PMB Electives 2023-2024

PMB students take one elective in their second year as part of their coursework. Courses not on the list may be permissible as long as they pertain to your research. Not all courses are offered every year. **The Program Director must approve all electives prior to registration.**

FALL 2023

Engineering

615.671 Applied Physics	Principles of Optics *Edwards, Ohl* This course teaches the student the fundamental principles of geometrical optics, radiometry, vision, and imaging and spectroscopic instruments. It begins with a review of basic, Gaussian optics to prepare the student for advanced concepts. From Gaussian optics, the course leads the students through the principles of paraxial ray-trace analysis to develop a detailed understanding of the properties of an optical system. The causes and techniques for the correction of aberrations are studied. The course covers the design principles of optical Instruments, telescopes, microscopes, etc. The techniques of light measurement are covered in sessions on radiometry and photometry. Prerequisite(s): Undergraduate degree in physics or engineering.	Online
540.630 Chemical & Biomolecular Eng.	Thermodynamics & Statistical Mechanics *Vo, Thi* In this course we will aim for understanding the thermodynamics of chemical and bio-molecular systems. We will first review classical, macroscopic thermodynamics covering concepts such as equilibrium, stability and the role of thermodynamic potentials. Our goal will be to gain a feel for the generality of thermodynamics. Statistical mechanics provides a link between the mechanics of atoms and macroscopic thermodynamics. We will introduce this branch in two distinct ways: 1) following standard methods of developing concepts such as ensembles and partition functions, and 2) where we will treat the basis of statistical mechanics as a problem in inference. With this foundation, we will consider concepts relevant to understanding the liquid state. Chemical transformations in a liquid are of importance in much of chemistry and biology; quasi-chemical generalizations of the potential distribution theorem will be introduced to present these ideas. We hope to give an overview of modern developments relating equilibrium work to non-equilibrium work, as these are of increasing importance in studies on single molecule systems. Course is open to Chemical and Biomolecular Engineering BS/MS Concurrent and MSE students	TTh 3:00-4:15
510.602.01 Materials Science & Eng.	Thermodynamics of Materials *Searson* An introduction to the classical and statistical thermodynamics of materials. Topics include the zeroth law of thermodynamics; the first law (work, internal energy, heat, enthalpy, heat capacity); the second law (heat engines, Carnot cycle, Clausius inequality, entropy, absolute temperature); equilibrium of single component systems (free energy, thermodynamic potentials, virtual variations, chemical potential, phase changes); equilibrium of multicomponent systems and chemical thermodynamics; basics of statistical physics (single and multiple particle partition functions, configurational entropy, third law; statistical thermodynamics of solid solutions); and equilibrium composition-temperature phase diagrams. Recommended Course Background: undergraduate calculus, chemistry, and physics or permission of instructor.	MF 1:30-2:45
510.621.01 Materials Science & Eng.	Biomolecular Materials I – Soluble Proteins and Amphiphiles *Hristova* Structure and function of cellular molecules (lipids, nucleic acids, proteins, and carbohydrates). Structure and function of molecular machines (enzymes for biosynthesis, motors, pumps). Protein synthesis using recombinant nucleic acid methods. Advanced materials development. Interactions of biopolymers, lipid membranes, and their complexes. Mean field theories, fluctuation and correlation effects. Self assembly in biomolecular materials. Biomedical applications. Characterization techniques	MF 1:30-2:45

520.622 Electrical & Computer Engineering	Principles of Complex Networked Systems *Goutsias* By employing fundamental concepts from diverse areas of research, such as statistics, signal processing, biophysics, biochemistry, cell biology, and epidemiology, this course introduces a multidisciplinary and rigorous approach to the modeling and computational analysis of complex interaction networks. Topics to be covered include: overview of complex nonlinear interaction networks and their applications, graph-theoretic representations of network topology and stoichiometry, stochastic modeling of dynamic processes on complex networks and master equations, Langevin, Poisson, Fokker-Plank, and moment closure approximations, exact and approximate Monte Carlo simulation techniques, time-scale separation approaches, deterministic and stochastic sensitivity analysis techniques, network thermodynamics, and reverse engineering approaches for inferring network models from data.	MW 1:30-2:45

