PHYSICS (PHYS)

PHYS 08699 Directed Research: Particle Physics (0-3 Credit Hours)
Directed Research course for high school students combining coverage of topics in particle physics with participation in experimental research in ongoing experiments conducted by particle physics faculty. Students maintain a research logbook and submit a written research summary at the conclusion of the research period.

PHYS 10033 Earth Focus (3 Credit Hours)
The Earth Focus course develops a narrative that pieces together the history of planet Earth over the last 4.5 billion years. Its violent beginnings, the changing orbital motions and seasons, the development of an atmosphere and oceans, all combined to produce a unique evolutionary history that formed a planet habitable by millions of life forms, including humans. The course introduces the science of natural climate change, including some drastic events that might leave you wondering how life could have survived. Understanding Earth's natural climate change is essential to analyzing and interpreting anthropogenic, i.e., human induced, climate change primarily brought about by the burning of fossil fuels over the last 150 years. The greenhouse effect will be used to explain how Earth has maintained its generally pleasant conditions, and climate models will be used to understand how small changes in CO2 levels can affect those conditions. With the ongoing consumption of fossil fuels, and the resulting addition of greenhouse gases into Earth's atmosphere, mankind is now conducting a unique experiment, one with potentially devastating consequences. Over the last century, the world has become highly industrialized and interconnected. The combustion of fossil fuels has played a major role in this process, and the consequences have become apparent with increasing pollution and climate issues. Earth is already beginning to react badly, e.g., a rise in ocean levels, weather extremes, ocean acidification, and extinction of species. How much the rising CO2 concentration and temperature will affect life on Earth is the question that scientists, politicians, economists, sociologists, as well as the rest of us, must consider in assessing what lies ahead. Decisions need to be made in the foreseeable future that will affect energy use, lifestyles, national economies, and international politics. Renewable and alternative energy sources such as wind, solar, hydroelectric, geothermal, and nuclear are essential components of the energy discussion. A clear understanding of the science involved in the climate warming debate and potential solutions are necessary. It is up to each of us to examine the basic evidence and answer fundamental questions regarding what to do next. The goal of the course is to provide the history, science, and an understanding of the basic energy issues that face us in the 21st century with the goal of finding effective solutions. The focus will be on the facts and the underlying science, but it is also about the options and decisions that we, individually and as a society, must make regarding the very real implications of climate change.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 10052 Concepts of Energy and the Environment (3 Credit Hours)
A course developing the basic ideas of energy and power and their applications. The fossil fuels are considered together with their limitations, particularly as related to global warming, pollution, and their nonrenewable character. The advantages and disadvantages of nuclear power are studied and compared with alternative energy sources such as solar energy, wind, and geothermal and hydroelectric power. Various aspects of energy storage and energy conservation are also considered. This course is designed for the non-specialist. It is open to first-year students only.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 10062 Science Literacy (3 Credit Hours)
A course that provides the tools for a basic understanding of scientific developments and their potential consequences. Developments in many areas of science will be discussed, including biology, chemistry, physics, astronomy, engineering, and computer science, with the view that basic physical laws serving as a common thread among them. Topics covered include the mechanisms of scientific discovery, the impact of scientific discoveries on society, science and ethics, and the tools of contemporary science. The course focuses on concepts rather than formulas and concentrates primarily on examples taken from current scientific developments. If taken by science or engineering students, this course counts as a general elective.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 10063 Radioactivity and Its Implications for Environment and Society (3 Credit Hours)
This course will provide a broad overview about one of the most divisive scientific topics in our society. Both the scientific and societal aspects of radioactivity will be considered. This provides an understanding of the physical principles for cause and effects of radioactive decay and radiation. It will also provide a basis to evaluate the cost benefit in the growing use of radioactivity as a tool in industry and technology. To cover the broad range of material, the course will be offered in four topical sections that address the science and scientific effects of radioactivity, as well as the environmental consequences and the societal impact of its growing number of applications: 1. The phenomenon of radioactivity 2. The origin of radioactivity 3. The environmental impact of radioactivity 4. Societal impact of radioactivity
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 10091 Principles of Physics I (3 Credit Hours)
This course is the AP-credit equivalent of PHYS 10111. PHYS 10111 is a prerequisite to PHYS 10222. A course intended for students who desire a grounding in all the major principles of physics but who plan to major in some area other than science or engineering. The ability to apply these principles to the solution of problems is a major goal of the course. The following topics are normally included; kinematics and dynamics of a particle, work, energy, momentum, harmonic motion, gravitation, and circular orbits; wave motion, interference, standing waves, the Doppler effect; and temperature, heat, first law of thermodynamics, and kinetic theory of gases. Additional material will be at the discretion of the instructor. The division between PHYS 10111 and 10222 will depend on the order of presentation.

PHYS 10092 Principles of Physics II (3 Credit Hours)
This course is the AP-credit equivalent of PHYS 10222. PHYS 10111 is a prerequisite to PHYS 10222. A course intended for students who desire a grounding in all the major principles of physics but who plan to major in some area other than science or engineering. The ability to apply these principles to the solution of problems is a major goal of the course. The following topics are normally included; electric charge, Coulomb's law, electric field and potential, current, resistance, and DC circuits; magnetic force, and electromagnetic induction; the nature of light, the spectrum; photons, photoelectric effect, Compton scattering, deBroglie waves, energy levels, X-rays; nuclei and radioactivity; and special relativity. Additional material will be at the discretion of the instructor. The division between PHYS 10111 and 10222 will depend on the order of presentation.

PHYS 10093 Engineering Physics I: Mechanics (4 Credit Hours)
This course is the AP-credit equivalent of PHYS 10310. The first course in a two-semester sequence in general physics. Topics include the kinematics and mechanics of a particle; work, energy and momentum, and associated conservation laws; rotation, torque and angular momentum; oscillations and wave motions. A course designed for students of science and engineering. Laboratory meetings in alternating weeks only. Weekly tutorial sessions. Students intending to seek a major where AP science credit is not accepted, or where two semesters of general physics with laboratories at the college level are required, almost universally waive their AP credit at Notre Dame and take the classes for academic degree credit. In these cases, PHYS 10093/10094 will revert to non-degree credit on their final transcript, when replaced by 8.0 letter-graded degree credits of PHYS 10310/11310 + 10320/11320 as determined by the requirements of their respective majors.

