**LECTURE-BASED COURSES**

**Materials Courses**

***MBSE/BEST 204: Materials Kinetics and Processing*** focuses on the application kinetic principles to the study of mass transport processes, transformations, and reactions. Thermal activation and rates of processes; nucleation and growth; phase transformations; control of micro- and nano-structure. Case studies relevant to the processing of metals, polymers, ceramics, and nanomaterials are also covered.

***MBSE/BEST 210: Structure and Property of* *Materials*** Topics include the structure and bonding of materials and their relationship to the mechanical, thermal, electrical, optical, and magnetic properties of materials within the context of structure-properties-processing performance relationships. Non- and quasi-crystalline materials and the role of defects are included, as well as, processing and device applications.

***MBSE/BEST 214: Tissue Engineering and Design*** Fundamental topics include: issues related to the cell source (including stem cells, plasticity, transdifferentiation, therapeutic cloning vs. reproductive cloning, bone marrow transplants, and cell differentiation and purification), cell culture and tissue organization, gene therapy delivery methods, cell adhesion and migration, issues in construct design, tissue preservation, and immunoisolation and/or modulation. We also cover current case studies and issues for FDA approval of tissue engineered products.

***MBSE/BEST 217: Lab on a Chip*** This course aims to 1) raise awareness and knowledge about global health issues 2) teach students critical engineering skills such as nano/micro-fabrication 3) enable students to design, build, and test their own diagnostics and 4) develop entrepreneurial skills.

***MBSE/BEST 224 Polymeric Materials*** Relationships between molecular characteristics, thermodynamics, kinetics, microstructure and properties in the context of polymeric materials. Students will apply their knowledge of physics, chemistry, mathematics and biology to develop a proficient understanding of how structure and processing affect the properties and performance of biological and synthetic polymers.

***MBSE/BEST 226: Nanodevice Fabrication*** This course covers basic properties of nanomaterials and their applications as transducers (the lecture part). Nanomaterial synthesis using both solution and vapor-based approaches will be performed and a transducer will be fabricated and tested (the lab part). The interactive and experiential education will be blended with theoretical concepts.

***MBSE/BEST 219: Materials Simulations*** Covers computational methods in materials research and their applications in theoretical studies. Among such methods are ab initio, molecular dynamics (MD), Mesoscale, Multiscale modeling and Finite element methods. Nanostructure evolution and materials properties will also be included.

***MBSE/BEST 221: Mechanical Behavior of Materials*** topics include matrix, tensor, and representation surface descriptions of stress, strain, and material properties (elastic, plastic, photoelastic and piezoelectric), isotropic and anisotropic properties, microscopic and macroscopic response of materials to stress, including plasticity due to dislocation motion, twinning and martensitic transformations, and kinetics of plastic deformation.

**Biomaterials**

***MBSE/BEST 211: Synthetic Biology*** Synthetic biology builds upon existing areas, such as genetic engineering, systems biology, and non-biological fields such as computer science, however; it is becoming evident that synthetic biology represents its own new engineering discipline. At the heart of synthetic biology is the aim to make the engineering of new biological functions predictable, safe, and quick and to aid in creating biological applications of benefit to society. Relevant topics in cellular and molecular biology and biophysics, dynamical and engineering systems, and design and operation of natural and synthetic circuits are covered in a concise manner that than allows the students to begin to design new biology-based systems.

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***MBSE/BEST 241: Cell-material interactions*** Materials are becoming increasingly important in biomedical applications because we now know that cells can sense and dynamically respond to information about their environment through the materials in which they encounter. Examples include: mechanical properties, cell-cell interactions, cell-matrix interactions, and soluble factors. This course presents the fundamental aspects of the design of biomaterials to promote or block these processes.

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***PHYS 231/BEST 231 Imaging and Spectroscopy for Interdisciplinary Biophysical Sciences, Biomaterials and Biotechnology*** This course will cover major principles of biochemistry are illustrated as students express, purify and analyze specific proteins. Experience is obtained with various techniques including DNA transformation, bacterial growth, expression, electrophoresis SDS-PAGE, and purification. Students will also explore the use of spectroscopic methods to study biological systems. Theory and application of techniques including UV-visible absorbance spectroscopy, circular dichroism, fluorescence, single molecule, nuclear magnetic resonance and mass spectroscopy, and their application to the study.

***ENGR 170: Introduction to Electron Microscopy*** Principles and techniques of electron microscopy used in the study of materials. Emphasis upon practical applications.

**Other relevant courses**

***CHEM 202: Bioorganic Chemistry*** The molecular basis of biological processes. Methods by which enzymes catalyze organic reactions; experimental methods by which the mechanisms of enzyme-catalyzed reactions are elucidated; chemistry of disease states and drug action.

**MATH 223: Asymptotics and Perturbation Methods** Asymptotic evaluation of integrals, matched asymptotic expansions, multiple scales, WKB, and homogenization. Applications are made to ODEs, PDEs, difference equations, and integral equations to study boundary and shock layers, nonlinear wave propagation, bifurcation and stability, and resonance.

