

PhD in BIOPHYSICS, ACADEMIC REQUIREMENTS, 2007-2008

SPECIAL COMMITTEE

Graduate students in Biophysics follow the guidelines of the Cornell Graduate School (see Graduate Bulletin) with respect to residency, composition of Special Committee, examinations, and thesis requirements: A student entering the program will select a **Special Committee consisting of a chairperson in the Field of Biophysics, a second faculty member representing the Field, and a faculty member representing an appropriate minor subject area.** It will be the responsibility of the Special Committee to (i) develop a coursework program appropriate for the student's needs, (ii) monitor the general progress of the student, and (iii) ensure that the program is successfully completed. It will be the responsibility of the chairperson of the Special Committee to counsel the student on a day-to-day basis.

In addition to the regular members of the Special Committee, an additional Field appointed member is assigned by the Director of Graduate Studies. This member will attend the A Exam and will ensure that Field requirements are being satisfied, but will not serve on subsequent committees.

The Chair of the Special Committee is expected to have detailed knowledge of the research project to be carried out by the student. We recommend that an orientation meeting be held as soon as the Special Committee is established to ensure a working relationship between student and committee, to establish expectations for the performance of the student, and to define any specific requirements for completion of the degree. The Committee will meet at least once per year thereafter, and send a report concerning the meeting to the Director of Graduate Studies of the field.

In general, the Special Committee is chosen during the summer after the first academic year, when rotations have been completed. Prior to that time, the DGS for Biophysics serves as the temporary Special Committee Chair, mainly to advise the student about courses and rotations.

REQUIREMENTS

1. Courses

The Field of Biophysics, in accordance with general Cornell Graduate School practice, does not have specific course requirements. However, students will be expected to achieve a broad interdisciplinary knowledge of fundamental principles in both biological and physical sciences. **Specific course selections will be tailored to the needs of the individual student by his/her Special Committee** so that students attain multidisciplinary competence encompassing five subject areas (see Table A). For convenience, levels of knowledge to be achieved are specified in terms of standard Cornell courses, but the pathway by which individual students achieve the specified levels is not limited to these courses; some components will have been learned in previous undergraduate study. **In addition, all students will be expected to (1) attend the weekly Wednesday Biophysics seminars; and (2) attend the all-day seminars in September, “Frontiers in Biophysics”.**

Biophysics covers a very wide range of areas; it is not considered realistic or desirable to attempt to train students in all of these facets. Thesis research should be the most important element of the student’s program. Thus, coursework will be selected in consultation with the Special Committee to meet the student’s needs, interests, and future plans. For example, a student involved in laser studies of proteins in biological membranes would require a strong background in quantum physics, instrumentation, chemistry, and biomembranes, while a student working in computational modeling of protein motions would need a strong background in statistical physics, computational science and chemistry.

Minors for doctoral students may be selected from a variety of Programs including Applied Physics, Biochemistry, Chemical Engineering, Chemistry, and Physics. A minor is required.

2. A Examination

The student will prepare a Thesis Proposal describing the background and motivation for the proposed thesis research, work accomplished so far, and an outline of the proposed research plan. The scope of the proposal should be arranged with the thesis adviser (10-15 double-spaced pages is suggested). This should be presented to the Committee members (**and including a Field appointed member**) at least one week prior to the exam. The exam will consist of an oral presentation elaborating the thesis proposal followed by oral examination covering, but not limited to, the student's understanding of material related to the research topic, the student's general background in the Areas of Required Competence (Table A), and the student's research proposal. The Committee will review the student's academic record and examine any potential weak areas to determine if additional course-work is required. The minor advisor may specify additional exam components as required for the minor.

The A exam should be taken at the end of the second year if possible, or before the start of the seventh semester at the latest. The chairperson of the Special Committee should prepare and send to the DGS a short report describing the exam results including:

- Courses or other criteria used to satisfy academic course requirements
- Evaluation of research progress and potential
- Evaluation of student competency based on the oral exam

Satisfaction of requirements for the minor will be assessed by the minor field member at the A exam. Note that the field does not normally award a Special Masters for completion of the A exam. (This degree can be offered if a student is not progressing to the Ph.D.; see below).