PHYS 10094 Engineering Physics II: Electricity & Magnetism (4 Credit Hours)
This course is the AP-credit equivalent of PHYS 10320. The second course in a two-semester sequence in general physics. Topics include electrostatics, electric current, and circuits; magnetism, electromagnetic induction, and waves; and geometrical optics. A course designed for students of science and engineering. Laboratory meetings in alternating weeks only. Weekly tutorial sessions. Students intending to seek a major where AP science credit is not accepted, or where two semesters of general physics with laboratories at the college level are required, almost universally waive their AP credit at Notre Dame and take the classes for academic degree credit. In these cases, PHYS 10093/10094 will revert to non-degree credit on their final transcript, when replaced by 8.0 letter-graded degree credits of PHYS 10310/11310 + 10320/11320 as determined by the requirements of their respective majors.

PHYS 10095 Physics for Life Sciences I (4 Credit Hours)
This course is the AP-credit equivalent of PHYS 20210. It requires demonstrated knowledge of the basic principles of mechanics, fluid mechanics, thermal physics, wave motion, and sound. Primarily for students in the life sciences. Laboratory meetings each week. Students intending to apply to medical or other professional schools where AP science credit is not accepted, or where two semesters of general physics with laboratories at the college level are required, almost universally waive their AP credit at Notre Dame and take the classes for academic degree credit. In these cases, PHYS 10095/10096 will revert to non-degree credit on their final transcript, when replaced by 8.0 letter-graded degree credits of either PHYS 20210/21210 + 20220/21220 or PHYS 10310/11310 + 10320/11320 as determined by the requirements of their respective majors.

PHYS 10096 Physics for Life Sciences II (4 Credit Hours)
This course is the AP-credit equivalent of PHYS 20220. It requires demonstrated knowledge of the basic principles of electricity, magnetism, optics, and modern physics. Primarily for students in the life sciences. Laboratory meetings each week. Students intending to apply to medical or other professional schools where AP science credit is not accepted, or where two semesters of general physics with laboratories at the college level are required, almost universally waive their AP credit at Notre Dame and take the classes for academic degree credit. In these cases, PHYS 10095/10096 will revert to non-degree credit on their final transcript, when replaced by 8.0 letter-graded degree credits of either PHYS 20210/21210 + 20220/21220 or PHYS 10310/11310 + 10320/11320 as determined by the requirements of their respective majors.

PHYS 10098 Engineering Physics I: Mechanics (4 Credit Hours)
This course is the transfer-credit equivalent of PHYS10310. The first course in a two-semester sequence in general physics. Topics include the kinematics and mechanics of a particle; work, energy, and momentum, and associated conservation laws; rotation, torque and angular momentum; oscillations and wave motions. A course designed for students of science and engineering. Laboratory meetings in alternating weeks only. Weekly tutorial sessions. This course is intended for transfer students seeking to take a calculus-based physics course and lab for their major or minor to Notre Dame.

PHYS 10099 Engineering Physics II: Electricity & Magnetism (4 Credit Hours)
This course is the transfer-credit equivalent of PHYS10320. The second course in a two-semester sequence in general physics. Topics include electrostatics, electric current, and circuits; magnetism, electromagnetic induction, and waves; and geometrical optics. A course designed for students of science and engineering. Laboratory meeting in alternating weeks only. Weekly tutorial sessions. This course is intended for transfer students seeking to take a calculus-based physics course and lab for their major or minor to Notre Dame.

PHYS 10111 Principles of Physics I (3 Credit Hours)
PHYS 10111 is a prerequisite to PHYS 10122. A course intended for students who desire a grounding in all the major principles of physics but who plan to major in some area other than science or engineering. The ability to apply these principles to the solution of problems is a major goal of the course. The following topics are normally included; kinematics and dynamics of a particle, work, energy, momentum, harmonic motion, gravitation, and circular orbits; wave motion, interference, standing waves, the Doppler effect; and temperature, heat, first law of thermodynamics, and kinetic theory of gases. Additional material will be at the discretion of the instructor. The division between PHYS 10111 and 10122 will depend on the order of presentation.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 10140 Descriptive Astronomy (3 Credit Hours)
A description of the motions and structure of the earth, moon, and planets; an exposition of the modern theories of solar and stellar structure, nebulae, and galaxies; basics of stellar evolution, black holes, quasars, and other recent developments; an introduction to cosmology. This course includes elementary observational projects.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 10222 Principles of Physics II: the Physics of Civilization (3 Credit Hours)
This non-calculus-based course is intended for students seeking an understanding of principles of physics beyond those discussed in a one-semester course. The course covers topics useful to but not limited to students in architecture and designed for students who plan to major in some area other than science or engineering. Among the topics discussed are phases of matter, thermodynamics, heat exchange, energy storage, vibrations and acoustics, and basic electricity and magnetism. The course will emphasize applications to practical problems and will explore challenges such as light pollution, earthquake-proofing, and energy conservation.
Prerequisites: PHYS 10111
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Enrollment limited to students in the College of Engineering or College of Science colleges.