Medicine

110.807 **Half credit**	Fundamentals of Fluorescence and Confocal Microscopy *Kuo* Teach fundamental concepts of fluorescence and confocal microscopy so that students can pose appropriate question for meaningful research results. Emphasis on computer-based tools, including ImageJ, Imaris and CellProfiler, for image preparation and analysis with sessions in computer lab almost every week, complementing lectures. Two additional lab days required for operating a generic fluorescence microscope and a confocal microscope, respectively, learning to avoid common errors that preclude quantitative image interpretation and evaluating signal-to-noise effects of confocal settings.	T 2:00-4:00 Aug 29-Nov 14
260.709 **Half credit**	Molecular Biology and Genomics *Coller* This course covers the molecular biology and genomics of both prokaryotes (using E. coli as the model organism) and eukaryotes, with a focus on "model organisms" including yeast, flies, worms, mice as well as humans. Both the molecular biology (reductionist) perspective and the genomics (systems biology) perspective will be provided on each topic, and there will be heavy emphasis on mechanism and regulation of fundamental processes in biological information transfer DNA->RNA->protein. This lecture module will cover genes and genomes, transcription and RNA world, replication, chromosome structure and function and genome instability.	MTThF 9:00-10:30 Oct 31-Dec 8

- **Half-credit Electives** (2 courses = 1 elective requirement)

SPRING 2024 ***(subject to change)***

Arts & Sciences

250.372 Biophysics	Biophysical Chemistry - offered Sp23 *Barrick* Course covers classical and statistical thermodynamics, spanning from simple to complex systems. Major topics include the first and second law, gases, liquids, chemical mixtures and reactions, conformational transitions in peptides and proteins, ligand binding, and allostery. Methods for thermodynamic analysis will be discussed, including calorimetry and spectroscopy. Students will develop and apply different thermodynamic potentials, learn about different types of ensembles and partition functions. Students will learn to use Mathematica and will use it for data fitting and for statistical and mathematical analysis. Background: Calculus, Organic Chemistry, and Introductory Physics.	MWF 9:00-9:50 W 12:00-12:50
030.623 Chemistry	Molecular Synthetic Biology - offered Sp23 *Fried* Principles and methods for the design and optimization of new biological systems, from a molecular perspective. Topics include: introduction to genetic parts and modern methods for their assembly; synthesis and incorporation of nucleic acids at the level of nucleotides, genes, and genomes; design of genetic programs; library generation and screening; directed evolution and its application to create new proteins and	TTh 1:30-2:45

	metabolic pathways; computational design of protein and RNAusing physical and bioinformatic approaches; non-canonical amino acids and genetic code expansion. This course will also feature critical evaluation of the primary literature in this fast-paced field, and practical experience with relevant software and computational tools.	

