Physics (PHYS)

Course information contained within the Bulletin is accurate at the time of publication in June 2025 but is subject to change. For the most up-to-date course information, please refer to the Course Catalog.

PHYS 0834. Exploring the Cosmos. 3 Credit Hours.
This course is typically offered in Fall, Spring, and Summer I.
This GenEd course will use the fascinating science surrounding the makeup, origin, and future of our Universe to teach the methods by which scientists study nature. The course will also explore the (sometimes controversial) history of the subject, including the intersections of ethics and science as well as the role of different cultures. Note: Students may not receive credit for both PHYS 0846 (The Universe As We Know It) and PHYS 0834 (Exploring the Cosmos).

Course Attributes: GS

Repeatability: This course may not be repeated for additional credits.

PHYS 0839. Powering the Future. 3 Credit Hours.
This course is typically offered in Fall and Spring.
How can we provide inexpensive, safe, environmentally clean energy supplies for the United States and the world as a whole despite rising population and increasing affluence? Study problems of our conventional fossil and nuclear fuel use, and how they might be relieved; explore the physical and technological possibilities for using energy much more efficiently; investigate various renewable-energy sources (such as solar, hydrogen cells, hydropower, and biofuels) that significantly reduce effects on the environment. In the course lab projects, you will research and develop a sustainable energy proposal for your own home, campus, or community. NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and Science & Technology Second Level (SB) for students under Core. Students cannot get credit for this course if they have successfully completed Physics 0939.

Course Attributes: GS, SE, SF, SP

Repeatability: This course may not be repeated for additional credits.

PHYS 0847. How Things Work: The Physics of Everyday Life. 3 Credit Hours.
This course is typically offered in Fall, Spring, and Summer I.
How does a computer store information? Do humans and other animals see color the same way? What is stopping terrorists from developing nuclear weapons? What makes certain musical notes sound good together? What are the facts about global warming? Does the radiation from cell phones cause cancer? A basic knowledge of science is essential to being a smart consumer, an informed voter, and a full participant in society. How Things Work will survey a variety of important, topical questions relevant to technology, the natural world, and current events using lectures combined with illustrative in-class demonstrations such as a rocket powered by water, a magnet made to levitate using superconductors and liquid nitrogen, a crank-operated electric generator, a CT scan machine, and an engine fueled by ice. NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and Science & Technology Second Level (SB) for students under Core.

Course Attributes: GS

Repeatability: This course may not be repeated for additional credits.

PHYS 0872. The Science of Sound. 3 Credit Hours.
This course is typically offered in Fall, Spring, and Summer I.
For living things the ability to hear sounds is an essential tool for survival, and sound is central to speech and languages. In the arts sound also plays a fundamental role, above all in music. The close connection between music, mathematics, and physics has long fascinated scientists. Advances in electronics and computing are revolutionizing the composition, production, and recording of sound. Science of Sound is an interdisciplinary course involving elements of physics, physiology, psychology, music, and engineering. After a four-week introduction to the fundamental physics of sound waves, we will consider human hearing and the human voice; scales, harmony, and sound production by musical instruments; architectural acoustics; and the electronic reproduction of sound. The course includes many in-class demonstrations. NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and Science & Technology Second Level (SB) for students under Core. Students cannot get credit for this course if they have completed Physics 1003: Acoustics.

Course Attributes: GS

Repeatability: This course may not be repeated for additional credits.

PHYS 0939. Honors Powering the Future. 3 Credit Hours.
This course is typically offered in Spring.
How can we provide inexpensive, safe, environmentally clean energy supplies for the United States and the world as a whole despite rising population and increasing affluence? Study problems of our conventional fossil and nuclear fuel use, and how they might be relieved; explore the physical and technological possibilities for using energy much more efficiently; investigate various renewable-energy sources (such as solar, hydrogen cells, hydropower, and biofuels) that significantly reduce effects on the environment. In the course lab projects, you will research and develop a sustainable energy proposal for your own home, campus, or community. (This is an Honors course.) NOTE: This course fulfills a Science & Technology (GS) requirement for students under GenEd and Science & Technology Second Level (SB) for students under Core. Students cannot get credit for this course if they have successfully completed Physics 0839.

Course Attributes: GS, HO, SE, SF, SP

Repeatability: This course may not be repeated for additional credits.

PHYS 1001. Physics: Matter and Motion. 4 Credit Hours.
This course is typically offered in Fall and Spring.
An introduction to the ideas and techniques used in the study of motion. Application to a wide variety of physical systems ranging from air molecules to footballs to black holes. Mostly descriptive using photographic techniques, films, and demonstrations. NOTE: (1) No laboratory. (2) This course can be used to satisfy the university Core Science & Technology First Level (SA) requirement. To determine if this course in combination with another course can satisfy the GenEd Science & Technology requirement, see your advisor. (3) Students who have taken a higher number introductory physics sequence cannot take this course for credit.

Course Attributes: SA

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (any MATH course numbered 0701 to 0702, any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001 (may be taken concurrently), 'Y' in STT2, STAT 1102 (may be taken concurrently), STAT 1902 (may be taken concurrently), 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

PHYS 1004. Introduction to Astronomy. 3 Credit Hours.
This course is typically offered in Fall.
After a description of local space which includes the universe of galaxies, red shift, and the big bang will be discussed. White dwarfs, red giants, pulsars, black holes, and quasars will be covered. The treatment will be mostly descriptive, utilizing slides, NASA films, and several trips to our planetarium. NOTE: (1) No laboratory. (2) This course can be used to satisfy the university Core Science & Technology Second Level (SB) requirement. To determine if this course in combination with another course can satisfy the GenEd Science & Technology requirement, see your advisor.

Course Attributes: SB

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1021, any MATH course numbered 1022 to 3080 (may be taken concurrently), 'Y' in MC5, 'Y' in MC6, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, or 'Y' in MC6T)

PHYS 1005. Light, Art, and Nature. 4 Credit Hours.
This course is typically offered in Spring.
An introduction to the properties of light, whether interpreted as rays, waves, or photons. Discussion of the basic ideas of geometric and wave optics, with application to the analysis of photography, color, vision, and modern physics. Emphasis is on factors that permit the artist and observer to understand and more fully control the design and interpretation of images of all kinds. Demonstrations, experiments, and video and computer simulations to analyze signals received by the eyes or instruments. NOTE: (1) Course is primarily designed for students interested in the visual arts, but is open to anyone. Minimal mathematics. (2) This course can be used to satisfy the university Core Science & Technology First Level (SA) requirement.

