Chapman & Hall / CRC, 2006. ISBN: 9781584886426.

2. Nowak, M. A. *Evolutionary Dynamics: Exploring the Equations of Life*. Belknap Press, 2006. ISBN: 9780674023383.

PB5030: Concepts in Soft Matter Systems (Dr.Balaji, CHE, 2 credits)

Content:

Introduction to Soft Matter-Polymer, colloids, gels, surfactants and liquid crystals. Soft Matter Solutions – Thermodynamics and Phase transition. Elastic Soft Matter – Networks and Gels. Soft Matter Surfaces – Surface tension, wetting, surfactants, interaction between surfaces, polymer grafted surfaces, self-consistent field theory. Liquid Crystals – structures and phase transitions. Soft Matter Dynamics – introduction to concepts.

References:

1. M. Doi, Soft Matter Physics, Oxford University Press, 2013.
2. L. S. Hirst, Fundamentals of Soft Matter Science, CRC Press 2013.
3. J. N. Israelachvili, Intermolecular and Surface Forces, 3rd Edition, Academic Press, 2011.
4. M. Kleman and O. D. Lavrentovich, Soft Matter Physics: An Introduction, Springer, 2003
5. M. Rubinstein and R. H. Colby, Polymer Physics, Oxford University Press, 2003.
6. P. G. de Gennes, F. Brochard-Wyart, D. Quéré, Capillarity and Wetting Phenomena, Drops, Bubbles, Pearls, Waves. Springer 2002.

PB5040: Transport in Biological Systems (Dr.Harish, MAE; 2 credits)

Contents:

Introduction; Vectors and tensor algebra and calculus; Conservation and Balance Laws; Dimensional analysis, Scaling, Continuity equation; Navier-Stokes equations; Boundary conditions; Constitutive equations; Fundamentals and applications of mass transport - Diffusion with convection, transport in porous media, fluid flow in circulation and tissues; transvascular transport; gas transfer in biological systems; renal modeling; drug transport in cells/tissues

References:

1. G. A. Truskey, F. Yuan, D. F. Katz DF, Transport Phenomena in Biological Systems. 2nd Edition, Prentice Hall, 2009.
2. R. B. Bird, W. E. Stewart, E. N. Lightfoot, Transport Phenomena, 2nd Edition, John Wiley and Sons, 2001.

PB5050: Introduction to Statistical Hypothesis Testing (Dr.Satyabrata, CHE, 2 credits)

Contents:

Basic definitions, Discrete probability distributions, Normal distribution and z-scores, Sampling distribution of the mean, Confidence intervals, Hypothesis testing, Comparison of means (T-testing), Comparison of variances, One-way and Two-way ANOVA

References

1. Principles of Biostatistics, Marcello Pagano and Kimberlee Gauvreau, Second edition, Brooks/Cole Cengage Learning, 2000
2. Design and Analysis of Experiment, R Panneerselvam, First edition, PHI Learning Pvt Ltd, 2012

PB5210: Intermolecular & Surface Sci. (Saptarshi Majumdar, CHE; 2 credits)

Content:
General Aspects, Background Thermodynamics, Strong intermolecular forces, Polar Interactions, Induced Interactions, Definition of van der Waals Forces, Special Interactions: H-bonding, Hydrophobic and Repulsive Interactions, Surfaces, Self-assembly, Ionic forces on particles & surfaces, Forces in Neutral & Ionic Polymers, Biological Applications

References:

1. Intermolecular & Surface Forces, Israelachvili, Academic Press, 3rd Edition, 2011.
2. Molecular Thermodynamics of Fluid Phase Equilibria, Prausnitz, Prentice Hall; 3rd Edition, 1998.
3. Thermodynamic Models for Industrial Applications, Kontogeorgis & Folas, Wiley, 2010.

PB5220: Advanced Fabrionics (Dr.Chandra, CHE & Dr.Suhanya, CHE; 2 credits)

Content:
Microfabrication: Deposition (physical and chemical vapor deposition), etching, photo lithography, soft lithography and 3D printing (Stereolithography, fused deposition moulding). Nanofabrication: Sol-gel, electrospinning, Self-assembly, Directed self-assembly and Surface modification.

Recommended textbooks:
Fundamentals of Microfabrication and Nanotechnology by M. Madou (CRC Press)

Reference Books:

1. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by Guozhong Cao, Imperial College Press 2004.
2. Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Edward L. Wolf, 2 nd Edition, Wiley 2006.

PB5230: Basics & Applications of AI/ML for Process Systems Engg (Dr. Kishalay, CHE; 2 credits)

Content:
Basics of Machine learning, Supervised learning (classification & regression), Unsupervised learning (clustering), Theory and algorithms, Optimization in Machine Learning, Multi-objective optimization, Genetic Algorithms, Artificial Neural Networks, Fuzzy Logic, practical problem solving with examples from optimal control, surrogate optimization, time series modeling.

References

1. Pattern Recognition and Machine Learning, Bishop, Christopher, First edition, Springer, 2006.
2. Multiobjective optimization using Evolutionary Algorithms, Kalyanmoy Deb, First Edition, John Wiley, 2001.

PB5240: Adsorption and Kinetics (Dr.Debaprasad, CHE; 2 credits)

Content:
Introduction to adsorption, Adsorption on surfaces, Thermodynamics and kinetics of surfaces; adsorption and desorption kinetics; Cell adhesion, ligand-receptor interactions and enzyme kinetics, Case studies on biological surface adsorption including internalization of nanoparticle in cells, gene delivery and virus internalization in eukaryotic cells.

References:

1. P.W. Atkins and Julio de Paula, Physical Chemistry, 9th Edition, Oxford University Press, 2009
2. D.A. McQuarrie and J.D. Simon, Physical Chemistry - A Molecular Approach, University Science Books, 1997
3. A.W. Adamson, A.P. Gast, Physical Chemistry of Surfaces, 6th Edition, Wiley 1997.
4. Alexandru Grumezescu, Surface chemistry of nanobiomaterial: application of nanomaterials, 1st edition, Elsevier, 2016
5. Hans Bisswanger, Enzyme Kinetics: Principles and Methods, 3rd edition, Wiley 2016
6. Alejandro G. Marangoni, Enzyme Kinetics: A Modern Approach, Wiley 2002
7. Peter D. Richardson, Principles of cell adhesion, 1st edition, CRC press 2019

PB5106: Industrial Lectures (1 credit)

Content: Few lectures from related industrial experts will be arranged. It will be mandatory for the students to attend those lectures. Later a comprehensive viva &/or seminars will be conducted to evaluate students on their experiences gained from the expert's lectures.