3. B Examination

The completed dissertation should be submitted to the committee at least 1 week before the examination. The exam will begin with a public seminar describing the thesis research. This will be followed by a closed oral examination covering the dissertation.

4. Additional seminar presentations

In addition to the required comprehensive and thesis exams, each student will be expected to present at least two half-hour summer seminars. The first will be presented in the Summer following the second year.

TABLE A
Areas of Required Competence

Advanced Mathematics: One semester of mathematics beyond 4 semesters at the elementary undergraduate level is required, two semesters recommended. For a 1-semester course, CHEM 787 is recommended. Appropriate 2-semester sequences are: (MATH 420 and 422), (AEP 321 and AEP 322), (TAM 310 and TAM 311 or TAM 610 and TAM 611).

Physical Chemistry: One course in statistical mechanics and thermodynamics (PHYS 562 or PHYS 653 or CHEM 795 or CHEM 796) **and** one course in quantum mechanics (CHEM 389 or CHEM 793 or PHYS 443 or PHYS 572).

Biochemistry, Molecular and Cell Biology: If you have not had basic biochemistry, take BIOBM 330, or BIOBM 331 plus BIOBM 332). To meet the Field requirement, cell biology BIOBM 432 or 636, or biochem lab BIOBM 440, or BIOBM 631 or 639, with at least a total of five credits at the 400 level or higher.

Computer Literacy or Laboratory Electronics and Instrumentation: In lieu of undergraduate experience, computer experience may be gained through either appropriate courses or research experience. Expertise in instrumentation electronics, if not previously acquired, is available through PHYS 360, AEP 363, BIOS 422 or 426 or ABEN 450.

Advanced Studies in Molecular Biophysics and Associated Areas of Biological and Physical Science: At least three credits are required. Some Cornell courses that are likely subjects for advanced studies are listed in Selected Biophysics Courses.

Note: Courses that are taken to satisfy requirements should be taken for a letter grade. A minimum of B is expected. One required course, and only one, may be taken Pass/Fail.

TABLE B: REPRESENTATIVE EXAMPLES OF STUDENT PROGRAMS

Interest:	Cell Surface Molecules	Membrane biophysics	Protein Structure
Undergraduate Major:	Physics	Biochemistry	Chemistry
Throughout training:	Biophysics Seminar Series Physics Seminar Series	Biophysics Seminar Series Biochemistry Seminar Series	Biophysics Seminar Series
	Weekly meetings in research groups Yearly seminar presentation on research progress		
Year 1:	Quantum Mechanics Statistical Mechanics Biochemistry Cell Biology Molecular Genetics Intermediate Biochemical Methods	Advanced Biochemical Methods Laboratory Mathematical Physics Protein Structure and Function Biosynthesis of Macromolecules Current Topics in Cell Biology The Nucleus	Thermodynamics and Statistical Thermodynamics Quantum Mechanics I Applicable Mathematics Physical Chemistry of Proteins Survey of Cell Biology
Year 1, Summer:			
Year 2:	Principles of Diffraction Membrane Biophysics Protein Structure and Function Membrane Ion Channels Solid state Physics Statistical Physics	Physical Chemistry III Thermodynamics Membranes and Bioenergetics Membrane Biophysics Kinetics and Regulation Enzymes Statistical Mechanics Mini-Courses	Spectroscopy Quantum Mechanics II Enzyme Catalysis and Regulation Protein Structure and Function
Year 2, Summer:	Thesis research	Thesis research	Thesis research
Years 3-5:	Admission to Candidacy Exam Thesis Research	Admission to Candidacy Exam Thesis Research	Admission to Candidacy Exam Thesis Research

APPENDIX I

Appropriate Cornell Courses for Biophysics Students

Advanced Mathematics

Applicable Mathematics (Math 420)

Ordinary and partial differential equations, Fourier series, numerical methods, vector calculus and Stokes theorem

Applicable Mathematics (Math 422)

Complex variables; Fourier transforms, Laplace transforms; an introduction to generalized functions; applications to partial differential equations.

Applicable Mathematics (Math 423)

Normed vector spaces; elementary Hilbert space theory; projections; Fredholm's alternative; eigenfunction expansions; applications to elliptic partial differential equations and to integral equations.