Course Attributes: SA

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (any MATH course numbered 0701 to 0702, any MATH course numbered 0800 to 4999 (may be taken concurrently), 'Y' in MC3, 'Y' in MC4, 'Y' in MC5, 'Y' in MC6, 'Y' in MC3A, 'Y' in MC6A, STAT 1001 (may be taken concurrently), 'Y' in STT2, STAT 1102 (may be taken concurrently), STAT 1902 (may be taken concurrently), 'Y' in MATW, 'Y' in MC3S, 'Y' in MC3D, 'Y' in MC3O, 'Y' in MC3T, or 'Y' in MC6T)

PHYS 1006. Medical Physics. 3 Credit Hours.
This course is not offered every year.
Medical Physics is an introductory science elective course that is open to students with little exposure to science or mathematics. With nominal (high school level) mathematics preparation, students can learn how basic principles of physics are utilized in medical processes. Topics to be examined include: the nature of radiation, radiation exposure, nuclear medicine, CT and MR imaging, and ultrasound techniques.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1021, any MATH course numbered 1022 to 3080 (may be taken concurrently), 'Y' in MC5, 'Y' in MC6, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, or 'Y' in MC6T)

PHYS 1007. Science & Science Fiction in Film. 3 Credit Hours.
This course is typically offered in Spring.
This course takes a captivating look at physical phenomena depicted in a collection of popular science fiction films. These include Deep Impact (1998) in which Earth is threatened by a giant comet, The Peacemaker (1998) where a terrorist's atomic bomb is planted in New York City, I Robot (2007) with a detective fighting to prevent a takeover of the human race by robots, and Contact (1997) featuring an astronomer who discovers the first real message from an alien civilization. Other films deal with global warming, astronomy, electricity and magnetism.

There are no in-person meetings of this class. Students discuss films on the course web site and submit answers to weekly questions via the Internet at times that are individually convenient for each student. E-Mail the course instructor, Dr. Dubeck, at ldubeck@temple.edu for access to the course web site.

Repeatability: This course may not be repeated for additional credits.

PHYS 1008. Physics Seminar I. 1 Credit Hour.
This course is typically offered in Fall.
Physics Seminar I serves as a survey introduction to physics of the 21st century and the numerous, diverse career paths followed by those with a physics degree. The intent of this course is to build a community of physics majors while they are at the beginning of their typical course of study, with the introductory physics courses providing common points of discussion. Students will attend talks, lab tours and open-ended question-and-answer roundtable discussions given by physics degree holders. One section of the class will focus on speakers from across the spectrum of physics related research at Temple University, including solid state, optical, nuclear, medical and chemical physics. The course will also provide a venue for those from non-academic sectors where the physics degree is highly valued, such as national laboratories, industrial research, patent law, finance and others. This is a required course for BS and BA in Physics and BS in Physics with Teaching majors and is recommended for other physics related majors.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1021 (may be taken concurrently), PHYS 1061 (may be taken concurrently), PHYS 1961 (may be taken concurrently), PHYS 2021 (may be taken concurrently), or PHYS 2921 (may be taken concurrently))

PHYS 1021. Introduction to General Physics I. 0 or 4 Credit Hours.
This course is typically offered in Fall, Spring, and Summer I.
This course is an algebra-based introduction to physics. Topics covered in this course include mechanics, waves and oscillations, and elements of thermodynamics. Biological applications discussed where appropriate.

NOTE:

(1) Completing a 2 semester physics sequence will satisfy your Science and Technology (GS) GenEd requirements. (2) Two sections are required for this course: a 0.0 credit Laboratory section and the 4.0 credit Lecture & Recitation section. The course number for the Lecture & Recitation are the same for the Laboratory, but have unique section numbers. (3) Some pre-professional health programs require a calculus-based course such as Physics 1061.

Course Attributes: SA

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1021, any MATH course numbered 1022 to 3080 (may be taken concurrently), 'Y' in MC5, 'Y' in MC6, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, or 'Y' in MC6T)

PHYS 1022. Introduction to General Physics II. 0 or 4 Credit Hours.
This course is typically offered in the Fall, Spring, and Summer II.
This second semester algebra-based introductory physics course is a follow-up to Physics 1021. Topics covered in this course include electricity and magnetism, optics, atomic, molecular, and nuclear physics. Biological applications discussed where appropriate.

NOTE:

(1) Completing a 2 semester physics sequence will satisfy your Science and Technology (GS) GenEd requirements. (2) Two sections are required for this course: a 0.0 credit Laboratory section and the 4.0 credit Lecture & Recitation section. The course numbers for the Lecture & Recitation are the same for the Laboratory, but have unique section numbers. (3) Some pre-professional health programs require a calculus-based course such as Physics 1062.

Course Attributes: SB

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1011, PHYS 1021, PHYS 1061, PHYS 2021, or PHYS 2921)

PHYS 1031. Physics I for Pre-Health Postbaccalaureates. 0 or 4 Credit Hours.
This course is typically offered in Fall.
This is the first semester of general physics for post-baccalaureate students. It includes a quantitative introduction to kinematics, dynamics, work, energy, momentum, static equilibrium, fluids, vibrations, waves, sound, temperature, kinetic theory, heat, and the laws of thermodynamics. Special emphasis is given to applications of these topics to health sciences.

Repeatability: This course may not be repeated for additional credits.

PHYS 1032. Physics II for Pre-Health Postbaccalaureates. 0 or 4 Credit Hours.
This course is typically offered in Spring.
This is the second semester of general physics for post-baccalaureate students. It includes a quantitative introduction to electricity and magnetism, optics, atomic, molecular, and nuclear physics. Special emphasis is given to applications of these topics to health sciences. Note: To register for this course, students must satisfy the prerequisite or obtain permission from the program director.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in PHYS 1031.

PHYS 1061. Elementary Classical Physics I. 0 or 4 Credit Hours.
This course is typically offered in Fall, Spring, and Summer I.
Calculus-based introductory physics focused on developing algorithmic problem-solving skills and intended as a preparation for advanced courses in physics as well as preparation for further study in upper division science and engineering. Topics include elementary vector algebra, one-dimensional motion, particle dynamics, work and energy, conservation of energy, conservation of linear momentum, collisions, rotational kinematics and dynamics, conservation of angular momentum, oscillations, waves, and gravitation.

NOTE:

(1) By completing a 2 semester physics sequence you will satisfy your Science and Technology (GS) GenEd requirements. (2) Students cannot receive credits for both Physics 1061 and 2021. (3) Two sections are required for this course: a 0.0 credit Laboratory section and the 4.0 credit Lecture & Recitation section. The course numbers for the Lecture & Recitation are the same for the Laboratory, but have unique section numbers. (4) Some pre-health programs require a calculus-based course such as this course, Physics 1061.

Course Attributes: SA

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (MATH 1041 (C or higher; may be taken concurrently), MATH 1941 (C or higher; may be taken concurrently), MATH 1038 (C or higher; may be taken concurrently), MATH 1042 (may be taken concurrently), MATH 1044 (may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MA06, 'Y' in MATW, 'Y' in CRMA08, or 'Y' in CRMA21)

PHYS 1062. Elementary Classical Physics II. 0 or 4 Credit Hours.
This course is typically offered in Fall, Spring, and Summer II.
This second semester calculus-based introductory physics course is a follow-up to Physics 1061. The course focuses on developing algorithmic problem-solving skills and is intended as a preparation for advanced courses in physics as well as preparation for further study in upper division science and engineering. Topics include temperature, heat and the first law of thermodynamics, kinetic theory of gases, entropy and the second law of thermodynamics, electrical charges, the electric field, Gauss's Law, electrostatic potential, capacitors and dielectrics, current, resistance, Kirchhoff's laws, the magnetic field, Ampere's Law, Faraday's Law, inductance, geometrical optics, and interference and diffraction of light.