PHYS 10240 Elementary Cosmology (3 Credit Hours)
An elective course for students planning to major in the arts and letters or business. It is designed to acquaint the non-mathematically inclined student with the most important discoveries in physics of the last few decades and how they have altered our perceptions of the origin and structure of the universe. This course examines such questions as: "Where did the universe come from?" "Why do scientists feel sure that it was born in a cosmic fireball called the Big Bang?" and "Where did the Big Bang itself come from?" This is a reading-intensive course based on popularizations of science written for the curious and intelligent layperson. The emphasis will be on class discussion of the readings. One book report and a term paper are required in addition to examinations. Science or Engineering students who are interested in a more rigorous treatment of the topics covered in this course should consider PHYS 30240 Introduction to Cosmology.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 10310 Engineering Physics I: Mechanics (4 Credit Hours)
The first course in a two-semester calculus-based sequence in general physics. Topics include the kinematics and mechanics of a particle; work, energy and momentum, and associated conservation laws; rotation, torque and angular momentum; oscillations and wave motions. A course designed for students of science and engineering. Laboratory meetings in alternating weeks only. Weekly tutorial sessions.
Prerequisites: (MATH 10550 (may be taken concurrently) or MATH 10091 or MATH 10850 (may be taken concurrently))
Corequisites: PHYS 11310, PHYS 12310
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 10320 Engineering Physics II: Electromagnetism (4 Credit Hours)
The second course in a two-semester calculus-based sequence in general physics. Topics include electrostatics, electric current, and circuits; magnetism, electromagnetic induction, and waves; and geometrical optics. A course designed for students of science and engineering. Laboratory meetings in alternating weeks only. Weekly tutorial sessions.
Prerequisites: (PHYS 10310 or PHYS 10093 or PHYS 10411) and (MATH 10560 or MATH 10092 or MATH 10860)
Corequisites: PHYS 11320, PHYS 12320
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 10342 Modern Physics from Quarks to Quasars (3 Credit Hours)
Restricted to Arts and Letters intents in the Honors Program. This course emphasizes themes of modern physics and will be organized around the concepts of symmetry and physical laws. For example, how do symmetries observed in nature lead to fundamental laws of conservation of energy and momentum? Examples from areas of modern physics such as cosmology and astrophysics are used to bring these topics to life. We consider questions such as: "What happens if one travels alongside a beam of light?" (which leads us into special relativity); "Why is the night sky so dark?" (the Big Bang); "What is matter?"; "What is mass"; "What are forces?" The course is a mix of lecture, discussions, and lab/demonstrations.
Prerequisites: ALHN 13950
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 10411 Physics A: Mechanics (3 Credit Hours)
The first semester of a three-semester sequence in general physics. Topics include the kinematics and mechanics of a particle; work, energy, and momentum, and associated conservation laws; rotation, torque, and angular momentum; oscillations and wave motions. A course designed for students intending to enter the Department of Physics. Laboratory meetings each week.
Prerequisites: (MATH 10550 (may be taken concurrently) or MATH 10091 or MATH 10850 (may be taken concurrently))
Corequisites: PHYS 11411
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 10422 Physics B: Electricity & Magnetism (3 Credit Hours)
The second semester of a three-semester sequence in general physics. Topics include electrostatics, electric current and circuits, magnetism, electromagnetic induction and waves. A course designed for students majoring in the Department of Physics. Laboratory meetings each week.
Prerequisites: (PHYS 10411 or PHYS 10310 or PHYS 10093) and (MATH 10560 (may be taken concurrently) or MATH 10092 or MATH 10860 (may be taken concurrently))
Corequisites: PHYS 11422
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 11310 Engineering Physics I Laboratory (0 Credit Hours)
The laboratory is a corequisite for PHYS 10310
Corequisites: PHYS 10310, PHYS 12310

PHYS 11311 Physics Problem Solving Skills Tutorial (1 Credit Hour)
This is a one-credit course taught in tandem with the Physics for Engineers I lecture. The aims of this course are to provide students with the tools to learn physics and to build a community of learners through collective engagement with the material. Topics include how to use the textbook effectively in concert with lecture, note-taking and how to solve physics problems.

PHYS 11320 Engineering Physics II Lab (0 Credit Hours)
The laboratory is a corequisite for PHYS 10320
Prerequisites: (MATH 10550 or MATH 10850) and (MATH 10560 (may be taken concurrently) or MATH 10860 (may be taken concurrently))
Corequisites: PHYS 10320, PHYS 12320

PHYS 11411 Physics A Lab (1 Credit Hour)
The laboratory is a corequisite for PHYS 10411
Corequisites: PHYS 10411

PHYS 11422 Physics B Lab (1 Credit Hour)
The laboratory is a corequisite for PHYS 10422
Corequisites: PHYS 10422

PHYS 12310 Engineering Physics I Tutorial (0 Credit Hours)
The tutorial is a corequisite for PHYS 10310
Corequisites: PHYS 10310, PHYS 11310

PHYS 12320 Engineering Physics II Tutorial (0 Credit Hours)
The tutorial is a corequisite for PHYS 10320
Corequisites: PHYS 10320, PHYS 11320

PHYS 13310 Physics Problem Solving Skills Tutorial (1 Credit Hour)
This is a one-credit course taught in tandem with the Physics for Engineers I lecture. The aims of this course are to provide students with the tools to learn physics, and to build a community of learners through collective engagement with the material. Topics include how to use the textbook effectively in concert with lecture, note-taking and how to solve physics problems.
Corequisites: PHYS 10310, PHYS 11310, PHYS 12310

PHYS 13320 Physics problem-solving skills tutorial (1 Credit Hour)
This is a one-credit course taught in tandem with the Physics for Engineers II lecture. The aims of this course are to provide students with the tools to learn physics, and to build a community of learners through collective engagement with the material. Topics include how to use the textbook effectively in concert with lecture, note-taking and how to solve physics problems.
Prerequisites: (PHYS 10310 or PHYS 10093 or PHYS 10411) and (MATH 10550 or MATH 10091 or MATH 10850) and (MATH 10560 (may be taken concurrently) or MATH 10092 or MATH 10860 (may be taken concurrently))
Corequisites: PHYS 10320, PHYS 11320, PHYS 12320

PHYS 14222 Physics of Civilization (3 Credit Hours)
The module is directed at students in Medical Science and Life Science programmes. Students are introduced to the concepts and basic principles of electricity, magnetism, electromagnetism, modern physics including waves, nuclear physics and applications. The physical principles of devices such as the electric pacemaker, mass spectrograph and cyclotron are explained.

PHYS 14310 Physics for Engineers (4 Credit Hours)
The module is directed at students in the first year of an Engineering programme. Special emphasis is put on development of basic analytical skills and critical thinking in students. The course begins with an introduction to main concepts and laws in classical mechanics (e.g. Newton's laws of motion, conservation laws) with multiple examples of applications. The principles of mechanics are used to describe motion of material points and solid bodies, oscillatory motion and energy transformations. Subsequent study is devoted to the areas of thermal properties of matter, wave motion, including light and sound. Practical applications which relate to Engineering are included wherever possible. Self-directed learning is encouraged in laboratory sessions and in problem-oriented classwork. A significant part of the coursework is done via WileyPlus web resource, which offers ample possibilites for interactive learning, self-assessment, and experimentation.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20054 Climate Physics (3 Credit Hours)
This course is a one-semester investigation of the processes leading to balance in the Earth's climate system. The course will study the physical processes driven by the laws of thermodynamics, convective hydrodynamics, and radiative energy transfer. The course is appropriate for undergraduate science as well as non-science majors and will count for science credit for science majors.
Prerequisites: MATH 10360 or MATH 10560 or MATH 10860
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20061 Nuclear Warfare (3 Credit Hours)
This course gives an overview of nuclear phenomena such as nuclear fission and fusion. The material also involves nuclear weapons and their medical and physical consequences. Scenarios for war and peace, proliferation of nuclear weapons material, and recent diplomatic history are also discussed. The course is open to all students and the typical enrollment is about 90.
Satisfies the following University Core Requirements: WKIN - Core Integration, WKST-Core Science & Technology