Numerical Solutions of Differential Equations (Math 425)

Methods and basic theory of the numerical solution of ordinary and partial differential equations. Linear multistep methods, Runge-Kutta methods, and the problem of stiffness for ordinary differential equations. Finite difference methods and Galerkin finite element methods for partial differential equations.

Mathematical Physics I (AEP 321)

Review of vector analysis, complex variable theory, Cauchy-Riemann conditions, complex Taylor and Laurent series, Cauchy integral formula and residue techniques, conformal mapping, Fourier series, Fourier & Laplace transforms, ordinary differential eg. separating of variables.

Mathematical Physics II (AEP 322)

Partial differential equations, Bessel functions, spherical harmonics, separation of variables, wave and diffusion equations, Laplace, Helmholtz, and Poisson's Equations, transform techniques.

Advanced Engineering Analysis I (T&AM 310)

Ordinary differential equations as applied in engineering context. Analytical and numerical methods. Special functions, initial value, boundary value, and eigenvalue problems in linear partial differential equations; introduction to nonlinear ordinary differential equations. Use of computer algebra and MACSYMA to solve problems.

Advanced Engineering Analysis II (T&AM 311)

Functions of several variables, introduction to complex variables, analytic functions, conformal mapping, method of residues. Application to the solution of Laplace's equation, and transform inversion techniques. Examples drawn from fluid mechanics, heat transfer, electromagnetics, and elasticity.

Methods of Applied Mathematics I (T&AM 610)

Emphasis is on applications. Linear algebra, calculus of several variables, vector analysis, series, ordinary differential equations, complex variables.

Methods of Applied Mathematics II (T&AM 611)

Emphasis on applications. Partial differential equations, transform techniques, tensor analysis, calculus of variations.

Methods of Applied Mathematics III (T&AM 612)

Review of complex variable theory; conformal mapping, special functions, integral transform, Wiener-Hopf technique, and singular integral equations. Problems drawn from electromagnetics, elasticity, fluid mechanics, heat transfer, and acoustics.

Methods of Applied Mathematics IV (T&AM 613)

Topics include asymptotic behavior of solutions of linear ODE (e.g., the WKB and multiple-scale methods), asymptotic expansion of integrals (method of steepest descent, stationary phase and Laplace methods). Regular and singular perturbation methods for PDE (e.g., method of composite expansions). Other topics (depending on instructor) may include normal forms, center manifolds, Liapunov-Schmidt reducers, Stokes phenomenon, and computer algebra exercises.

Physical Chemistry

Statistical Thermodynamics (Chem 678)

Principles of equilibrium thermodynamics; thermodynamic functions; First and Second Laws; gases and condensed phases; solutions; phase equilibrium; chemical equilibrium; surface thermodynamics; electrolytes; statistical thermodynamics and the Third Law.

Physical Chemistry III (Chem 681)

An introduction to the principles of quantum theory and statistical mechanics, atomic and molecular spectra, and elementary valence theory.

Physical Organic Chemistry I (Chem 765)

Application of computational and experimental techniques to studies of organic reaction mechanisms and the properties of reactive intermediates.

Principles of Chemical Kinetics (Chem 780)

Principles and theories of chemical kinetics, special topics such as fast reactions in liquids, enzymatic reactions energy transfer, and molecular beams.

X-ray Crystallography (Chem 789)

A beginning course in the application of X-ray crystallography to structural chemistry. Topics include symmetry properties of crystals, diffraction of X-rays by crystals, interpretation of diffraction data, and refinement of structures.

Spectroscopy (Chem 791)

Principles of one- and two-dimensional magnetic resonance spectroscopies.

Quantum Mechanics I (Chem 793)

Schrödinger's equation, wave packets, uncertainty principle, WKB theory, matrix mechanics, orbital and spin angular momentum, exclusion principle, perturbation theory, variational principle, Born-Oppenheimer approximation.

Quantum Mechanics II (Chem 794)

Electronic structure of atoms and molecules; quantum chemical calculations; group theory; time-dependent phenomena in quantum mechanics and light/matter interactions; spectroscopies.