NOTE:

(1) By completing a 2 semester physics sequence you will satisfy your Science and Technology (GS) GenEd requirements. (2) Students cannot receive credit for both Physics 1062 and 2022. (3) Two sections are required for this course: a 0.0 credit Laboratory section and the 4.0 credit Lecture & Recitation section. The course numbers for the Lecture & Recitation are the same for the Laboratory, but have unique section numbers. (4) Some pre-health programs require a calculus-based course such as this course, Physics 1062.

Course Attributes: SB

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1061, PHYS 2021, or PHYS 2921) and (MATH 1042 (may be taken concurrently), MATH 1044 (may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), or 'Y' in MATW)

PHYS 1083. Directed Reading/Study. 1 to 4 Credit Hour.
This course is typically offered in Fall, Spring, and Summer I.
Independent study in physics. NOTE: This course may be repeated for credit.

Repeatability: This course may be repeated for additional credit.

PHYS 1454. Observational Astronomy Through Design. 4 Credit Hours.
This course studies astronomy through direct measurements made by students through devices they design and produce through the Temple University Lorretta C. Duckworth makerspace. Weekly classroom meetings will verse students in basic astronomy, use of the makerspace, and transition to active discussions as observations accumulate. Students will become familiar with basic instrument design, data acquisition, and data analysis as they observe the Sun, Moon, bright stars, planets (when visible) and time-sensitive targets of opportunity. Students will be able to propose their own observational targets as well. Note: Regular observations will need to be made at regular intervals outside of class time.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1021, any MATH course numbered 1022 to 3080 (may be taken concurrently), 'Y' in MC5, 'Y' in MC6, 'Y' in MC6A, STAT 1001, 'Y' in STT2, STAT 1102, STAT 1902, 'Y' in MATW, or 'Y' in MC6T)

PHYS 1961. Honors Elementary Classical Physics I. 0 or 4 Credit Hours.
This course is typically offered in Fall.
This undergraduate level course is intended for Honors students majoring in physics and related fields. Physics 1961 is the first part of a two-semester course in classical physics starting with classical mechanics for Physics 1961 and electricity and magnetism for Physics 1962. Topics for Physics 1961 include one- and two-dimensional motion; forces and particle dynamics, work and energy, conservation of energy, linear momentum, and angular momentum; collisions, rotational kinematics and dynamics, gravitation, oscillations, waves, and fluid dynamics. This course differs from the Physics 1061 course in the number of topics and a more mathematical treatment and discussion. A strong background in algebra and trigonometry and some understanding of vector algebra is required. A math review will take place during the first week of classes including basic elements of algebra, trigonometry, vector algebra and some calculus. This course is taught in the Studio Physics format combining elements of lecturing and recitation supplemented with a separate, but integrated lab. Each student is assigned to a certain lecture section (Lecture plus Recitation) and lab section. This course requires registration for a 0.0 credit Laboratory section in addition to the 4.0 credit Lecture and Recitation section. The Laboratory sections corresponding to a course are listed under the same course number as the Lecture and Recitation sections, but have unique section numbers.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (MATH 1941 (C or higher; may be taken concurrently), MATH 1041 (C or higher; may be taken concurrently), MATH 1038 (C or higher; may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1042 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MA06, 'Y' in MATW, 'Y' in CRMA08, or 'Y' in CRMA21)

PHYS 1962. Honors Elementary Classical Physics II. 0 or 4 Credit Hours.
This course is typically offered in Spring.
This undergraduate level course is intended for Honors students majoring in physics and related fields. Physics 1962 is the second part of a two semester course in classical physics starting with classical mechanics for Physics 1961 and electricity and magnetism for Physics 1962. Topics for Physics 1962 include temperature, heat and the first law of thermodynamics, kinetic theory of gases, entropy and the second law of thermodynamics, electrical charges, the electric field, Gauss's Law, electrostatic potential, capacitors and dielectrics, current, resistance, the magnetic field, Ampere's Law, Faraday's Law, inductance, geometrical optics, and interference and diffraction of light. This course differs from Physics 1062 in the number of topics and a more mathematical treatment and discussion. A strong background in algebra and trigonometry along with elementary understanding of vector algebra is required. Basic understanding of calculus is helpful. A math review will take place during the first week of classes including basic elements of vector algebra and calculus, in particular vector calculus. This course is taught in the Studio Physics format combining elements of lecturing and recitation supplemented with a separate, but integrated lab. Each student is assigned to a certain lecture section (Lecture plus Recitation) and lab section. This course requires registration for a 0.0 credit Laboratory section in addition to the 4.0 credit Lecture and Recitation section.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 1942 (may be taken concurrently), MATH 1042 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), or 'Y' in MATW) and (PHYS 1961, PHYS 1061, PHYS 2921, or PHYS 2922)

PHYS 2021. General Physics I. 0 or 4 Credit Hours.
This course is typically offered in Fall.
Calculus-based introductory physics. Topics include mechanics, gravitation, energy conservation, fluids and waves. Biological applications discussed where appropriate. NOTE: By completing a 2 semester physics sequence you will satisfy your Science and Technology (GS) GenEd requirements. Students cannot receive credits for both Physics 1061 and 2021. This course is an option for pre-health, neuroscience and genomic medicine majors.

Two sections are required for this course. This course requires registration for a 0.0 credit Laboratory section in addition to the 4.0 credit Lecture & Recitation section. The Laboratory sections corresponding to a course are listed under the same course number as the Lecture & Recitation sections, but have unique section numbers.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (MATH 1042 (may be taken concurrently), MATH 1044 (C or higher; may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MATW, or 'Y' in CRMA10)

PHYS 2022. General Physics II. 0 or 4 Credit Hours.
This course is typically offered in Spring.
Normally follows Physics 2021. Calculus-based introductory physics. Topics include electricity and magnetism, optics, atomic, molecular, and nuclear physics. Biological applications discussed where appropriate. NOTE: By completing a 2 semester physics sequence you will satisfy your Science and Technology (GS) GenEd requirements. Students cannot receive credits for both Physics 1062 and 2022. This course is an option for pre-health, neuroscience and genomic medicine majors.