PHYS 20063 Radioactivity & Society (3 Credit Hours)
This course will provide a broad overview about one of the most divisive scientific topics in our society. Both the scientific and societal aspects of radioactivity will be considered. This provides an understanding of the physical principles for cause and effects of radioactive decay and radiation. It will also provide a basis to evaluate the cost benefit in the growing use of radioactivity as a tool in industry and technology. To cover the broad range of material, the course will be offered in four topical sections that address the science and scientific effects of radioactivity, as well as the environmental consequences and the societal impact of its growing number of applications: 1. The phenomenon of radioactivity 2. The origin of radioactivity 3. The environmental impact of radioactivity 4. Societal impact of radioactivity
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20065 The Science and Strategy of Nuclear War (3 Credit Hours)
An introductory course, for non-science majors, providing an overview to a broad range of topics and aspects of nuclear weapons and warfare in the 21st century, providing students with both an understanding of the science behind nuclear weapons (including nuclear fission and fusion, effects of shock and thermal radiation, electromagnetic pulses, etc.) as well as an understanding of the strategic aspects of the nuclear revolution. This course is jointly taught and sponsored by the Department of Physics and the Department of Political Science.
Satisfies the following University Core Requirements: WKIN - Core Integration, WKST-Core Science & Technology

PHYS 20071 The Physics of Sound and Music (3 Credit Hours)
The physics of sound and music, including musical acoustics and sound reproduction. The course will introduce basic Newtonian mechanics, oscillating systems, wave motion, sound, Fourier synthesis, psychoacoustics and hearing, and the musical acoustics of various instruments. It will also include a short introduction to electricity and magnetism, and the physics of microphones, loudspeakers, phonographs, digital recording, and electronic synthesizers. The course will make use of some algebra and trigonometry, but no other physics or mathematics background is necessary.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20105 Physics & Biomech. of Sports (3 Credit Hours)
Physics plays a crucial role in sports by providing a deep understanding of the fundamental principles that govern athletic performance and sporting activities, improving techniques, and driving innovation in sports equipment design. Sports involve forces, motion, energy, and the interaction between objects and the environment, all of which can be explained through physics. In addition, physics is essential in creating devices for athletes, such as performance tracking tools and biomechanics sensors that optimize training and monitor activity, while also enhancing sports medicine by improving injury understanding and rehabilitation techniques. In this course, the students will explore how various principles of physics are applied within the context of sports. They will learn about diverse applications of physics in different sports settings, focusing on the role of physics across various aspects of sports, such as movement, performance analysis, and equipment design.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20140 Descriptive Astronomy (3 Credit Hours)
A description of the motions and structure of the Earth, moon, and planets. An exposition of the modern theories of solar and stellar structure, nebulae, and galaxies. Basics of stellar evolution, black holes, quasars, and other recent developments. An introduction to cosmology. This course includes elementary observational projects.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 20210 Physics for Life Sciences I (3 Credit Hours)
The basic principles of mechanics, fluid mechanics, thermal physics, wave motion, and sound. Primarily for students in the life sciences. Laboratory meetings each week. This is the first semester of a 2 semester calculus based course.
Prerequisites: MATH 10092 or MATH 10360 or MATH 10460 or MATH 10560 or MATH 10860 or MATH 14360
Corequisites: PHYS 21210
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20220 Physics for Life Sciences II (3 Credit Hours)
The basic principles of electricity, magnetism, optics, and modern physics. Primarily for students in the life sciences. Laboratory meetings each week. This is the second semester of a 2 semester calculus based course.
Prerequisites: (PHYS 10093 or PHYS 10095 or PHYS 10310 or PHYS 10411 or PHYS 20210 or PHYS 24210 or PHYS 30210 or PHYS 34210) and (MATH 10092 or MATH 10360 or MATH 10560 or MATH 10860 or MATH 14360)
Corequisites: PHYS 21220
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20330 General Physics III (3.5 Credit Hours)
A third semester in general physics. Topics include 1) interference and diffraction; 2) quanta and the wave-particle duality; 3) introduction to quantum mechanics; 4) atomic, nuclear, and particle physics; 5) physics of the solid state; and 6) astrophysics and cosmology. A course designed for students of science and engineering. Laboratory meetings in alternating weeks only.
Prerequisites: (PHYS 10320 or PHYS 10094 or PHYS 10422) and (MATH 20850 or MATH 20550 or MATH 10093)
Corequisites: PHYS 21330
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20333 Earth Focus (3 Credit Hours)
The Earth Focus course develops a narrative that pieces together the history of planet Earth over the last 4.5 billion years. Its violent beginnings, the changing orbital motions and seasons, the development of an atmosphere and oceans, all combined to produce a unique evolutionary history that formed a planet habitable by millions of life forms, including humans. The course introduces the science of natural climate change, including some drastic events that might leave you wondering how life could have survived. Understanding Earth's natural climate change is essential to analyzing and interpreting anthropogenic, i.e., human induced, climate change primarily brought about by the burning of fossil fuels over the last 150 years. The greenhouse effect will be used to explain how Earth has maintained its generally pleasant conditions, and climate models will be used to understand how small changes in CO2 levels can affect those conditions. With the ongoing consumption of fossil fuels, and the resulting addition of greenhouse gases into Earth's atmosphere, mankind is now conducting a unique experiment, one with potentially devastating consequences. Over the last century, the world has become highly industrialized and interconnected. The combustion of fossil fuels has played a major role in this process, and the consequences have become apparent with increasing pollution and climate issues. Earth is already beginning to react badly, e.g., a rise in ocean levels, weather extremes, ocean acidification, and extinction of species. How much the rising CO2 concentration and temperature will affect life on Earth is the question that scientists, politicians, economists, sociologists, as well as the rest of us, must consider in assessing what lies ahead. Decisions need to be made in the foreseeable future that will affect energy use, lifestyles, national economies, and international politics. Renewable and alternative energy sources such as wind, solar, hydroelectric, geothermal, and nuclear are essential components of the energy discussion. A clear understanding of the science involved in the climate warming debate and potential solutions are necessary. It is up to each of us to examine the basic evidence and answer fundamental questions regarding what to do next. The goal of the course is to provide the history, science, and an understanding of the basic energy issues that face us in the 21st century with the goal of finding effective solutions. The focus will be on the facts and the underlying science, but it is also about the options and decisions that we, individually and as a society, must make regarding the very real implications of climate change.
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 20420 Computational Methods in Physics (3 Credit Hours)
The principal goal of this course is to develop competence and experience in the use of computers as tools for scientific studies. The course is intended primarily for physics majors, with no assumption of prior programming experience. The main purpose of the course is for students to learn programming in a modern computer language, and how to apply computer techniques to numerical problems, scientific data analysis, model calculations and simulations. This course will provide the foundation for computing modules in upper-level physics courses.
Prerequisites: PHYS 20444 (may be taken concurrently) or PHYS 20464 (may be taken concurrently)