Statistical Mechanics (Chem 796)

Microstates, ensembles, partition functions, and fluctuations; quantum statistics; thermodynamic properties of ideal gases and crystals; chemical equilibrium; dense gases; structure of classical liquids; phase transitions and critical phenomena; introduction to nonequilibrium statistical mechanics: density matrix and response theory, transport processes, Brownian motion.

Introduction to Quantum Mechanics (Phys 443)

Introduction to concepts and techniques of quantum mechanics, at the level of Introduction to Quantum Mechanics by Dicke and Wittke.

Quantum Mechanics I (Phys 572)

The formulation of quantum mechanics in terms of states and operators. Symmetries and the theory of angular momentum.

Quantum Mechanics II (Phys 574)

Discussion of various aspects of quantum mechanics; such as path integral formulation, collision theory; theory of spectra of atoms and molecules, theory of solids, second quantization, emission of radiation.

Advanced Chemical Eng. Thermodynamics (ChemE 711)

Postulatory approach to thermodynamics. Applications of thermodynamic methods to advanced problems in chemical engineering. Monte Carlo methods, and theory of liquids.

Chemical Kinetics and Dynamics (ChemE 713)

Microscopic and macroscopic viewpoints. Connections between phenomenological chemical kinetics and molecular reaction dynamics. Molecular beam scattering. Transition state theory. Complex chemically reacting systems: reactor stability, multiple steady states, oscillators, and bifurcation. Free-radical mechanisms in combustion and pyrolysis.

Advanced Fluid Mechanics and Heat Transfer (ChemE 731)

Derivation of the equations of motion for Newtonian fluids Low Reynolds number fluid dynamics, lubrication theory, inviscid fluid dynamics. Boundary layer theory. Convective and conductive heat transfer.

Intro Quantum Mechanics (AEP 361)

A first course in the systematic theory of quantum phenomena. Topics include the harmonic oscillation, the Dirac formalism, angular momentum, the hydrogen atom, and perturbation theory.

Statistical Thermodynamics (AEP 423)

Quantum statistical basis for equilibration thermodynamics, microcanonical, canonical and grand canonical ensembles, and partition functions. Quantum and classical ideal gases and paramagnetic systems. Fermi-Dirac, Bose-Einstein.

Quantum Mechanics and Applications (EIEE 407)

Review of basic quantum mechanical concepts. Harmonic oscillator. Annihilation and creation operators. Application of the WKB approximation to bound states and transmission coefficients.

Lasers and Optical Electronics (EIEE 430)

An introduction to the operation of stimulated-emission devices such as lasers and devices based on linear and nonlinear optics. Material covered includes diffraction-limited optics, propagation of Gaussian laser beams, optical resonators, interaction of radiation with matter, physics of laser operation, laser design. Applications of coherent radiation to nonlinear optics, communication, and research will be discussed as time permits.

Quantum Electronics I (EIEE 531)

A detailed treatment of the physical principles underlying lasers, related fields, and applications. Topics include the interaction of radiation and matter, including emission, absorption, scattering and basic spectroscopic properties of key laser media; theory of the laser including methods of achieving population inversions, dispersive effects, and laser oscillation spectrum.

Quantum Electronics II (EIEE 532)

A continuation of 531. Topics include density matrix; nonlinear optical processes; properties of nonlinear optical materials; optical parametric oscillators; spontaneous and stimulated Raman and Brillouin processes; theory of coherence; pico- and femto-second optics; ultrafast processes in semi conductors and moleculae; optical properties of semiconductor-doped glasses, quantum-well structures, and super lattices.

Protein Kinetics (Chem 672)

Protein structure and dynamics; thermodynamics and kinetics of ligand binding; steady state and transient enzyme kinetics; enzyme catalysis and regulation; role of cell membrane receptors in regulating cellular activities.

Physical Chemistry of Proteins (Chem 686)

Chemical constitution, molecular weight, and structural basis of proteins; thermodynamic, hydrodynamic, optical, spectroscopic, and electrical properties; protein and enzyme reactions; statistical mechanisms of helix-coil transition in biopolymers; conformation of biopolymers; protein folding.