Two sections are required for this course. This course requires registration for a 0.0 credit Laboratory section in addition to the 4.0 credit Lecture & Recitation section. The Laboratory sections corresponding to a course are listed under the same course number as the Lecture & Recitation sections, but have unique section numbers.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (PHYS 1061, PHYS 2021, or PHYS 2921) and (MATH 1042 (may be taken concurrently), MATH 1044 (C or higher; may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MATW, or 'Y' in CRMA10)

PHYS 2063. Wave Physics. 3 Credit Hours.
This course is typically offered in Fall.
This course uses oscillatory phenomena to form a bridge from first year physics and mathematics to more complex physics topics. A thorough mathematical treatment of mechanical vibrations and alternating current circuits is followed by a description of waves propagating in one dimension. This treatment will include techniques for solving linear ordinary and partial differential equations. Strings and sound waves are used to illustrate transverse and longitudinal wave phenomena. Next, this is extended into electromagnetic waves in three dimensions, as well as transmission lines. Fourier methods are introduced, followed by waves and interference phenomena in optical systems. Applications to geometrical and physical optics are described and analyzed. The end of the course contains introductions to quantum mechanical waves and also to nonlinear phenomena.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (PHYS 1062, PHYS 1962, PHYS 2022, PHYS 2922 (C or higher), or 'Y' in CRPH01) and (MATH 1042 (C or higher), MATH 1942 (C or higher), MATH 1951 (C or higher), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MATW, 'Y' in CRMA09, or 'Y' in CRMA11)

PHYS 2083. Directed Reading/Study. 2 to 4 Credit Hours.
This course is typically offered in Fall, Spring, Summer I and Summer II.
Undergraduate independent study in physics. NOTE: This course may be repeated for credit.

Repeatability: This course may be repeated for additional credit.

PHYS 2101. Classical Mechanics. 3 Credit Hours.
This course is typically offered in Spring.
Newton's laws of motion, one-dimensional motion, second order differential equations, harmonic oscillators (damped, forced), vector analysis, conservation laws, three-dimensional motion, central forces, motion in electromagnetic fields, collisions, center-of-mass transformations, two-body problem, numerical/computer solutions, coupled oscillators. Rigid body rotation, statics, elasticity, fluid equilibrium, gravitation.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1062, PHYS 1962, PHYS 2022, or PHYS 2922) and (MATH 2043 or MATH 2943)

PHYS 2502. Mathematical Physics. 4 Credit Hours.
This course is typically offered in Spring.
Infinite series, determinants and matrices, ordinary differential equations, vector analysis, curvilinear coordinate systems, Fourier series, properties of Legendre and Bessel functions, partial differential equations. Laboratory portion of course provides training in use of Mathematica, an integrated environment for technical computing, to solve problems in mathematical physics. NOTE: No prior computer experience is necessary.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1062, PHYS 1962, PHYS 2022, or PHYS 2922) and (MATH 2043 or MATH 2943)

PHYS 2511. Scientific Computing I. 1.5 Credit Hour.
This course is typically offered in Spring.
An introduction to computing as a tool for solving scientific problems. No previous programming experience is assumed. Students completing this course will be able to write their own computer programs to solve introductory science problems, and will be prepared to understand more advanced techniques. Topics include the basic computer science needed to understand hardware and software processes, program organization and debugging, spreadsheet programs (Excel), interpreted programming languages (Python), compiled programming languages (C++), basic numerical methods for solving physics problems, basic error analysis, and information visualization techniques.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1021, PHYS 1061, PHYS 1961, PHYS 2021, or PHYS 2921) and (MATH 1021, any MATH course numbered 1022 to 3080, 'Y' in MC5, 'Y' in MC6, 'Y' in MC6A, 'Y' in MA03, 'Y' in MATW, or 'Y' in MC6T)

PHYS 2796. Introduction to Modern Physics. 4 Credit Hours.
This course is typically offered in Fall and Spring.
The course will provide an introduction to the special theory of relativity and quantum mechanics, with emphasis of their applications to atomic, molecular and solid state physics. The course is calculus based and writing intensive; it relies heavily on problem solving and technical writing.

Course Attributes: WI

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1062, PHYS 1962, PHYS 2022, or PHYS 2922) and (MATH 2043 (may be taken concurrently) or MATH 2943 (may be taken concurrently))

PHYS 2921. Honors General Physics I. 0 or 4 Credit Hours.
This course is typically offered in Fall.
This is the honors version of Physics 2021. Topics include mechanics, gravitation, energy conservation, fluids and waves. Biological applications discussed where appropriate.

Two sections are required for this course. This course requires registration for a 0.0 credit Laboratory section in addition to the 4.0 credit Lecture & Recitation section. The Laboratory sections corresponding to a course are listed under the same course number as the Lecture & Recitation sections, but have unique section numbers.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (MATH 1042 (may be taken concurrently), MATH 1044 (C or higher; may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MATW, or 'Y' in CRMA10)

PHYS 2922. Honors General Physics II. 0 or 4 Credit Hours.
This course is typically offered in Spring.
This is the honors version of Physics 2022 and normally follows Physics 2921. Topics include electricity and magnetism, optics, atomic, molecular, and nuclear physics. Biological applications discussed where appropriate.

Two sections are required for this course. This course requires registration for a 0.0 credit Laboratory section in addition to the 4.0 credit Lecture & Recitation section. The Laboratory sections corresponding to a course are listed under the same course number as the Lecture & Recitation sections, but have unique section numbers.

Course Attributes: HO

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (PHYS 1061, PHYS 2021, or PHYS 2921) and (MATH 1042 (may be taken concurrently), MATH 1044 (C or higher; may be taken concurrently), MATH 1942 (may be taken concurrently), MATH 1951 (may be taken concurrently), any MATH course numbered 2043 to 3080 (may be taken concurrently), 'Y' in MATW, or 'Y' in CRMA10)

PHYS 3000. Contemporary Physics. 1 or 2 Credit Hour.
This course is not offered every year.
This introduces students to an active research area in Physics, in particular an area currently represented in the Temple Physics Department. This includes both theoretical and experimental physics topics. Examples would include computationally intensive techniques, research connected with national facilities used by the faculty, and emerging new fields based on the recent discoveries. The format will reflect the specific outcomes of the course syllabus as offered. As this is a low-credit course, the course may NOT be used to fulfill a Physics or Science elective in any major. Students must have completed PHYS 2511 and PHYS 2796. Other prerequisites will depend on the particular topic.

Repeatability: This course may be repeated for additional credit.

Pre-requisites: Minimum grade of C- in PHYS 2511 and PHYS 2796.

PHYS 3083. Directed Reading/Study. 3 Credit Hours.
This course is typically offered in Fall, Spring, Summer I and Summer II.
This course offers the opportunity for more advanced independent study. NOTE: This course may be repeated for credit.

Repeatability: This course may be repeated for additional credit.

PHYS 3091. Research Methods. 3 Credit Hours.
This course is typically offered in Spring.
Research Methods is required for all of the TUteach with Teaching majors. It is one of several content courses specially designed to meet the needs of future teachers. Sections meet two hours per week for non-traditional, interactive lectures and two hours per week for lab. The course is cross-listed in Biology, Chemistry, Earth and Environmental Science, and Physics. The goals of the course are (1) to provide students with the tools that scientists use to solve scientific problems; (2) to give students the opportunity to use these tools in a laboratory setting; (3) to make students aware of how scientists communicate with each other through peer-reviewed scientific literature; and (4) to enable students to understand how scientists develop new knowledge and insights, the most important of which are eventually presented in textbooks and taught in conventional science classes. Students design and carry out four independent inquiries, which they write up and present in the manner that is common in the scientific community. The inquiries incorporate mathematics and the various science disciplines, thus the team of instructors teaching this course have expertise in different disciplines and are available to supervise all students as they work on their inquiries in the lab. The combination of Research Methods and the TUteach course "Perspectives on Science and Mathematics" (Philosophy 2196) provides prospective science and mathematics teachers with an in-depth understanding of how the scientific enterprise works. NOTE: Physics 3091 is only available for major credit in the Physics with Teaching BS program.