PHYS 20430 Intro Circuitry & Electronics (1.5 Credit Hours)
An introduction to the basics of circuitry and electronics, including both theory and laboratory practice. This course provides a stand-alone foundation which students will develop in later courses. This course is intended to be taken by Physics majors and is a co-requisite of PHYS 20433.
Prerequisites: PHYS 10093 or PHYS 10310 or PHYS 10411
Corequisites: PHYS 20433

PHYS 20433 Physics C: Thermo & Relativity (3 Credit Hours)
The third semester of the a three -semester course in general physics. Topics include classical thermodynamics, fluids and acoustics;wave motions, geometric and physical optics; special relativity. The course is intended primarily for physics majors but is open to other qualified students.
Prerequisites: (PHYS 10310 or PHYS 10093 or PHYS 10411) and (MATH 10560 or MATH 10092 or MATH 10860) and (MATH 10550 or MATH 10091 or MATH 10850)
Corequisites: PHYS 20430

PHYS 20444 Physics D: Modern (3 Credit Hours)
The fourth semester of a four-semester sequence in general physics, concentrating on the foundations of quantum physics. Topics include: the breakdown of classical physics and the arguments for quantum mechanics; wave mechanics and the Schroedinger equation; properties of atoms; interactions of electromagnetic fields with atoms; atomic structure and atomic spectra; fine structure and Zeeman effect; multiplet analysis; exclusion principle, periodic table and spectra of multi-electron atoms; and an introduction to the statistics of quantum mechanical systems. This course is intended primarily for physics majors but is open to other qualified students.
Prerequisites: PHYS 20433

PHYS 20451 Mathematical Methods in Physics I (3.5 Credit Hours)
A two-semester course in the study of methods of mathematical physics. Topics include linear algebra (including matrices and determinants), vector and tensor analysis, vector calculus, curvilinear coordinates, series, ordinary differential equations, partial differential equations, orthogonal functions and vector spaces, special functions (including Bessel, Legendre, and Hermite), calculus of variations, Fourier series, and group theory. The division between PHYS 20451 and 20452 will depend on the order of presentation. Weekly tutorial sessions.
Prerequisites: MATH 20550 (may be taken concurrently) or MATH 10093 or MATH 20850 (may be taken concurrently)
Corequisites: PHYS 22451
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

PHYS 20452 Mathematical Methods in Physics II (3.5 Credit Hours)
A two-semester course in the study of methods of mathematical physics. Topics include linear algebra (including matrices and determinants), vector and tensor analysis, vector calculus, curvilinear coordinates, series, ordinary differential equations, partial differential equations, orthogonal functions and vector spaces, special functions (including Bessel, Legendre, and Hermite), calculus of variations, Fourier series, and group theory. The division between PHYS 20451 and 20452 will depend on the order of presentation. Weekly tutorial sessions.
Prerequisites: PHYS 20451 or MATH 20570
Corequisites: PHYS 22452
Satisfies the following University Core Requirements: WKQR- Core Quantitat Reasoning

PHYS 20454 Intermediate Classical Mechanics (3 Credit Hours)
Newtonian mechanics of particles in one, two, and three dimensions; oscillations; non inertial reference frames; gravitation, central forces; systems of particles; kinetics and dynamics of rigid body motion; Lagrangians; Hamilton's equations.
Prerequisites: (PHYS 20451 or MATH 20570) and (PHYS 10411 or PHYS 10310)

PHYS 20481 Introduction to Astronomy and Astrophysics for Majors (3 Credit Hours)
This one-semester course uses basic physical principles of mechanics, optics, and radiation to provide an introduction to modern astronomy and astrophysics. Topics include the solar system, stars, interstellar matter, galaxies, and cosmology. The underlying observations (from radio to gamma rays) are used to provide a fundamental understanding of topics and their historical background. Several observing projects will be completed at the observatory in the Jordan Hall of Science.
Prerequisites: PHYS 10310 or PHYS 10093 or PHYS 10411 or PHYS 30210 or PHYS 10095

PHYS 21210 Physics for Life Sciences I Lab (1 Credit Hour)
The laboratory is a corequisite for PHYS 20210
Prerequisites: PHYS 20210 (may be taken concurrently) or PHYS 24210 or PHYS 34210

PHYS 21220 Physics for Life Sciences II Lab (1 Credit Hour)
The laboratory is a corequisite for PHYS 20220.
Prerequisites: PHYS 20210 (may be taken concurrently) or PHYS 24210 or PHYS 34210
Corequisites: PHYS 20220

PHYS 21330 General Physics III Laboratory (0 Credit Hours)
The laboratory is a corequisite for PHYS 20330
Corequisites: PHYS 20330

PHYS 22451 Mathematical Methods in Physics I Tutorial (0 Credit Hours)
The tutorial is a corequisite for PHYS 20451
Corequisites: PHYS 20451

PHYS 22452 Mathematical Methods in Physics II Tutorial (0 Credit Hours)
The tutorial is a corequisite for PHYS 20452.
Corequisites: PHYS 20452

PHYS 23411 Sophomore Seminar (1 Credit Hour)
An introduction to the physics major, career and post-graduate options, and current topics in physics research. Classes are conducted by staff members.
Enrollment is limited to students with a major in Physics.

