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008. Physics for Architects I. (I) Physical World Sector. All classes.Prerequisite(s): Entrance credit in algebra and trigonometry. Credit is awarded for only one of the following courses: PHYS 008, PHYS 101, PHYS 150, or PHYS 170. Students with AP or Transfer Credit for PHYS 091 or 093 who complete PHYS008 will thereby surrender the AP or Transfer Credit.

An introduction to the classical laws of mechanics, including static equilibrium, elasticity, and oscillations, with emphasis on topics most relevant to students in architecture. Credit is awarded for only one of the following courses: PHYS 008, PHYS 101, PHYS 150, or PHYS 170. Students with AP or Transfer Credit for PHYS 091 or 093 who complete PHYS008 will thereby surrender the AP or Transfer Credit.

009. Physics for Architects II. (J) Physical World Sector. All classes. Credit is awarded for only one of the following courses: PHYS 009, PHYS 102, PHYS 151, or PHYS 171. Students with AP or Transfer Credit for PHYS 092 or 094 who complete PHYS008 will thereby surrender the AP or Transfer Credit.

A continuation of PHYS 008 introducing waves, sound, light, fluids, heat, electricity, magnetism, and circuits, with emphasis on topics most relevant to students in architecture. Credit is awarded for only one of the following courses: PHYS 009, PHYS 102, PHYS 151, or PHYS 171. Students with AP or Transfer Credit for PHYS 092 or 094 who complete PHYS008 will thereby surrender the AP or Transfer Credit.

016. Energy, Oil, and Global Warming. (C) Natural Science & Mathematics Sector. Class of 2010 and beyond.Prerequisite(s): Algebra and Trigonometry. May be counted as Science Studies for students in Class of 2009 and prior. Target audience: Non-science majors (although science/ engineering students are welcome).

The developed world's dependence on fossil fuels for energy production has extremely undesirable economic, environmental, and political consequences, and is likely to be mankind's greatest challenge in the 21st century. We describe the physical principles of energy, its production and consumption, and environmental consequences, including the greenhouse effect. We will examine a number of alternative modes of energy generation - fossil fuels, biomass, wind, solar, hydro, and nuclear - and study the physical and technological aspects of each, and their societal, environmental and economic impacts over the construction and operational lifetimes. No previous study of physics is assumed.

050. Physics Laboratory I. (C) Prerequisite(s): AP score of 5 on the Physics B or Physics C - Mechanics exam, or transfer credit for PHYS 91 or PHYS 93. Only for students with above prerequisites. Course carries .5 course unit and student receives grade. Permit required. Only for students with above prerequisites.

Experiments in classical mechanics.

051. Physics Laboratory II. (C) Prerequisite(s): AP score of 5 on the Physics B or Physics C - Electricity and Magnetism exam, or transfer credit for PHYS 92 or PHYS 94. PHYS 050. Only for students with above prerequisites. Course carries .5 course unit and student receives grade. Permit required. Only for students with above prerequisites.

Experiments in electromagnetism and optics.

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101. General Physics: Mechanics, Heat and Sound. (S) Physical World Sector. All classes.Prerequisite(s): Entrance credit in algebra and trigonometry, and a background in calculus. Corequisite(s): PHYS 101 LAB.Credit is awarded for only one of the following courses: PHYS 008, PHYS 101, PHYS 150, or PHYS 170. Students with AP or Transfer Credit for PHYS 91 or PHYS 93 who complete PHYS 101 will thereby surrender the AP or Transfer Credit.

An introduction to the classical laws of motion requiring a background in calculus. Suggested for students in a pre-health program. Credit is awarded for only one of the following courses: PHYS 008, PHYS 101, PHYS 150, or PHYS 170. Students with AP or Transfer Credit for PHYS 91 or PHYS 93 who complete PHYS 101 will thereby surrender the AP or Transfer Credit.

102. General Physics: Electromagnetism, Optics, and Modern Physics. (S) Physical World Sector. All classes.Prerequisite(s): PHYS 101. Corequisite(s): PHYS 102 LAB.Credit is awarded for only one of the following courses: PHYS 009, PHYS 102, PHYS 151, or PHYS 171. Students with AP or Transfer Credit for PHYS 92 or PHYS 94 who complete PHYS 102 will thereby surrender the AP or Transfer Credit.