Repeatability: This course may be repeated for additional credit.

Pre-requisites: Minimum grade of C- in (SCTC 1289 or SCTC 1389)

PHYS 3101. Analytical Mechanics. 3 Credit Hours.
This course is typically offered in Fall.
Moving coordinate systems, three-body problems, partial differential equations, wave propagation (strings, membranes, fluids), boundary value problems, normal modes, fluid equations of motion, viscosity; virtual work, Lagrange's equations, Hamilton's equations; angular momentum of a rigid body, inertia tensor, Euler's equations, Euler angles, tops and gyroscopes, small vibrations.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in PHYS 2101.

PHYS 3301. Electricity and Magnetism. 4 Credit Hours.
This course is typically offered in Fall.
Electrostatics, magnetostatics, microscopic interpretation of polarization P and magnetization M, electrostatic and magnetostatic energy, Faraday's Law, self and mutual inductance, magnetic circuits; integral and differential forms of Gauss, Ampere, and Faraday laws; AC circuits; introduction to the displacement current and Maxwell's equations. Laboratory portion of the course provides investigation on DC and AC circuits, bridge circuits, sources of emf, Hall effect, and operational amplifier circuits.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1062, PHYS 1962, PHYS 2022, or PHYS 2922) and (MATH 2043 or MATH 2943)

PHYS 3302. Classical Electromagnetism. 3 Credit Hours.
This course is typically offered in Spring.
Solutions to the equations of Poisson and Laplace; multipole expansions; electrostatic and magnetostatic energy, forces, and torques; Maxwell's equations; the wave equation; radiation fields, Poynting's Theorem, microwave and optical waveguides.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in PHYS 3301 and (PHYS 2502 or MATH 4041)

PHYS 3424. Introduction to Astrophysics. 3 Credit Hours.
This course will cover details of basic astronomy, introductory stellar physics (including stellar structure, fusion processes, stellar evolution, and stellar remnants), the properties of galaxies and dark matter, introductory cosmology and general relativity.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in PHYS 2796 and (MATH 2043, MATH 2943, 'Y' in MA08, or 'Y' in CRMA12)

PHYS 3511. Scientific Computing II. 1.5 Credit Hour.
This course is typically offered in Fall.
This course in computational techniques for solving physical problems is for students who have taken PHYS 2511 Scientific Computing I or had previous programming experience. Topics include iterative solutions such as Runge-Kutta, solutions to coupled differential equations, common problems and algorithms in physics, Monte Carlo techniques, Stochastic methods, and Object Oriented Programming (C++).

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (PHYS 1022, PHYS 1062, PHYS 1962, PHYS 2022, or PHYS 2922) and (MATH 1042, MATH 1044 (C or higher), MATH 1942, MATH 1951, any MATH course numbered 2043 to 3080, 'Y' in MATW, or 'Y' in CRMA10)

PHYS 3701. Introduction to Quantum Mechanics I. 3 Credit Hours.
This course is typically offered in Spring.
Introduction to the formalism of Quantum Mechanics. Schrodinger equation and its solutions in one-, two-, and three-dimensions. Hermitian operators, eigenfunctions and eigenvalues. Angular momentum and Spin. Approximation methods including the variational principle and perturbation theory. Time-dependent potentials and transition rate. Theory of scattering.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 2701 or PHYS 2796) and (PHYS 2502 or MATH 4041)

PHYS 3702. Optical and Electronic Properties of Materials. 4 Credit Hours.
This course is typically offered in the Fall.
Primarily for B.S. in Materials Science and Physics students, but open to others.

This course will introduce the basic theory behind and examine the process/structure/property/performance relationships that dictate the optical and electronic properties of materials with an emphasis on quantum materials, thin films and materials for energy storage and production. The classroom component will also describe the techniques commonly used in research and industrial settings to characterize these material properties, as well as their relationship to mechanical and thermal properties. Students will gain significant hands-on experience with these materials characterization techniques in the laboratory component of the course.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 2043 or MATH 2943) and (PHYS 2796 or CHEM 3302)

PHYS 3703. Quantum Materials: Properties, Characterization and Application. 4 Credit Hours.
This course is typically offered in the Spring.
Primarily for B.S. in Materials Science and Physics students, but open to others.

This course introduces exotic properties occurring in so-called quantum materials that can offer opportunities for applications in information and clean energy technology. The materials that host such properties are therefore at the forefront of solid state research. The goal is building a phenomenological understanding of topics including the origin of magnetism and superconductivity, interactions and long range order, graphene and two-dimensional systems and heterostructures and their applications. The course will have a lab component aimed at providing hands-on experience with fabrication and characterization of quantum materials.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (MATH 2043 or MATH 2943) and (PHYS 2796 or CHEM 3302)

PHYS 4000. Special Topics in Physics. 3 or 4 Credit Hours.
This course is not offered every year.
This course covers an active research area in Physics, in particular an area currently represented in the Temple Physics Department. This includes both theoretical and experimental physics topics. Examples would include computationally intensive techniques, research connected with national facilities used by the faculty, and emerging new fields based on the recent discoveries. The format will reflect the specific outcomes of the course syllabus as offered. Students must have completed PHYS 2502 and PHYS 2796. Other prerequisites will depend on the particular topic.

Repeatability: This course may be repeated for additional credit.

PHYS 4091. Undergraduate Research. 2 to 3 Credit Hours.
This course is typically offered in Fall, Spring, Summer I and Summer II.
This course offers the opportunity for undergraduate research in physics.

Repeatability: This course may be repeated for additional credit.

PHYS 4101. Thermal Physics. 3 Credit Hours.
This course is typically offered in Fall.
The three laws of thermodynamics; thermodynamic potentials; ideal and non-ideal gases; phase transitions; chemical equilibrium. Introduction to equilibrium statistical mechanics; statistical definition of entropy; applications to fluids, magnetic systems, the ideal quantum gas. Prior to Fall 2017, this course was named "Thermodynamics and Kinetic Theory". Students may only earn credit once for PHYS 4101.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 1062, PHYS 1962, PHYS 2022, or PHYS 2922) and (MATH 2043 or MATH 2943)

PHYS 4301. Electronics. 3 Credit Hours.
This course is typically offered in Spring of odd years.
Basic circuit ideas, Thevenin/Norton theorems, input/output impedance, diodes, transistors, feedback, operational amplifiers, elements of digital electronics, transducers for physical measurements. NOTE: Course offered on odd-numbered years.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in PHYS 3301.