PHYS 24210 Physics for Life Sciences I (3-4 Credit Hours)
The first semester of a two semester calculus-based introductory physics course intended primarily for students of the life sciences. The basic principles of mechanics, fluids, thermal physics, wave motion and sound are covered. Two semesters of an introductory calculus course are prerequisites. The usual related one hour lab will not be available. The one hour lab component is available in Puebla but not in London.
Prerequisites: MATH 10360 or MATH 10460 or MATH 10560 or MATH 10092 or MATH 10860
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 27310 Engineering Physics Problems & Pedagogy (0 Credit Hours)
This course is intended for upper class undergraduate students who are currently serving as Huddle leaders in an Engineering Physics lecture course (instructor approval is required for enrollment). The purpose of this course is to engage in problem-solving and review current topics from the corresponding Engineering Physics lecture in preparation for assisting undergraduate learners in peer-facilitated study groups.
Prerequisites: (PHYS 10310 or PHYS 10411)

PHYS 30020 Practicing Programming (1 Credit Hour)
This course offers students with beginning to intermediate knowledge of Python an opportunity to practice writing better code. Students will treat programming similarly to a writing skill: code will be evaluated for clarity, reusability, and generality rather than simple functionality. Simple programs are a solution to a single problem, but in time, novice programmers will find their code needs to do more. This course offers students a chance to transition to better code through practice, and will treat projects as the construction of valuable tools that are to be reused rather than one-off assignments. Activities in the course will include discussion of the elements of programming style, and students will create programming projects that execute those principles. Projects will be submitted as drafts and revised several times to improve implementation of the principles of coding style, based on peer and instructor feedback. The instructor will also introduce advanced features of Python that can help make code simpler to edit and revise, based on student interest and skill level. The course is designed to be valuable for a wide range of student knowledge but is designed for students that are comfortable programming in Python. Course is appropriate for graduate or undergraduate students with appropriate Python Skills.

PHYS 30210 Physics I (3 Credit Hours)
The basic principles of mechanics, fluid mechanics, thermal physics, wave motion, and sound. Primarily for students in the life sciences. Laboratory meetings each week. This is the first semester of a 2 semester calculus based course.
Prerequisites: (MATH 10360 or MATH 10460 or MATH 10560 or MATH 10092 or MATH 10860)
Corequisites: PHYS 31210
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering college may **not** enroll.

PHYS 30239 Elementary Cosmology (3 Credit Hours)
An elective course for students planning to major in the arts and letters or business. It is designed to acquaint the non-mathematically inclined student with the most important discoveries in physics of the last few decades and how they have altered our perceptions of the origin and structure of the universe. This course examines such questions as: "Where did the universe come from?" "Why do scientists feel sure that it was born in a cosmic fireball called the Big Bang?" and "Where did the Big Bang itself come from?" This is a reading-intensive course based on popularizations of science written for the curious and intelligent layperson. The emphasis will be on class discussion of the readings. One book report and a term paper are required in addition to examinations. Science or Engineering students who are interested in a more rigorous treatment of the topics covered in this course should consider PHYS 30240 Introduction to Cosmology.
Satisfies the following University Core Requirements: WKST-Core Science & Technology
Students in the College of Engineering or College of Science colleges may **not** enroll.

PHYS 30240 Introduction to Cosmology (3 Credit Hours)
A course primarily for engineering and science students who have completed the introductory physics sequence and who want to know more about what has traditionally been taught in the next course in the introductory sequence, modern physics. Also, open to any university students who have the necessary prerequisites and who have completed an introductory calculus-based physics sequence. Relativity, quantum mechanics, and big bang cosmology will be introduced. The course will emphasize understanding concepts and use appropriate physics and mathematics to explain and understand new ideas about the fluidity of space-time and the paradoxes of relativity and quantum mechanics. Open questions about the concepts will be discussed so students appreciate that new knowledge is still being created. This course will survey how new discoveries in astrophysics, quantum mechanics, and cosmology have advanced our understanding about our world. This course is appropriate for students interested in the link between modern physics and astronomy, cosmology, information science, and leading-edge engineering.
Prerequisites: (MATH 10091 or MATH 10550 or MATH 10850) and (MATH 10092 or MATH 10560 or MATH 10860)
Satisfies the following University Core Requirements: WKST-Core Science & Technology

PHYS 30432 Lasers and Modern Optics (3 Credit Hours)
Principle and practical aspects of laser operation and applications in modern optics. Propagation of light. Ray optics and wave optics. Polarization. Diffraction and interference. Applications in research and industry. A course primarily intended for physics majors and aerospace engineers.
Prerequisites: PHYS 20330 or (PHYS 10424 and PHYS 20435)
Corequisites: PHYS 31432

PHYS 30461 Thermal Physics (3 Credit Hours)
The first half of this course covers classical thermodynamics, from ideal gases to thermodynamic potentials, finishing with phase transitions. The second half is devoted to statistical mechanics as the basis of thermodynamics. Classical and quantum distributions will be introduced to explain the collective behavior of particles, ending with Bose-Einstein condensation.
Prerequisites: PHYS 20454

PHYS 30471 Electricity & Magnetism (3 Credit Hours)
Electro-and magnetostatics. Laplace's and Poisson's equations. Boundary value problems. Multipole fields. Dielectric and magnetic phenomena. Maxwell's equations.
Prerequisites: (PHYS 20435 or PHYS 10320 or PHYS 10094) and (PHYS 20452 or MATH 20670)

PHYS 30472 Electromagnetic Waves (3 Credit Hours)
Study of electromagnetic waves, physical optics, radiation from accelerating charges, and some topics from the special theory of relativity.
Prerequisites: PHYS 30471

PHYS 31210 Physics I Laboratory (1 Credit Hour)
The laboratory is a corequisite for PHYS 30210
Prerequisites: PHYS 30210 (may be taken concurrently) or PHYS 34210
Corequisites: PHYS 20210

PHYS 31432 Lasers and Modern Optics Lab (0 Credit Hours)
Accompanying lab for PHYS 30432.
Corequisites: PHYS 30432

PHYS 31453 Computational Laboratory in Statistical Mechanics (1.5 Credit Hours)
Students will be introduced to the ideas of statistical simulations, learn the concepts of Monte Carlo simulations, and use them to simulate physical systems and solve interdisciplinary problems. They will work on projects which will simultaneously improve their comprehension of statistical mechanics and hone their computational skills. This course is open to all students of science and engineering who have completed a course in Thermodynamics. This course does not serve as a first introduction to computing; students must have taken either PHYS 20420, a computing course from another department, or have permission from the instructor based on computer skills obtained in another setting.