A continuation of PHYS 101 emphasizing an introduction to classical electricity and magnetism, relativity theory, optics, and the quantum theory of matter, requiring a background in calculus. Suggested for students in a pre-health program. Credit is awarded for only one of the following courses: PHYS 009, PHYS 102, PHYS 151, or PHYS 171. Students with AP or Transfer Credit for PHYS 92 or PHYS 94 who complete PHYS 102 will thereby surrender the AP or Transfer Credit.

137. Community Physics Initiative. (A)

This is an Academically Based Community Service Course (ABCS). It will be aligned to the Philadelphia School District curriculum in introductory physics at University City High School (UCHS). The UCHS curriculum roughly parallels the contents of first semester introductory physics (non-calculus) at Penn.

140. Principles of Physics I (without laboratory). (C) Corequisite(s): MATH 104.For Engineering students whose course of study does not require a physics laboratory course. Those who are enrolled in a dual degree program with the College must register for the lab-based version of this course, PHYS 150.

Classical laws of motions; interactions between particles; conservation laws and symmetry principles; particle and rigid body motion; gravitation, harmonic motion. Engineering students only.

141. Principles of Physics II (without laboratory). (S) Prerequisite(s): PHYS 140. Corequisite(s): MATH 114.For Engineering students whose course of study does not require a physics laboratory course. Those who are enrolled in a dual degree program with the College must register for the lab-based version of this course, PHYS 151.

Electric and magnetic fields; Coulomb's, Ampere's, and Faraday's laws; Maxwell's equations; emission, propagation, and absorption of electromagnetic radiation; interference, reflection, refraction, scattering, and diffraction phenomena. Engineering students only.

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150. Principles of Physics I: Mechanics and Wave Motion. (C) Physical World Sector. All classes. Corequisite(s): MATH 104, PHYS 150 LAB.Credit is awarded for only one of the following courses: PHYS 008, PHYS 101, PHYS 150, or PHYS 170. Students with AP or Transfer Credit for PHYS 91 or PHYS 93 who complete PHYS 150 will thereby surrender the AP or Transfer Credit.

This calculus-based course is recommended for science majors and engineering students. Classical laws of motion; interactions between particles; conservation laws and symmetry principles; particle and rigid body motion; gravitation, harmonic motion. Credit is awarded for only one of the following courses: PHYS 008, PHYS 101, PHYS 150, or PHYS 170. Students with AP or Transfer Credit for PHYS 91 or PHYS 93 who complete PHYS 150 will thereby surrender the AP or Transfer Credit.

151. Principles of Physics II: Electromagnetism and Radiation. (S) Physical World Sector. All classes.Prerequisite(s): PHYS 150 or PHYS 170. Corequisite(s): MATH 114, PHYS 151 LAB.Credit is awarded for only one of the following courses. PHYS 009, PHYS 102, PHYS 151, or PHYS 171. Students with AP or Transfer Credit for PHYS 92 or PHYS 94 who complete PHYS 151 will thereby surrender the AP or Transfer Credit.

The topics of this calculus-based course are electric and magnetic fields; Coulomb's, Ampere's, and Faraday's laws; Maxwell's equations; emission, propagation, and absorption of electromagnetic radiation; interference, reflection, refraction, scattering, and diffraction phenomena. Credit is awarded for only one of the following courses. PHYS 009, PHYS 102, PHYS 151, or PHYS 171. Students with AP or Transfer Credit for PHYS 92 or PHYS 94 who complete PHYS 151 will thereby surrender the AP or Transfer Credit.

240. Principles of Physics IV: Modern Physics (without laboratory). (B) Prerequisite(s): PHYS 151 or 171. Corequisite(s): MATH 240.

Special relativity, an introduction to the principles of quantum mechanics, properties of electrons, protons, neutrons, and the elements of atomic structure and nuclear structure. Electromagnetic radiation and photons; interaction of photons with electrons, atoms, and nuclei.

SM 170. Honors Physics I: Mechanics and Wave Motion. (A) Physical World Sector. All classes.Prerequisite(s): MATH 104 or permission of the instructor. Corequisite(s): MATH 114 or permission of instructor.Benjamin Franklin Seminar. Credit is awarded for only one of the following courses: PHYS 008 PHYS 101, 150, or PHYS 170. Students with AP or Transfer Credit for PHYS 91 or PHYS 93 who complete PHYS 170 will thereby surrender the AP or Transfer Credit.