PHYS 4302. Optics. 3 Credit Hours.
This course is typically offered in Fall.
The emphasis of this course is on physical and laser optics. Topics include review of geometric optics, matrix methods in paraxial optics, fiber optics, wave equations, superposition and interference of light, diffraction, polarization of light, coherence, laser operation, characteristics of laser beams and selected modern optics applications.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 2701, PHYS 2796, CHEM 3301, or CHEM 3302)

PHYS 4501. Computational Design of Novel and Quantum Materials. 3 Credit Hours.
This course is typically offered in the Fall.
Primarily for B.S. in Materials Science and Physics students, but open to others.

The course provides state-of-the-art computational and data-driven approaches for accelerating the discovery, synthesis, and development of novel functional materials and solid-state materials with exotic quantum phases. It begins with a brief overview of current practical computational tools for materials design in the field. Data-driven approaches, such as machine learning and materials database, will be introduced as complementary tools to discover and design novel materials. The course will describe ways to utilize both computational and data-centric approaches to enable the "virtual design" of functional materials. Applications based on both molecule systems and solid-state materials will be discussed. Machine learning and computational practices will be provided through Python-based weekly projects. Topics that will be covered in the course: computational methods for molecules and solid-state materials, data-driven material design approaches (database query, simulation input/output management, workflows), shallow and deep machine learning models for material property predictions, design of quantum materials for quantum information science and technologies.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in SCTC 1013 and PHYS 3703.

PHYS 4502. Theoretical/Computational Materials Science. 3 Credit Hours.
This course is typically offered in the Spring.
Primarily for B.S. in Materials Science and Physics students, but open to others.

The course explains how quantum mechanics can predict what materials can exist, and with what properties, and thus can be used to design useful new materials on the computer. It begins with a summary of the quantum mechanics of one-electron and of interacting many-electron systems. This leads up to the Kohn-Sham density functional theory, which describes the ground-state energy and density of a many-electron system in a way that is formally exact, by solving a set of self-consistent one-electron Schrodinger equations. The computational efficiency and predictive accuracy of approximations to the exact density functional for the exchange-correlation energy have made this approach the most widely used method in physics or chemistry. Simple approximations are explained, and their successes and failures for materials prediction are summarized. Briefly described are methods that can be more accurate but more computationally expensive, including correlated wavefunction methods like quantum Monte Carlo and quasi-particle methods like GW.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in PHYS 3703.

PHYS 4511. Scientific Computing III. 1.5 Credit Hour.
This course is typically offered in Spring.
This course in computational techniques for solving physical problems is for students who have taken PHYS 3511 Scientific Computing II or had extensive previous programming experience. This course covers advanced topics in computational problem solving such as machine learning, probability density function optimization, and Baysian statistical methods, GPU programming. The instructor may add additional topics of interest.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- (except where noted) in (PHYS 1022, PHYS 1062, PHYS 1962, PHYS 2022, or PHYS 2922) and (MATH 1042, MATH 1044 (C or higher), MATH 1942, MATH 1951, any MATH course numbered 2043 to 3080, 'Y' in MATW, or 'Y' in CRMA10)

PHYS 4701. Introduction to Solid State Physics. 3 Credit Hours.
This course is typically offered in Spring of even years.
Elementary theory of the solid state. Survey of mechanical, thermal, optical, electrical, and magnetic properties of solids. NOTE: Course offered on even-numbered years.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in PHYS 3701.

PHYS 4702. Introduction to Quantum Mechanics II. 3 Credit Hours.
This course is typically offered in Fall.
Applications of Quantum Mechanics to physical systems. Atomic and molecular structure, spectra, and selection rules. Condensed matter systems including periodic solids. Quantum statistical phenomena. Properties of atomic nuclei, radioactive decays, and nuclear reactions. Elementary particles and their interactions.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in PHYS 3701.

PHYS 4796. Experimental Physics. 3 Credit Hours.
This course is typically offered in Spring.
An intermediate laboratory course with an introduction to data analysis and error estimation. Students independently perform two or three experiments, with suitable reports. NOTE: Capstone writing course.

Course Attributes: WI

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 2701 or PHYS 2796)

PHYS 4801. Atomic, Molecular and Optical Physics. 4 Credit Hours.
This course on Atomic, Molecular and Optical (AMO) Physics will provide upper level undergraduate students a preparation for research in AMO science through building a solid foundation for interaction of light with atoms and molecules. The course includes a review of atomic structure, interaction of atoms and molecules with external fields, semiclassical theory of light-matter interaction, introduction to dressed quantum states by laser radiation, experimental techniques of laser spectroscopy, cooling and trapping of atoms, Bose-Einstein condensation, nonlinear phenomena with light and ultrafast laser science. The computational component of the course involves using molecular potential energy functions to solve the radial Schroedinger equation for diatomic molecules. This component of the course is introduced in the context of labs in the laser laboratory of the AMO Physics group in SERC. The resulting wavefunctions can be used with theoretical electronic transition dipole moments to calculate fundamental parameters in the interaction of light with matter such as Einstein's coefficients for absorption of light, stimulated and spontaneous emission of light as well as Rabi frequencies. Note: Graduate students taking this course should have completed PHYS 5301 instead of PHYS 3301. Similarly Graduate students should have completed PHYS 5701 or CHEM 5301 instead of PHYS 3701.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C- in (PHYS 2796, CHEM 3301, or CHEM 3302), (PHYS 3301 or PHYS 4302), and PHYS 3701 (may be taken concurrently)

PHYS 5000. Topical Seminar. 3 Credit Hours.
This course considers special topics in Physics, not considered in our other courses. The level of this course is graduate, but the content could be accessible to upper-level undergraduate Physics majors.

Repeatability: This course may be repeated for additional credit.

PHYS 5001. Introduction to Quantum Computing. 3 Credit Hours.
This course will give an elementary introduction to some basics of quantum information and quantum computing that are accessible to not only physicists but also people with a variety of backgrounds. It will introduce the students to the latest scientific and technological advancement, and prepare for further study and/or initiating research if one wishes to pursue in this field.

Repeatability: This course may not be repeated for additional credits.

PHYS 5002. Physics Research and Ethics. 1 Credit Hour.
This course will introduce new graduate students to the diverse faculty research programs in physics at Temple, and help them to make an informed choice of research advisor and topic. It will also make sure that all students are aware of the ethical code for physicists. The course will meet for one hour per week. In the first 3 to 5 weeks, the instructor will lecture on the ethical and etiquette responsibilities of students, teachers, and researchers in physics. In each of the next 10 to 12 weeks, a faculty volunteer will explain his or her research program and opportunities for student participation in it. A faculty member may also nominate a graduate student to speak to the class. Former graduate students who hold physics research positions could also be invited to speak. Students will have ample opportunity to ask questions. They will be required to turn in one-page summaries of the lectures for grading by the lecturers; this should measure the students' understanding and improve their writing skills. A possible text for the ethics lectures would be the National Academy of Sciences booklet "On Being a Scientist".

Repeatability: This course may not be repeated for additional credits.

PHYS 5101. Analytical Mechanics. 3 Credit Hours.
Variational principles, Lagrange's and Hamilton's equations; canonical transformations; small oscillations; dynamics of particles, rigid bodies, strings and membranes; hydrodynamics; chaos in deterministic systems.