Engineering

530.410 Mechanical Eng.	Biomechanics of the Cell - offered Sp23 *Sun* Mechanical aspects of the cell are introduced using the concepts in continuum mechanics. Discussion of the role of proteins, membranes and cytoskeleton in cellular function and how to describe them using simple mathematical models.	MWF 3:00-3:50
580.688 Biomedical Eng.	Foundations of Computational Biology & Bioinformatics - offered Sp23 *Karchin* This course will introduce probabilistic modeling and information theory applied to biological sequence analysis, focusing on statistical models of protein families, alignment algorithms, and models of evolution. Topics will include probability theory, score matrices, hidden Markov models, maximum likelihood, expectation maximization and dynamic programming algorithms. Homework assignments will require programming in Python. Recommended Course Background: Math through linear algebra and differential equations, EN.580.221 or equivalent, EN.601.226 or equivalent.	MW 4:30-5:45
540.637 Chemical & Biomolecular Eng.	Application of Molecular Evolution to Biotechnology - offered Sp23 *Ostermeier* One of the most promising strategies for successfully designing complex biomolecular functions is to exploit nature's principles of evolution. This course provides an overview of the basics of molecular evolution as well as its experimental implementation. Current research problems in evolution-based biomolecular engineering will be used to illustrate principles in the design of biomolecules (i.e. protein engineering, RNA/DNA engineering), genetic circuits and complex biological systems including cells	TTh 1:30-2:45
540.614 Chemical & Biomolecular Eng.	Computational Protein Structure Prediction and Design - offered Sp23 *Gray* This class will introduce the fundamental concepts in protein structure, biophysics, optimization and informatics that have enabled the breakthroughs in computational structure prediction and design. Problems covered will include protein folding and docking, design of ligand-binding sites, design of turns and folds, design of protein interfaces. Class will consist of lectures and hands-on computer workshops. Students will learn to use molecular visualization tools and write programs with the PyRosetta protein structure software suite, including a computational project. Programming experience is recommended.	TTh 3:00-4:15

Public Health

140.615 Biostatistics	Statistics for Laboratory Scientists I *Ruczinski* Introduces the basic concepts and methods of statistics with applications in the experimental biological sciences. Demonstrates methods of exploring, organizing, and presenting data, and introduces the fundamentals of probability. Presents the foundations of statistical inference, including the concepts of parameters, estimates, and the use of confidence intervals and hypothesis tests. Includes topics: experimental design, linear regression, the analysis of two-way tables, and sample size and power calculations. Introduces and employs the freely available statistical software, R, to explore and analyze data.	3rd Term (1/22-3/15) MWF 10:30 - 11:20
140.616 Biostatistics	Statistics for Laboratory Scientists II *Ruczinski* (See above)	4th Term (3/25-5/17) MWF 10:30 - 11:20, W 1:30 - 2:20

Medicine

110.728 **Half credit** Cell Biology	Cell Structure and Dynamics - offered Sp23 *Liu* The objective of this course is to provide the basics of cell biology, including the structure, function and biogenesis of cellular organelles. Also covered are essential concepts on the cytoskeleton, cell-cell and cell-extracellular matrix interactions, cell motility, chaperones, protein turnover and stem cells.	MTThF 9:00-10:30 Jan 19-Feb 16
360.728 **Half credit**	Pathways & Regulation - offered Sp23 *Kralli, Qiu* This course will cover the principles of membrane transport, bioenergetics, metabolic pathways, cell cycle and cell death with particular emphasis on regulatory mechanisms including receptor-mediated signaling, small GTPases, lipid molecules, kinases and phosphatases.	MTThF 9:00-10:30 Feb 17-Mar 17

Previously Approved Courses - Discontinued

100.706 **Full credit** alternating years with 100.707	Fundamentals of Protein Crystallography *Amzel* An introductory course designed to present the core knowledge and theoretical underpinnings of protein crystallography necessary to function in the laboratory. Assigned readings and problem sets will be given.	**Discontinued** Last Offered - Sp18
100.707 **Full credit** alternating years with 100.706	Advanced Topics in Protein Crystallography *Staff* This course is taught in a journal club format examining standard advanced topics in crystallography as well as aspects of current literature. Topics may include: refinement, approaches to the phase problem, fourier transform methods, etc.	**Discontinued** Last Offered - Sp20
330.710 **Half credit**	Mechanisms in Bioorganic Chemistry* *Freel Meyers* This course deals with the mechanisms of action of enzymes, and is intended to introduce some of the basic principle of catalysis and illustrate how our knowledge of organic reaction mechanisms can help in interpreting enzyme-catalyzed processes.	**Discontinued** Last Offered - Unknown