This course parallels and extends the content of PHYS 150, at a significantly higher mathematical level. Recommended for well-prepared students in engineering and the physical sciences, and particularly for those planning to major in physics. Classical laws of motion: interaction between particles; conservation laws and symmetry principles; rigid body motion; noninertial reference frames; oscillations. Credit is awarded for only one of the following courses: PHYS 008 PHYS 101, 150, or PHYS 170. Students with AP or Transfer Credit for PHYS 91 or PHYS 93 who complete PHYS 170 will thereby surrender the AP or Transfer Credit.

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SM 171. Honors Physics II: Electromagnetism and Radiation. (B) Physical World Sector. All classes.Prerequisite(s): MATH 114 and PHYS 150 or PHYS 170, or permission of instructor. Corequisite(s): MATH 240 or permission of instructor.Benjamin Franklin Seminar. Credit is awarded for only one of the following courses: PHYS 009, PHYS 102, PHYS 151, or PHYS 171. Students with AP or Transfer Credit for PHYS 92 or PHYS 94 who complete PHYS 171 will thereby surrender the AP or Transfer Credit.

This course parallels and extends the content of PHYS 151, at a somewhat higher mathematical level. Recommended for well-prepared students in engineering and the physical sciences, and particularly for those planning to major in physics. Electric and magnetic fields; Coulomb's, Ampere's, and Faraday's laws; special relativity; Maxwell's equations, electromagnetic radiation. Credit is awarded for only one of the following courses: PHYS 009, PHYS 102, PHYS 151, or PHYS 171. Students with AP or Transfer Credit for PHYS 92 or PHYS 94 who complete PHYS 171 will thereby surrender the AP or Transfer Credit.

230. Principles of Physics III: Thermal Physics and Waves. (A) Prerequisite(s): PHYS 150/151 or PHYS 170/171 and MATH 104, MATH 114 or 116. Corequisite(s): MATH 240.

Elementary thermodynamics and statistical physics including heat engines and the Maxwell-Boltzmann distribution, independent and forced harmonic motion, coupled oscillators, normal modes, longitudinal and transverse sound and light waves, interference and diffraction, and elementary Fourier analysis and the uncertainty principle.

250. Principles of Physics IV: Modern Physics. (B) Prerequisite(s): PHYS 150/151 or PHYS 170/171. Corequisite(s): MATH 240.PHYS 250 students take a two-hour lab

Special relativity, an introduction to the principle of quantum mechanics, properties of electrons, protons, neutrons, and the elements of atomic structure and nuclear structure. Electromagnetic radiation and photons; interaction of photons with electrons, atoms, and nuclei.

280. (BCHE280) Physical Models of Biological Systems. (A) Prerequisite(s): PHYS 101 (or higher), MATH 104-MATH 114 or MATH 104-MATH 115 or MATH 116. Recommended: previous or concurrent PHYS 102; basic background in chemistry and biology.

Classic case studies of successful reductionistic models of complex phenomena, emphasizing the key steps of making estimates, using them to figure out which physical variables and phenomena will be most relevant to a given system, finding analogies to purely physical systems whose behavior is already known, and embodying those in a mathematical model, which is often implemented in computer code. Topics may include bacterial genetics, genetic switches and oscillators; systems that sense or utilize light; superresolution and other newmicroscopy methods; and vision and other modes of sensory transduction.

299. Independent Study. (C) Repetitive credit

Special projects and independent study under the direction of faculty member.

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L/R 314. (ENVS312, ENVS640) Ocean-Atmosphere Dynamics and Implications for Future Climate Change. Marinov.Prerequisite(s): MATH 114 or permission of the instuctor.

This course covers the fundamentals of atmosphere and ocean dynamics, and aims to put these in the context of climate change in the 21st century. Large-scale atmospheric and oceanic circulation, the global energy balance, and the global energy balance, and the global hydrological cycle. We will introduce concepts of fluid dynamics and we will apply these to the vertical and horizontal motions in the atmosphere and ocean. Concepts covered include: hydrostatic law, buoyancy and convection, basic equations of fluid motions, Hadley and Ferrel cells in the atmosphere, thermohaline circulation, Sverdrup ocean flow, modes of climate variability (El-Nino, North Atlantic Oscillation, Southern Annular Mode). The course will incorporate student led discussions based on readings of the 2007 Intergovernmental Panel on Climate Change (IPCC) report and recent literature on climate change. Aimed at undergraduate or graduate students who have no prior knowledge of meteorology or oceanography or training in fluid mechanics. Previous background in calculus and/or introductory physics is helpful. This is a general course which spans many subdisciplines (fluid mechanics, atmospheric science, oceanography, hydrology).