Repeatability: This course may not be repeated for additional credits.

PHYS 5103. Ionizing Radiation on Living Systems. 3 Credit Hours.
This course will include topics related to the study of the action of ionizing radiation on living things and more specifically the human body. Some of the topics covered are: cellular response to radiation, radiation carcinogenesis, radiation effects on the developing embryo and fetus, and whole-body radiation effects. Additional emphasis is given on the effect of ionizing radiation in the context of radiation treatments and in particular on factors affecting the therapeutic ratio.

Repeatability: This course may not be repeated for additional credits.

PHYS 5201. Physics of Medical Imaging I. 3 Credit Hours.
This is an introductory course in the physics of Medical Imaging. The goal of the course is to allow the students to gain insight of how modern imaging systems work and what they can tell us about the function and health of our body. The course will discuss how various physics concepts are applied to medicine and state of the art diagnostic radiology and radiotherapy techniques. It is the first of a series of two courses and will be primarily focused on the interaction of radiation with matter and all the physics principles that are involved with applications in medicine. Examples include x-rays, tomography, radiation detection and radioactivity. Topics covered are: 1) Interaction of radiation with matter; 2) X-rays and X-ray CT; 3) Mammography; 4) Fluoroscopy; 5) Radioisotopes and Radiopharmaceuticals; 6) Radiation detectors; 7) SPECT, PET; and 8) Introduction to Radiation Therapy.

Repeatability: This course may not be repeated for additional credits.

PHYS 5202. Physics of Medical Imaging II. 3 Credit Hours.
This will be the second of a series of two courses that will be focused on physics principles and their use in medical imaging. This second course reviews the production of medical images with ultrasound, MRI and other state of the art imaging techniques. Additional fundamental principles of physics important to the production and use of radiation for treatment and diagnostic purposes are reviewed. More detailed radiation detection methods, focused on dose measurement, utilizing a variety of methods, are discussed along with the appropriate instrumentation. More specialized topics of Radiation Safety and Radiation Protection in Diagnostic Radiology will be covered in association with The Environmental Health and Radiation Safety Department of Temple University. Topics covered are: 1) MRI; 2) Ultrasounds; 3) Infrared Imaging; 4) Imaging of Tissue Electrical Impedance; 5) Optical Imaging; 6) Multimodality Imaging; 7) Medical Image Processing; 8) Radiation safety.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of C in PHYS 5201.

PHYS 5301. Electromagnetic Theory. 3 Credit Hours.
Boundary value problems of the electrostatic and magnetostatic fields; Maxwell's equations; plane waves at boundaries in dielectric and conducting media; potentials in the Lorentz gauge; Green's functions for wave and Helmholtz equations; multipole radiation; material dispersion; diffraction.

Repeatability: This course may not be repeated for additional credits.

PHYS 5302. Advanced Electromagnetic Theory. 3 Credit Hours.
Maxwell stress tensor; relativistic dynamics; Lagrangian formulation of electrodynamics; Noether's theorem; laser resonant cavities and optics of Gaussian beams; Eikonal and geometrical optics limit; synchrotron radiation.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in PHYS 5301.

PHYS 5401. Medical Dosimetry I. 3 Credit Hours.
In this course the students should become familiar with treatment planning principles for the most common cases of cancer patients. Techniques of simulation of treatment set-ups are reviewed and advanced methods of virtual simulation are explored. The course is accompanied by a laboratory giving students the opportunity to practice the material. The laboratory sections will be designed to accompany the corresponding lectures and will allow the students to gain hands-on experience on treatment planning and simulation problems, while using the state of the art software currently used in clinical facilities. Topics covered are: 1) Statistical terminology; 2) Treatment simulation; 3) Dose calculation methods; 4) External Beam Radiation Therapy; 5) Dose calculation for external beams; 6)Treatment Planning: External Beam; 7) Localization.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B in BIOL 5333.

PHYS 5402. Medical Dosimetry II. 3 Credit Hours.
This course will continue building upon the material introduced during Medical Dosimetry I. More details are discussed about the factors that affect dose delivered in radiation treatments and how these factors are accounted for in dose calculations. Methods of treatment planning techniques for various diseases using single and multiple field arrangements using photons and electrons are discussed. Advanced treatment planning techniques of conformal radiation therapy including 3D treatment planning, IMRT, IGRT, Gating, Protons, and Stereotactic are also discussed. The use of Brachytherapy in radiation therapy is addressed. Characteristics of sources utilized for treatment as well as determination of source activity and dose delivered are included. Methods and instruments utilized to apply Brachytherapy treatment planning techniques to clinical treatment situations are discussed. Finally, the Ethical Standards and procedures that have been set by the Medical Dosimetrist Certification Board ("the MDCB") must also be discussed. The course is accompanied by a laboratory giving students the opportunity to practice the material. The laboratory sections will be designed to accompany the corresponding lectures and will allow the students to gain hands-on experience on advanced treatment planning problems, while using the state of the art software currently used in clinical facilities. Topics covered are: 1) Advanced Dose Calculation techniques; 2) Advanced Treatment Planning; 3) Brachytherapy; 4) Quality Assurance; 5) Ethical Standards.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B in PHYS 5401.

PHYS 5501. Mathematical Physics. 3 Credit Hours.
Tensor analysis; group theory; complex variable theory; partial differential equations; Sturm-Liouville systems; integral transforms; integral equations and Green's function methods.

Repeatability: This course may not be repeated for additional credits.

PHYS 5502. Computational and Mathematical Physics. 3 Credit Hours.
Preliminaries; numerical applicability, survey of algorithms, computer modeling, programming considerations; basic numerical methods; numerical linear algebra; numerical solution to ordinary and partial differential equations; molecular dynamics; Monte Carlo simulations; nonlinear methods.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in PHYS 5501.

PHYS 5701. Quantum Mechanics I. 3 Credit Hours.
Fundamental principles of quantum mechanics; relation to classical mechanics; Schroedinger and operator formulations; path integrals; Aharonov-Bohm effect; examples of exact solutions; central forces and angular momentum; scattering theory; Bell's theorem.

Repeatability: This course may not be repeated for additional credits.

PHYS 5702. Quantum Mechanics II. 3 Credit Hours.
Matrix mechanics; theory of electron spin; Hilbert space formulation of quantum mechanics; transformation theory; theory of rotations; spin and statistics; stationary approximation methods with application to atomic systems; time-dependent perturbation theory; exponential decay.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in PHYS 5701.

PHYS 8001. Practicum Teaching of Physics. 1 Credit Hour.
Required of all graduate teaching assistants in their first semester. Consists of supervised instruction in undergraduate laboratories and a weekly two-hour class.

Repeatability: This course may not be repeated for additional credits.

PHYS 8004. Problems in Experimental Physics. 1 to 6 Credit Hour.
Special problems in the field of experimental physics. The course is designed to acquaint the student with the research techniques employed in experimental physics.

Repeatability: This course may be repeated for additional credit.

PHYS 8005. Problems in Theoretical Physics. 1 to 6 Credit Hour.
Special problems in the field of theoretical physics. The course is designed to acquaint the student with the research techniques employed in theoretical physics.