Statistical Physics (Phys 653)

Survey of topics in modern statistical physics: Dynamical statistical physics (kinetic theory, Boltzmann equation, hydrodynamics); theory of simple fluids; scaling theories and the renormalization group; phase transitions in disordered systems; pattern formation in nonlinear systems; percolation theory.

Statistical Mechanics (Phys 562)

Thermodynamic functions, equations of state; Second Law phase equilibria; thermodynamic inequalities; kinetic theory, Boltzmann's equation, transport theory.

Biochemistry and Molecular Biology

Chemistry of Nucleic Acids (Chem 677)

Properties, synthesis, reactions, and biochemical reactions of nucleic acids.

Principles of Biochemistry, Individualized Instruction (BIO BM 330)

The core material of the course includes protein structure and function, enzymes, basic metabolic pathways, DNA, RNA, protein synthesis, and an introduction to gene cloning. There are no formal lectures; the course has an autotutorial format. Each student also participates in discussions on research papers, and review papers.

Principles of Biochemistry, Lectures (BIO BM 331)

Lectures cover protein structure and function; metabolism and bioenergetics; and nucleic acids, protein synthesis, and gene exploration.

Survey of Cell Biology (BIO BM 432)

A survey of a wide array of topics focusing on the general properties of eucaryotic cells. The topics include methods used for studying cells, the structure and function of the major cellular organelles, and analyses of cellular processes such as mitosis, endocytosis, cell motility, secretion, cell-to-cell communication, gene expression, and oncogenesis.

Principles of Biochemistry (BIO BM 332)

A comprehensive examination of the molecular biology of prokaryotic and eukaryotic cells. Topics include DNA and chromatin structure; genomic organization; replication, recombination, mutability, and repair of DNA; synthesis and processing of RNA and protein; and regulation of gene expression. The principles of recombinant DNA technology are discussed.

Photosynthesis (BIO PL 445) (also A&EP 601)

A detailed study of the processes by which plants utilize light energy to grow. Structure of the photosynthesis apparatus, light absorption and antenna processes, photochemistry, and electron transport are emphasized.

Light and Video Microscopy for Biologists (BIO G 450)

Theoretical and practical aspects of light microscopy, including brightfield, darkfield, phase-contrast, polarization, Hoffman-modulation contrast, interference, differential-interference-contrast, and fluorescence microscopy, as well as video- and computer based digital image enhancement, are studied. Students learn both qualitative and quantitative techniques to probe noninvasively the structure and function of living plant cells.

Membrane Ion Channels (BIO NB 495)

The functional and mechanistic aspects of membrane ion channels, beginning with basic concepts and model systems. Theories of ion permeation and channel gating are discussed. Development of membrane ion channels during neuron differentiation and the role of membrane channels in disease states are also considered.

Neurochemistry and Molecular Neurobiology (BIO NB 497)

This course focuses primarily on synaptic neurochemistry. The presynaptic regulation of release and postsynaptic mechanism of action of the major classes of neurotransmitters are discussed, as well as selected neuromodulators and hormones. Second-messenger mechanisms are stressed. Readings are primarily from journal articles.

Protein Structure and Function (BIO BM 631)

Lectures on the principles of protein structure and the nature of enzymatic catalysis.

Membranes and Bioenergetics (BIO BM 632)

Structure and dynamics of biological membranes, physical methods, model membranes, ionophores, ion-transport ATPases, mitochondrial and chloroplast electron transfer chains, and examples of transport from plants, animals, and bacteria.

Biosynthesis of Macromolecules (BIO BM 633)

Synthesis of DNA, RNA, and proteins, and regulation of gene expression.

Cell Biology (BIO BM 636)

Lectures covering current topics in cell biology, including a detailed discussion of secretion, endocytosis, membrane-bound organelles, membrane recycling, the cytoskeleton, cell motility, junctions, the cell cycle, and related topics.

Intermediate Biochemical Methods (BIO BM 638)

Selected experiments on proteins, enzymes, DNA, and bioenergetics to illustrate basic biochemical properties. The course emphasizes quantitative aspects and techniques currently used in biochemical research.

The Nucleus (BIO BM 639)

Lectures on topics of eucaryotic gene organization, regulation of gene expression, RNA processing, chromatin structure, the structure and movement of chromosomes, and the architecture of the nucleus.