351. Analytical Mechanics. (B) Prerequisite(s): PHYS 150/151 or PHYS 170/171, MATH 104/114, and MATH 240, or permission of instructor.

An intermediate course in the statics and dynamics of particles and rigid bodies. Langrangian dynamics, central forces, non-inertial reference frames, and rigid bodies.

361. (PHYS561) Electromagnetism I: Electricity and Potential Theory. (A) Prerequisite(s): PHYS 151 or 171, and MATH 241.

An intermediate course. Electrostatic fields and potentials, dielectrics, and direct currents.

411. (PHYS511) Introduction to Quantum Mechanics I. (A) Prerequisite(s): PHYS 150 or 170, 240 or 250, and MATH 241.

An introduction to the principles of quantum mechanics designed for physics majors and graduate students in physics-related disciplines. The Schrodinger equation operator formalism, central field problem, angular momentum, and spin Application to one-dimensional and central field problems.

362. (PHYS562) Electromagnetism II: Magnetism, Maxwell's Equations, and Electromagnetic Waves. (B) Prerequisite(s): PHYS 361.

A continuation of PHYS 361. Magnetic fields and potentials, electromagnetic induction, Maxwell's equations, electromagnetic waves, and radiation.

364. (PHYS564) Laboratory Electronics. (A) Prerequisite(s): Familiarity with electricity and magnetism at the level of PHYS 102, 141, 151 or 171.

A laboratory-intensive survey of analog and digital electronics, intended to teach students of physics or related fields enough electronics to be comfortable learning additional topics on their own from a reference such as Horowitz and Hill. Specific topics will vary from year to year from the selection of topics listed below. Analog topics may include voltage dividers, impedance, filters, operational amplifier circuits, and transistor circuits. Digital topics may include logic gates, finite-state machines, programmable logic devices, digital-to-analog and analog-to-digital conversion, and microcomputer concepts. Recommended for students planning to do experimental work in physical science.

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401. (PHYS581) Thermodynamics and the Introduction to Statistical Mechanics and Kinetic Theory. (A) Prerequisite(s): PHYS 240 or 250.

Temperature, entropy and generalized potentials, phase transitions, and introduction to ensemble theory and distribution functions.

412. (PHYS512) Introduction to Quantum Mechanics II. (B) Prerequisite(s): PHYS 411.

Perturbation theory, variational principle, application of the quantum theory to atomic, molecular, and nuclear systems, and their interaction with radiation.

414. Laboratory in Modern Physics. (B) Prerequisite(s): PHYS 411.

Supervised experiments in modern physics.

421. (PHYS529) Modern Optics. (J) Prerequisite(s): PHYS 240 or 250 and 362, or permission of instructor.

Interaction of light with matter. Interference and diffraction, absorption and dispersion, stimulated emission and coherence, spectroscopy, non-linear processes.

433. Order of Magnitude Physics. (C) Prerequisite(s): Prerequisites: PHYS 411 or permission from instructor.

This course focuses on the art of estimating physical quantities to within the nearest factor of ten. Problem solving techniques such as dimensional analysis and scaling relations will be covered and applied to a wide range of topics including fluid mechanics, waves and sound, atomic physics, material properties, astrophysics, everyday life, and more. The course is intended for advanced undergraduate students.

499. Senior Honor Thesis. (C) Prerequisite(s): PHYS 412 and 414.

Experimental and theoretical research projects in various areas of physics planned by student in consultation with a member of faculty. A written thesis and an oral presentation and defense are required.

500. (MATH594) Mathematical Methods of Physics. (A)

A discussion of those concepts and techniques of classical analysis employed in physical theories. Topics include complex analysis. Fourier series and transforms, ordinary and partial equations, Hilbert spaces, among others.

501. Introduction to Research. (C) Taken by all first-year graduate students. This is a required seminar that does not carry credit or a grade.

Introduction to research in particle, nuclear, condensed matter and astrophysics. Selected current topics from journals.

503. General Relativity. (C)

This is a graduate level, introductory course in general relativity. The basics of general relativity will be covered with a view to understanding the mathematical background, the construction of the theory, and applications to the solar system, black holes, gravitational waves and cosmology. The latter part of the course will cover some of the basic modern topics in modern cosmology, including the current cosmological model, the accelerating universe, and open questions driving current research.

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505. Introduction to Cosmology. (M) Prerequisite(s): Graduate standing in physics or permission of instructor.