Repeatability: This course may be repeated for additional credit.

PHYS 8020. Topical Seminar I. 3 Credit Hours.
This course considers special topics in Physics, not considered in depth in our other courses.

Repeatability: This course may be repeated for additional credit.

PHYS 8030. Topical Seminar II. 3 Credit Hours.
This course considers special topics in Physics, not considered in depth in our other courses.

Repeatability: This course may be repeated for additional credit.

PHYS 8050. Physics Seminar. 0 Credit Hours.
This course provides the graduate students with the state of the field knowledge about Physics. Students attend 10 to 12 Colloquium/Seminars per semester given by the experts, mostly drawn from national and international authorities in the field. The students are graded on the basis of their attendance in these seminars, and are encouraged to discuss their research with these visiting experts. Last year's colloquium included among other experts, a Nobel Laureate, Sir Anthony Leggett, 2003.

Repeatability: This course may be repeated for additional credit.

PHYS 8102. Statistical Mechanics. 3 Credit Hours.
Review of thermodynamics; kinetic theory; statistical definition of entropy; microcanonical, canonical, and grand canonical ensembles; applications to gases, diatomic molecules, magnetic systems, phase transitions; quantum statistics; ideal boson and fermion systems; Bose-Einstein condensation; black body radiation; models of solids; properties of liquid helium.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in (PHYS 5501 and PHYS 5701)

PHYS 8701. Quantum Field Theory. 3 Credit Hours.
Properties of quantized radiation field; emission, absorption and scattering of photons by atoms; nonrelativistic Lamb shift; Dirac equation: nonrelativistic limit, Lorentz covariance, exact solutions; hole theory; Lagrangian field theory; field quantization; S-matrix; covariant perturbation theory; Feynman rules for QED with application to various processes.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in PHYS 5702.

PHYS 8702. Solid State Physics. 3 Credit Hours.
Crystal and x-ray diffraction; lattice vibrations and thermal properties; energy bands and electronic properties; semiconductors; optical and dielectric properties; para-, ferro-, and antiferromagnetism; introduction to superconductivity and superfluidity.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in PHYS 5701 and PHYS 5702.

PHYS 8703. Nuclear and Elementary Particle Physics. 3 Credit Hours.
The Standard Model (SM); gauge invariance, non-Abelian gauge theories, SM Lagrangian, electroweak theory and QCD, Higgs mechanism, confinement; experimental considerations: accelerators and detectors, elastic scattering and form factors, deep inelastic scattering and structure functions; advanced topics in the SM: grand unification, neutrino mass, big bang cosmology, dark matter.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in PHYS 5701 and PHYS 5702.

PHYS 8704. Many Electron Theory. 3 Credit Hours.
The course is at an intermediate level and is appropriate for students of experimental and theoretical condensed matter and AMO physics. The course familiarizes students with the theory of correlated electrons and states with broken electron symmetry, it also provides a framework for the description of experimental properties in materials with electron correlations. Topics include: Phenomenology of cohesion in molecules and solids, Many-electron wavefunctions, Functionals and their extrema, Wavefunction variational principles, Hellmann-Feynman theorem, One- and two-particle density matrices, and the electron density Wavefunction vs. density functional methods, Hohenberg-Kohn theorem, Functional derivatives, Uniform electron gas Kohn-Sham spin-density functional theory, Approximate functionals, Linear Response Theory and Stability, Collective Excitations, Superconducting Instability, Magnetic Instabilities, Charge Density Wave Instabilities in low-dimensional systems, Ferromagnetic, Spin and Orbital density wave phases, Instabilities of the Half-Filled Band, BCS Theory of Superconductivity, s, p and d wave pairing, the Integer and Fractional Quantum Hall States, Collective Excitations and Goldstone Modes.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in PHYS 8702.

PHYS 8705. Advanced Topics in Nuclear and Particle Physics. 3 Credit Hours.
The course is at an intermediate level and is appropriate for students of experimental and theoretical nuclear and particle physics. Topics include: Accelerators, Detectors, Essential elements of data analysis and statistics, Selected advanced topics in QFT, Hard scattering processes and the parton structure of hadrons, Breaking of global and local symmetries (Higgs mechanism), Effective field theory, Neutrino physics, Physics beyond the SM, Nuclear matter under extreme conditions, Overview of nuclear structure and reactions.

Repeatability: This course may not be repeated for additional credits.

Pre-requisites: Minimum grade of B- in PHYS 8703.

PHYS 8985. Teach in Higher Ed: Phys. 2 Credit Hours.
Teaching in Higher Ed: Physics. This course focuses on learning theory and the best teaching practices, with the aim of preparing students for effective higher education teaching.

Repeatability: This course may not be repeated for additional credits.

PHYS 9991. Master's Research Projects. 1 to 6 Credit Hour.
Short-term, limited research project or laboratory project in the field. This course is not the capstone project course, nor can it be used for thesis based research. The course is for master's students only, including PSM, MA or MS. This class will not confer full-time program status unless nine credits are taken.

Repeatability: This course may be repeated for additional credit.

PHYS 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.
This course is required for students who are preparing for the preliminary or candidacy examination. Students should enroll after coursework is completed or when preparing for the candidacy exam until the time that the preliminary or candidacy examination is completed. This course will confer full-time status at the minimum credit hour registration limit of one credit. All students must complete a minimum of one credit of this course. Students must complete a total of 6 credit hours of 9994, 9998 and 9999.

Repeatability: This course may be repeated for additional credit.

PHYS 9995. Capstone Project. 1 to 6 Credit Hour.
Capstone project for master's students including students in PSM, MA or MS. This class will provide full-time status. Students in PSM programs need to register for at least one credit of this course to fulfill program requirements. Additional credits may be required for specific programs. This course will confer full-time status at the minimum credit hour registration limit of one credit.

Repeatability: This course may be repeated for additional credit.

PHYS 9996. Master's Thesis Research. 1 to 6 Credit Hour.
Course for master's thesis research. Only intended for students in thesis bearing master's programs. A minimum of one credit is required. This course will confer full-time status at the minimum credit hour registration limit of one credit.

Repeatability: This course may be repeated for additional credit.

PHYS 9998. Pre-Dissertation Research / Elevation to Candidacy. 1 to 6 Credit Hour.
This course is intended for students who are performing research prior to candidacy. Students can register for this course after required courses are completed. This course will confer full-time status at the minimum credit hour registration limit of one credit. Students must be registered for this course during the semester that they are to be elevated to candidacy examination. Students must complete a total of 6 credit hours of 9994, 9998 and 9999.

Repeatability: This course may be repeated for additional credit.

PHYS 9999. Dissertation Research. 1 to 6 Credit Hour.
The course is for Ph.D. students who have been elevated to candidacy. During the course of their candidacy students must complete a minimum of two credits of dissertation research. This course will confer full-time status at the minimum credit hour registration limit of one credit. Students must complete a total of 6 credit hours of 9994, 9998 and 9999.

Repeatability: This course may be repeated for additional credit.