Transport of Solutes and Water in Plants (BIO PL 649)

Transport of ions, water, and organic materials in plants; mechanisms of ion transport; relationships between ion transport and metabolism; ion uptake and transport in higher plants; phloem transport; and water relations of single cells and whole plants.

Advanced Biochemical Methods I (BIO BM 831)

To learn the basic concepts and approaches to biochemical research, students participate in discussions and perform experiments on proteins, enzymes, DNA, and cell biology experiments of their choice. First half of the fall term is an intensive, structured course. Letter grades are assigned for this laboratory portion of the course. Second half of the fall term is devoted to a rotation project in different labs selected by the students. S-U grades only are assigned for the rotation portion of the course.

Advanced Biochemical Methods II (BIO BM 832)

Research in the laboratories of two or three different professors chosen by the student. Arrangements are made jointly between the graduate field representative and the research adviser.

Current Topics in Biochemistry (BIO BM 735)

Lectures and seminars on specialized topics.

Biological Engineering Analysis (ABEN 685)

Engineering problem-solving strategies and techniques are explored. Students solve several representative engineering problems that inherently involve biological properties. Emphasis is on formulation and solution of mathematical models and the interpretation of results.

Receptor Binding: Theory and Techniques (VETPR 703)

Practical and theoretical tools needed to set up and use a radioligand binding assay to measure and characterize physiologically and pharmacologically relevant neurotransmitter hormone drug receptors. The emphasis is on the quantitative and physical chemical aspects of receptor binding. Topics discussed in the course are historical background of receptor theory; the basic methods of a radioligand binding assay, including various methods of separating and measuring bound and free ligand; methods of analyzing equilibrium binding, the thermodynamic basis of the binding; equilibrium binding for complex binding mechanisms, including allosteric mechanisms; coupling of binding to response; antagonism of response and inhibition of binding; the kinetics of simple and complex binding mechanisms; and common artifacts encountered in radioligand binding assays.

Methods and Logic in Biochemistry, Molecular and Cell Biology (BIO BM 835)

A seminar course with critical discussion by students of original research papers. A variety of topics in biochemistry, molecular and cell biology are covered.

Laboratory in Cell Biology (BIO BM 630)

The course emphasizes approaches to experimental design and theory of experimental techniques as well as providing experience in handling and experimenting with cells of different kinds. Limited numbers of vertebrate animals are used for two experiments where no alternative approach exists.

Computer Literacy or Laboratory Electronics and Instrumentation

Modern Experimental Optics (Phys 330)

A practical lab course in basic and modern optics. Students spend 2/3 of the course experimenting with the physics of basic optical phenomena: interference, diffraction, coherence, polarization, and image formation.

Computational Physics (Phys 480)

Ability to write programs in any computer language. No previous knowledge of numerical analysis is assumed.

Computational Physics (Phys 680)

A course designed to familiarize students with numerical techniques for solving diverse problems in physics and related fields. Numerical techniques discussed in the course will include ordinary and partial differential equations, linear algebra and eigenvalue problems, Monte Carlo techniques, solving nonlinear equations, fast Fourier transforms, etc.

Mathematical Methods of Chemical Engineering Analysis (CHEME 751)

Application of advanced mathematical techniques to chemical engineering analysis. Mathematical modeling, scaling, regular and singular perturbation, multiple scales, asymptotic analysis. Linear and nonlinear ordinary differential equations, partial differential equations.

Electronics for Neurobiology (BIO NB 426)

The course deals with electronics as applied to neurobiology and behavior. Analog circuits centered around operational amplifiers are emphasized. Topics include a review of basic electrical concepts; the cell as circuit, voltage, and current amplifiers; transducers (temperature, light, pressure, etc.); filtering, timing circuits; radiotelemetry; basic

trouble shooting; and reading schematics. Students design and contrast a circuit of their own choosing relative to their research and/or interests.

Electronic Circuits (Phys 360)

An experimental survey of some devices and circuits in two general areas, analog and digital electronics. The analog circuits covered include operational amplifiers, filters, diodes, bipolar and field effect transistors.