Introduction to physical cosmology emphasizing recent ideas on the very early evolution of the universe. The course will introduce standard big bang cosmology, new theories of the very early universe, and the key observations that have tested and will be testing these ideas. No prior knowledge of astrophysics, cosmology, general relativity, or particle physics will be assumed, although aspects of each will be introduced as part of the course. The course is intended for graduate students and advanced undergraduates.

516. Electromagnetic Phenomena. (B)

Survey of electrodynamics, focusing on applications to research done in the Department. Topics include mathematical structure and relativistic invariance properties of Maxwell equations, tensor methods, and the generation and scattering of radiation, in vacuum and in materials. Applications vary from year to year but include optical manipulation, astrophysical phenomena, and the generalizations from Maxwell's theory to those of other fundamental interactions (strong, electroweak, and gravitational forces).

522. Introduction to Elementary Particle Physics. (M) Prerequisite(s): Permission of instructor required.

An introduction to elementary particles (photons, leptons, hadrons, quarks), their interactions, and the unification of the fundamental forces.

517. Particle Cosmology. (C)

This introduction to cosmology will cover standard big bang cosmology, formation of large-scale structure, theories of the early universe and their observational predictions, and models of dark energy. It is intended for graduate students or advanced undergraduates. No prior knowledge of general relativity or field theory will be assumed, although aspects of each will be introduced as part of the course.

518. Introduction to Condensed Matter Physics. (B) Prerequisite(s): Undergraduate training in quantum mechanics and statistical thermodynamics.

An introduction to condensed matter physics designed primarily for advanced undergraduate and graduate students desiring a compact survey of the field. Band theory of solids, phonons, electrical magnetic and optical properties of matter, and superconductivity.

521. Advanced Laboratory. (B)

Directed experiments in classical and modern physics designed to acquaint the student with modern laboratory instrumentation and techniques.

525. Special Projects. (C) Repetitive credit

Special projects under the direction of a faculty member.

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526. Astrophysical Radiation. (H)

This is a course on the theory of the interaction of light and matter designed primarily for graduate and advanced undergraduate students to build the basic tools required to do research in astrophysics. Topics to be discussed include structure of single- and multi-electron atoms, radiative and collisional processes, spectral line formation, opacity, radiation transfer, analytical and numerical methods, and a selection of applications in astrophysics based on student research interest.

528. Introduction to Liquid Crystals. (C)

Overview of liquid crystalline phases, their elasticity, topology, and dynamics.

530. Modern Optical Physics and Spectroscopy. (K) Prerequisite(s): Working knowledge of electricity and magnetism and quantum mechanics. Graduate level course designed for beginning or intermediate graduate students in physics, but it is likely to be of use to a broader community including beginning graduate students whose research involves light scattering in electrical engineering, chemistry, and biophysics, and advanced undergraduates.

Introduction to contemporary optics. Topics include propagation and guiding of light waves, interaction of electromagnetic radiation with matter, lasers, non-linear optics, coherent transcient phenomena, photon correlation spectroscopies and photon diffusion.

531. Quantum Mechanics I. (A) Prerequisite(s): A minimum of one semester of quantum mechanics at the advanced undergraduate level.

Wave mechanics, complementarity and correspondence principles, semi-classical (WKB) approximation, bound state techniques, periodic potentials, angular momentum, scattering theory, phase shift analysis, and resonance phenomena.

532. Quantum Mechanics II. (B) Prerequisite(s): PHYS 531.

Spin and other two dimensional systems, matrix mechanics, rotation group, symmetries, time independent and time dependent perturbation theory, and atomi and molecular systems.

533. Topics in Cosmology. (M)

This course aims to survey three or four topics of current research interest in cosmology, mostly at the level of review articles. The topics will be covered in greater depth and with more connections to ongoing research than the introductory cosmology course, ASTR 525. The course will be largely accesible to first and second year graduate students. Some exposure to cosmology and general relativity will be helpful but the first two weeks will attempt to bridge that gap. The topic selection will be done in part with input from the students. For the Fall 2009 semester, Dark Energy will be the first topic, Nonlinear Dynamics the likely second topic and Gravitational Lensing (focus on strong lensing) is a possible third topic. A few short problem sets and a presentation/write-up on a topic of interest, based on a review article or selected papers, will make up the course requirement.

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SM 535. (BIOL535) Topics in Theory of Living Systems. (M) Kim, Goulian, Akcay, Balasubramanian, Raj, Mossel.Prerequisite(s): Permission of instructor.