**MATH 231: Numerical Solution of Differential Equations I** Examines fundamental methods typically required in the numerical solution of differential equations. Topics include direct and indirect methods for linear systems, nonlinear systems, interpolation and approximation, eigenvalue problems, ordinary-differential equations (IVPs and BVPs), and finite differences for elliptic partial-differential equations. A significant amount of programming is required.

**MATH 232: Numerical Solution of Differential Equations II** Fundamental methods presented in Math 231 are used as a base for discussing modern methods for solving partial-differential equations. Numerical methods include variational, finite element, collocation, spectral, and FFT. Error estimates and implementation issues are discussed. A significant amount of programming is required.

**ME 221: *Rheology*** Basic concepts (forces, displacements, stress, tensor, strain, etc.), linear and nonlinear elastic solids, linear viscous fluids, linear viscoelastic fluids and solids, and selected topics in nonlinear viscoelastic behavior.

**ME 231: Conduction Heat Transfer**

**ME 236: *Advanced Mass Transfer*** Steady and unsteady mass diffusion; mass convection, simultaneous heat and mass transfer; Fick’s law in a moving medium; similarity and integral methods in mass transfer; high mass transfer theory; research project in mass transport.

**ME 261: *Energy Storage*** Course provides students an overview on energy storage schemes/devices with major focus on electrochemical storages including ionic batteries, fuel cells and super-capacitors. The course will cover operating principles, physics behind them, characterization methods and advantages/issues of each scheme. Exposure to thermodynamics is recommended but not mandatory.

**PHYS 204: *Biophysics*** Aims to give students an understanding of relevant physical principles for biological systems, introduce them to experimental and theoretical techniques of biophysics and to communicate the excitement of cutting-edge biophysics research. Topics include diffusion, fluids, entropic force, motor proteins, enzymes, nerve impulses, networks and evolution.

**PHYS 241: *Condensed Matter Physics*** An introduction to the physics of materials designed for graduate students in physics or chemistry. The course will cover traditional solid state physics and include topics in soft matter. This class will examine the relationship between microscope structure and bulk properties in different properties.

**PHYS 210: *Electrodynamics and Optics I*** Introduction to electrodynamics. Electrostatics including Poisson and Laplace Equations, Green’s Theorem and different Boundary Value Problems, Polarizibility, Susceptibility and dielectric media. Magnetostatics, Maxwell’s equations, Plane Electromagnetic Waves, Polarization of light, Electromagnetic radiation in different media.

**PHYS 211: Electrodynamics and Optics II** Continuation of electrodynamics. Wave guides and resonant cavities, Multipole radiation, Relativistic charged particles in electromagnetic fields, Collisions between charged particles and radiation from moving charges with relativistic corrections, introductory magnetohydrodynamics.

***QSB 202: Graduate Level Biochemistry*** The overall objective of QSB 202 is to teach students fundamental principles and concepts of biochemistry as a scientific discipline at the graduate level. The emphasis will be on the relationship between macromolecular structure and function.

***QSB 212: Advanced Signal Transduction and Growth Control*** Signal transduction in mammalian cells with emphasis on molecular and genetic regulation of these processes and their role in cell function. Graduate requirement includes an advanced discussion section involving research methodology and data interpretation led by the instructor.

***QSB 250: Embryos, Genes, and Development***. Principles of developmental biology as revealed through analysis of invertebrate and vertebrate system. Animal models are used to examine the molecular and cellular mechanisms that influence cell fate. Cell signaling is studied in the context of embryonic pattern formation and the development of body plans and organ systems. Graduate level students read discuss and critique current research papers relevant for the field.

***QSB 252: Cancer Genetics and Tumor Biology*** Topics include viral and hormonal carcinogenesis, molecular aberrations in cancer, tumor development, epigenetic and cancer, tumor immunology, and oncogenes.

***QSB 261: Human Physiology*** Understanding the mechanisms underlying function of major human organs. Emphasis includes neural transmission and action potential, cardiovascular, renal and gastrointestinal physiology, metabolism, and endocrinology. Laboratory experiments demonstrating and reinforcing topics covered in lecture with an emphasis on scientific method. Discussion section critically reads and evaluates papers in physiology and provides an opportunity for the students to practice presenting scientific data to an audience.

***QSB 280: Advanced Mathematical Biology*** Graduate level mathematical modeling and data analysis skills for life science researchers taught through hands-on computational laboratories. Topics include population models, predator-prey and competition systems, epidemic models with applications to sexually transmitted diseases, dynamic diseases, enzyme kinetics, biological oscillators, and switches.

**Additional Required Courses**

***MBSE/BEST 291: Research Seminar Series (1 unit)*** covering current topics in bioengineering and materials sciences presented by faculty and visiting speakers. This course is designed to expose graduate students to current research in multiple areas of bioengineering and materials and to foster critical evaluation skills. This course must be taken for credit at least 2 semesters.

***MBSE/BEST 292: Group Meeting (1 unit)***

***MBSE/BEST 293: Journal Club (1 unit)***

***MBSE/BEST 294: Responsible Conduct in Research (1 unit)*** Seminar covering responsibilities and expectations for researchers as well as advice for success in graduate school and science careers.

***MBSE/BEST 295: Graduate Research (1-12 units)*** Supervised research with BEST faculty.