Introduction to Scientific Computation (also COM S 222) (ENGRD 222)

Students write MATLAB/FORTRAN programs to solve representative problems from elementary calculus. Emphasis is on the design of numerical software that is efficient, reliable, stable, and portable. Special topics include supercomputing and parallel computation.

Instrument Design: Signal Processing and Data Acquisition (ABEN 450)

An introduction to static and dynamic characteristics of instruments, electronic instruments, digital and analog signal conditioning circuits and techniques, data acquisition and instrument control with personal computers and micro-controllers, and computer data analysis. Biological and agricultural examples of instrument problems and designs are used.

Matrix Computations (CoSci 621)

Engineering Computation (ENGRD 241)

Advanced Studies in Molecular Biophysics and Associated Areas of Biological and Physical Science

Mathematical Ecology (BIO ES 662) (also Stats 662)

Mathematical and statistical analysis of populations and communities: theory and methods; spatial and temporal pattern analysis; deterministic and stochastic models of population dynamics; model formulation, parameter estimation, simulation, and analytical techniques.

Electronic Circuits (A&EP 363)

This laboratory course focuses on designing, building, and testing analog, digital, and microprocessor-based circuits that are useful in electronic instrumentation.

Advanced Experimental Physics (Phys 510)

About 70 different experiments are available in acoustics, optics, spectroscopy, electrical circuits, electronics and ionics, magnetic resonance, X-rays, Students perform 4 to 8 experiments selected to meet individual needs. Independent work is stressed.

Classical Electrodynamics (Phys 561)

Maxwell's equations, electromagnetic potentials, electrodynamics of continuous media (selected topics) special relativity, radiation theory. At the level of Classical Electrodynamics, by Jackson.

Principles of Diffraction (A&EP 711)

Introduction to diffraction phenomena as applied to solid-state problems; scattering and absorption of neutrons, electrons, and X-ray beams, with particular emphasis on synchrotron radiation X-ray sources.

Physical and Integrated Optics (AEP 436)

The fundamentals of optics: diffraction, polarization, interference, birefringence, scattering, Fourier optics. Applications to optical wave guides, nonlinear optics, integrated optics, optical storage, coherent detection, optical communications. Emphasis on hands-on experimental laboratory demonstrations and computer synthesis of optical phenomena.

Advanced Topics in Orthopaedic Biomechanics (M&AE 665)

Chemical Communications (Chem 622)

The production, transmission, and reception of chemical signals in communitive interactions of animals, plants, and microorganisms. Communication involving insects is emphasized. Specific topics are treated, with varying emphasis on chemical, biochemical, neurobiological, ecological, and evolutionary principles.

Chemical Aspects of Biological Processes (Chem 668)

A representative selection of the most important classes of enzyme-catalyzed reactions will be examined from a mechanistic perspective. Topics discussed will include the chemical basis of enzymatic catalysis, techniques for the elucidation of enzyme mechanism, cofactor chemistry, the biosynthesis of penicillin, chlorophyll, methane, ethylene and amino acids. The application of chemical principles to understanding biological processes will be emphasized.

Special Topics in Biophysical and Bioorganic Chemistry (Chem 782)

Topics vary from year to year.

Introduction to Bioprocess Engineering (ChemE 643)

A discussion of principles involved in using microorganisms, tissue cultures, and enzymes for processing. Application to food, fermentation, and pharmaceutical industries and to biological waste treatment.

Advanced Concepts in Biological Engineering (Chem E 645)

Fundamentals of biochemical and biomedical engineering, with additional emphasis on cell and membrane biophysics.

Selected Topics in Biochemical Engineering (CHEME 741)

Discussion of current topics and research in biochemical engineering for graduate students.

Molecular Biophysics of Cellular Dynamics (A&EP 615)

Molecular structure and supramolecular organization of cell membranes; model membranes and membrane models; molecular mechanisms of membrane transport, electrophysiology and cell-cell interaction, molecular channels.

Environmental Biophysics (SCAS 483)

Introduction to basic principles of energy and water transfer and storage in soil-plant systems. Energy budgets, soil heat flow, water movement in saturated and unsaturated soils, evapotranspiration, and water dynamics in the soil-plant-atmosphere continuum will be covered. Applications to agronomic and environmental problems and instrument design and use are considered through discussion and problem sets.