The goal of this course is to discuss broad conceptual theories that address complex phenomena of living systems. Example questions include: what is the molecular architecture of information processing in cells and developing organisms? What is the functional architecture of cooperative organization from molecules in a cell to whole organism social interactions? How is complex multi-factorial information represented in organisms? The course will meet once a week and students will research relevant papers, lead discussions, and generate synopsis of group discussions. At the end of the semester, faculty and students are expected to co-author a review report of the discussed topics.

564. (PHYS364) Laboratory Electronics. (A)

A laboratory-intensive survey of analog and digital electronics, intended to teach students of physics or related fields enough electronics to be comfortable learning additional topics on their own from a reference such as Horowitz and Hill. Specific topics will vary from year to year from the selection of topics listed below. Analog topics may include voltage dividers, impedance, filters, operational amplifier circuits, and transistor circuits. Digital topics may include logic gates, finite-state machines, programmable logic devices, digital-to-analog and analog-to-digital conversion, and microcomputer concepts. Recommended for students planning to do experimental work in physical science.

580. (BCHE580) Biological Physics. (M) Prerequisite(s): MATH 240 and MATH 241 (or equivalent preparation), PHYS 401 or familiarity with statistical mechanics and thermodynamics. Recommended: Basic background in biology.

The course will explore the basic physical principles behind the structure and function of life across many length and time scales (molecule, cell, organism, population). Emphasis will be given on overarching physical themes such as entropy and biological noise, and how they affect the organization of living matter and its emergent properties. Topics may include biopolymers and single molecule biophysics, molecular motors, gene and transcription networks, pattern formation in biological systems, phyllotaxis, neural computing and evolution.

581. (PHYS401) Thermodynamics. (A)

582. (BE 580) Medical Radiation Engineering. (A)

This course in medical radiation physics investigates electromagnetic and particulate radiation and its interaction with matter. The theory of radiation transport and the basic concept of dosimetry will be presented. The principles of radiation detectors and radiation protection will be discussed.

585. (BE 530, BIBB585, NGG 594, PSYC539) Theoretical and Computational Neuroscience. (B)

This course will develop theoretical and computational approaches to structural and functional organization in the brain. The course will cover: (i) the basic biophysics of neural responses, (ii) neural coding and decoding with an emphasis on sensory systems, (iii) approaches to the study of networks of neurons, (iv) models of adaptation, learning and memory, (v) models of decision making, and (vi) ideas that address why the brain is organized the way that it is. The course will be appropriate for advanced undergraduates and beginning graduate students. A knowledge of multi-variable calculus, linear algebra and differential equations is required (except by permission of the instructor). Prior exposure to neuroscience and/or Matlab programming will be helpful.

601. Introduction to Field Theory. (A)

Elementary relativistic quantum field theory of scalar, fermion, and Abelian gauge fields. Feynman Diagrams.

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611. Statistical Mechanics. (A) Prerequisite(s): PHYS 401, 531, or equivalent.

Introduction to the canonical structure and formulation of modern statistical mechanics. The thermodynamic limit. Entropic and depletion forces. Gas and liquid theory. Phase transitions and critical phenomena. The virial expansion. Quantum statistics. Path integrals, the Fokker-Planck equation and stochastic processes.

612. Advanced Statistical Mechanics. (M) Prerequisite(s): PHYS 611 or equivalent.

In depth study of classical and quantum lattice spin models, perturbation techniques, and the renormalization group.

622. Introduction to Elementary Particle Physics. (M) Prerequisite(s): PHYS 601.

Introduction to the phenomenology of elementary particles, strong and weak interactions, symmetries.

632. Relativistic Quantum Field Theory. (M) Prerequisite(s): PHYS 601.

Advanced topics in field theory, including renormalization theory.

633. Relativistic Quantum Field Theory. (M) Prerequisite(s): PHYS 632.

A continuation of PHYS 632, dealing with non-Abelian gauge theories.

661. Solid State Theory I. (M)

This course is intended to be an introductory graduate course on the physics of solids, crystals and liquid crystals. There will be a strong emphasis on the use and application of broken and unbroken symmetries in condensed matter physics. Topics covered include superconductivity and superfluidity.

662. Solid State Theory II. (M)

A continuation of PHYS 661.

696. Advanced Topics in Theoretical Physics. (M)

990. Masters Thesis. (C)

995. Dissertation. (C)

999. Independent Study. (C)