PHYS 31454 Computational Laboratory in Quantum Mechanics (1.5 Credit Hours)
This course is designed to be taken as a computational laboratory in association with PHYS 40454 - Quantum Mechanics II. Students in the class will work on projects in which they will hone their computational skills in order to solve problems in quantum mechanics, including a variety of applications in modern physics. The course will focus on translating physical problems to the computer, improving programming skills, and developing proficiency in numerical techniques, with quantum mechanics as the theme for the problems. This course is not intended as a first introduction to computing; students will be required to have taken PHYS 20420, or have permission from the instructor based on computer skills obtained in another setting.
Prerequisites: PHYS 20420 and PHYS 40454 (may be taken concurrently)

PHYS 33411 Junior Seminar (1 Credit Hour)
A discussion of current topics in physics by staff members. Enrollment is limited to students with a major in Physics.

PHYS 34432 Optics (2,3 Credit Hours)
Principles and practical aspects of laser operation and applications in modern optics. Propagation of plane electromagnetic waves. Diffraction and interference of light. Gaussian beam propagation and optical resonators. Theory of laser oscillation. Gas, solid, semiconductor, and dye lasers. Detectors of optical radiation. Nonlinear optics. Applications in research and industry. Laboratory exercises include polarization, interference, Fourier optics, holography, gas, diode and turnable lasers, and harmonic generation. A course primarily intended for physics majors.

PHYS 34461 Thermal Physics (3 Credit Hours)
Taught at a host instituion. PHYC 30010 Thermodynamics and Statistical Physics at UCD; Themodynamics and Statistical Physics sees wide application across the sciences. This module derives its understanding from first principles and translates this to wide application for example in relation to fluids, solid-state, phase change, radiation and laser physics, boson and fermion statistics. Introduced and widely applied are tools such as concepts of exact and inexact differentials, Maxwell's relations and the Lagrange method of multipliers. When taught in Dublin Ireland: PHYC 30010 Thermodynamics and Statistical Physics at UCD; Themodynamics and Statistical Physics sees wide application across the sciences. This module derives its understanding from first principles and translates this to wide application for example in relation to fluids, solid-state, phase change, radiation and laser physics, boson and fermion statistics. Introduced and widely applied are tools such as concepts of exact and inexact differentials, Maxwell's relations and the Lagrange method of multipliers. When taught at Trinity: PI 4041 Post-Kantian Philosophy: Self-Reference and Self-Awareness at TCD; When we speak or think we cannot avoid making use of the personal pronoun. We say 'I think' 'I am in pain', 'I am hungry' or 'I was born in the last century'. In all these instances reference to a bearer of thought seem inevitable. Yet there are many who wish to convince us that what seems unavoidable, in everyday talk, is nothing other than a linguistic convention. The words #I' and #my' are mere adornments of speech. There is a #necessity of syntax' which compels us to speak of a positional self, however as soon as we have a closer look we come to realise that the pronoun #I' is not a place holder for anything in particular. Indeed, without much trouble we can replace the phrase #I was thinking' with #there was thinking going on', and #I am in pain with #there is pain' since there is no self separable from the thought or the sensation of pain. Proof for this lies in the fact that we cannot perceive such a self but if at all only our objects of thoughts, feelings, sensations or impressions. This is why Hume already concluded that no introspection will ever yield a pure self. Against this view this course wishes to show why we need to hold fast to the claim that #I' is a referring expression. There is something distinctive about the use of the first person pronoun. No description, not even one containing indexicals (other than the first person pronouns themselves) can be substituted for 'I'. We shall do this by focusing on the writings on Wittgenstein, Sartre, Kant and Husserl.

PHYS 34472 Electromagnetic Waves (3 Credit Hours)
Study of electromagnetic waves, physical optics, radiation from accelerating charges, and some topics from the special theory of relativity.

PHYS 40435 Physics of the Brain (3 Credit Hours)
The brain is the most complex organ in the human body. Paradoxically, it helps us understand the world but little about itself. Despite many breakthroughs in psychology and neuroscience, the brain remains largely a mystery. However, it always behaves according to the known laws of physics! In this course, the structure and functions of the brain will be discussed on the basis of fundamental physics principles, including topics such as soft-tissue mechanics; bioelectricity and biomagnetism; transport; fluid dynamics; the energetics of spiking, quantum phenomena; and neuronal networks. After studying the physics-related concepts behind the brain's functions, students will investigate both classical and cutting-edge techniques used for imaging the brain and for measuring its activity. This course will also survey how new discoveries in neurophysics and neuroscience have advanced our understanding about the neuronal system. This course is appropriate for students interested in the link between physics and medical fields.
Prerequisites: PHYS 10320 or PHYS 10422 or PHYS 20220

PHYS 40453 Introduction to Quantum Mechanics I (3 Credit Hours)
A two-semester course on the experimental basis for the wave picture of matter and the fundamental ideas of quantum mechanics. The first semester covers: scattering and bound state solutions to the Schrodinger equation in one and three dimensions; Hilbert spaces and the mathematical formalism underlying quantum mechanics; angular momentum and spin; the hydrogen atom; and multi-particle wavefunctions and identical particles.
Prerequisites: (PHYS 20464 or PHYS 20444) and PHYS 20452 and (MATH 20580 or MATH 20610)

PHYS 40454 Introduction to Quantum Mechanics II (3 Credit Hours)
A two-semester course on the experimental basis for the wave picture of matter and the fundamental ideas of quantum mechanics. The second semester covers: corrections to the hydrogen atom, including fine structure, hyperfine splitting and Zeeman effect; approximation techniques, including WKB, perturbation theory, and variational principle; adiabatic theorem; geometrical phases; and scattering theory.
Prerequisites: PHYS 40453

PHYS 40455 Introduction to Quantum Computing (3 Credit Hours)
This is a one-semester introductory course in quantum computing and information. The course will start with a review of linear algebra and its application to quantum mechanics including many-particle quantum states, entanglement, and measurement. We will introduce basic principles in quantum information and quantum gates and quantum circuits and how these circuits are used to implement quantum algorithms. We will start with simple algorithms and work our way to more important ones such as Grover's search and Shor's factorization. The last part of the course will look at the physical implementations of quantum computers and time-permitting, quantum error correction.

PHYS 41441 Modern Physics I Laboratory (3 Credit Hours)
The laboratory is a co-requisite for PHYS 40441
Prerequisites: PHYS 20464

PHYS 41442 Modern Physics II Laboratory (3 Credit Hours)
A two-semester laboratory course stressing experiments in atomic, nuclear, and solid-state physics. The course is designed to introduce the student to experiments and methods closely related to modern-day research. Students will be introduced to the fundamentals of semiconductor devices and the construction and use of such devices.
3.000 Credit hours 0.000 Lecture hours 3.000 Lab hours

PHYS 43411 Senior Seminar (1 Credit Hour)
A discussion of current topics in physics by students and staff members.

PHYS 44453 Foundations of Quantum Mechanics (3 Credit Hours)
Taught as MAPH 30210 "Foundations of Quantum Mechanics" at host institution. This module starts with the formulation of Quantum Mechanics in its modern mathematical setting. Then several traditional models, including tunnelling and the Hydrogen atom are treated. Some time-dependent perturbation theory is introduced. The module ends with the notion of time evolution in Quantum Mechanics. Course outline: Mathematical Structure: Hilbert spaces, self-adjoint and unitary operators, spectral measures. Postulates of Quantum Mechanics: States, observables and measurements, the correspondence principle, the Heisenberg uncertainty principle. One-dimensional systems: The harmonic oscillator, creation and annihilation operators, potential barriers and wells, tunnelling. Angular momentum and the hydrogen atom. Approximations: Elements of time-independent perturbation theory, the WKB approximation. Time evolution in the Schrödinger and Heisenberg pictures. When taught in Dublin, Ireland the course PHYC 30030 Quantum Mechanics at UCD; Postulates of Quantum Mechanics. Operators, observables and eigenfunctions. Co-ordinate and momentum representations. Hermitian operators. Matrix methods. Uncertainty Principle. Ehrenfest's theorem. Harmonic Oscillator, Ladder operators. Angular momentum. Schrödinger theory of the hydrogen atom. Degeneracy. Fine-structure. Normal Zeeman effect. Pauli theory of electron spin. Stern-Gerlach experiment, Spin-orbit interaction. Total angular momentum. Clebsch-Gordan coefficients. Anomalous Zeeman effect. Time independent perturbation theory, charged harmonic oscillator, Stark effect. Variation method. When taught in Trinity: PY3P01 Quantum Mechanics at TCD; Mathematical foundations of quantum mechanics: description of quantum states and dynamical variables, eigenvalue equations, superposition principle, expectation values. Solution of Schrödinger equation for 1-dimensional systems: SHO using ladder operators, Kronig-Penney model. Angular momentum: calculation of spectrum using ladder operators, orbital angular momentum and parity, spin, addition of angular momenta. Solution of Schrödinger equation in 3 dimensions: the hydrogen spectrum, relativistic corrections and spin-orbit coupling. Time independent perturbation theory.

PHYS 44454 Intro to Quantum Mechanics II (3 Credit Hours)
The purpose of this course is to derive relativistic equations which describe quantum systems and understand their relationship with symmetries and group theory. [Advanced Quantum Mechanics] Addition of angular momentum. Spin angular momentum. Introduction to the standard model of particle physics. [Symmetries and Group Theory] Abstract groups and their representations. Lie groups and infinitesimal generators. Lie algebras. [Spacetime Symmetries] The Lorentz group. The Poincare group. Casimir operators. [Relativistic Wave Equations] Maxwell's equations and gauge theory. The lack of Lorentz invariance of the Schrodinger equation. The Klein-Gordon equation. [The Dirac Equation] Properties of the Dirac equation. The non-relativistic limit. Spinors. Negative-energy solutions: hole theory and anti-particles. [Relativistic Scattering] The free solution of the Dirac equation. The time-independent Dirac equation. The Dirac equation in the presence of a potential. [Introduction to Quantum Field Theory] The Klein-Gordon field.

PHYS 44470 Special Topics (1.5-6 Credit Hours)
This course is used by the Department of Physics to administratively accommodate study abroad course work by students. In the past, it has included course work in the following studies: Phase portraits, flows and evolution. Linear systems; Classification of linear systems, phase portraits of linear systems. Non-linear systems in the plane: Local and global behaviours, fixed points, linearization, stability of fixed points, limit points and limit cycles, Poincare-Bendixson theory. Non-linear systems in higher dimensions: Hyperbolic and non-hyperbolic fixed points, closed orbits, attracting sets and attractors. Chaotic orbits. More recently, it has been used to record a student's completion of a course in Nuclear Physics: Introduction and summary/review of elementary concepts. Natural and artificial radioactivity. Radioactive Decay. Radioactive equilibrium. Interaction of radiation with matter (heavy charged particles, electrons, gamma and X-rays, neutrons). Overview on modes of radioactive decay. Theory of alpha decay - Gamow theory of alpha decay. Beta decay and the electron neutrino. Fermi theory of beta decay. Parity and its non-conservation in the weak interaction. Gamma decay and internal conversion. Liquid drop model of the nucleus. Spontaneous and induced fission. Modern fission reactors. Neutron activation analysis. Nuclear reactions. Nuclear fusion, including properties and confinement of high temperature plasmas. Proto-type fusion reactor. On completion of this module the student should have acquired a basic knowledge of key topics in modern nuclear physics. The student should also be able to solve problems related to the various topics covered, having acquired a competence in the manipulation of appropriate mathematical tools. The module should provide the appropriate foundation for more advanced courses in nuclear physics at postgraduate level.

PHYS 44480 Undergraduate Research (1-4 Credit Hours)
Research in collaboration with members of the faculty. Three to nine hours each week, arranged individually for each student.

PHYS 46490 Directed Readings in Physics (1-3 Credit Hours)
Study of topics not covered or only briefly covered in other courses. Readings, problems and reports.
Course may be repeated.

PHYS 48480 Undergraduate Research (0-3 Credit Hours)
Research in collaboration with members of the faculty. Five to fifteen hours each week, arranged individually for each student. One to three credits.
Course may be repeated.

PHYS 48490 Undergraduate Research (0 Credit Hours)
Research in collaboration with members of the faculty. Arranged individually for each student. Zero credits.

PHYS 48491 Undergraduate Research (0 Credit Hours)
Research in collaboration with members of the faculty. Arranged individually for each student. Zero credit hours and paid.

PHYS 48500 Physics Honors Thesis (0 Credit Hours)
For students who are completing the terminal semester of the Physics Honors Track. Thesis will be submitted to Physics Undergraduate Research Committee by November 1 for fall semester, April 1 for spring semester.

PHYS 48998 Physics Graded Research Education for Undergraduates (6 Credit Hours)
This course has been created so that select students can take it for a grade/credit. It is the same as Phys 48999 and will be held at the same time in the same location.

PHYS 48999 Physics Research Education for Undergraduates (0 Credit Hours)
Students are granted stipends, university housing, and assistance with travel and food expenses. REU program gives valuable research experience, to help students decide if physics research is right for them.