PHYS - PHYSICS

PHYS102 Physics of Music (3 Credits)
A study of the physical basis of sound, acoustical properties of sound, the human ear and voice, reproduction of sound, electronic music, acoustical properties of auditoriums, and other selected topics.
Prerequisite: Must have math eligibility of MATH107 or higher.
Credit Only Granted for: PHYS102 and PHYS499C.
Additional Information: CORE Distributive Studies Physical Sciences Laboratory Course only when taken concurrently with PHYS103.

PHYS103 Physics of Music Laboratory (1 Credit)
Optional laboratory to accompany PHYS 102. Laboratory experiments, including the velocity of sound, sound quality and wave shape, traveling and standing waves, fourier synthesis and analysis, musical synthesizer, psychoacoustics, and audio equipment.

PHYS105 A Global Challenge: Energy and Climate Change (3 Credits)
How will the world address the energy needs of a growing population and its impact on climate change? This class will explore potential solutions to mitigate our atmospheric impact, including technological innovations and policy measures. Additionally, we will analyze the roles of economics, government, and industry in shaping our responses within the context of modern science.
Additional Information: This course is aimed at the non-science major.

PHYS106 Light, Perception, Photography, and Visual Phenomena (3 Credits)
Intended for the general student, this course will cover topics in optics which require minimal use of mathematics. Principles of optics, lenses, cameras, lasers and holography, physics of the eye, color vision and various visual phenomena such as rainbows.

PHYS107 Light, Perception, Photography and Visual Phenomena Laboratory (1 Credit)
Optional laboratory to accompany PHYS106. Laboratory experiments include geometrical optics (lenses, cameras, eye), optical instruments (telescope, binoculars), photography, perception, color phenomena, and wave phenomena.

PHYS111 Physics in the Modern World (3 Credits)
A survey course in general physics emphasizing the role that physics plays in science, technology, and society today. The course is concept oriented and minimal use of mathematics is made. Intended for the general student; does not satisfy the requirements of the professional schools.

PHYS115 Inquiry into Physics (4 Credits)
Intended for students majoring in neither the physical nor the biological sciences. Use of laboratory-based and inquiry-based methods to study some of the basic ideas of physical sciences.
Recommended: High School Physics.
Restriction: Must not have completed PHYS117; and must be in one of the following programs (Elementary Education; Early Childhood Education; Middle School Education).
Credit Only Granted for: PHYS115 or PHYS117.

PHYS121 Fundamentals of Physics I (4 Credits)
The first part of a two-semester course in general physics treating the fields of mechanics, heat, sound, electricity, magnetism, optics, and modern physics. Together with PHYS122, this generally satisfies the minimum requirement of medical and dental schools.
Prerequisite: MATH113 or MATH115.
Credit Only Granted for: PHYS121, PHYS131, or PHYS331.

PHYS122 Fundamentals of Physics II (4 Credits)
A continuation of PHYS121, which together with it, generally satisfies the minimum requirement of medical and dental schools.
Prerequisite: PHYS121; or students who have taken courses with comparable content may contact the department.
Credit Only Granted for: PHYS122, PHYS132, or PHYS332.

PHYS131 Fundamentals of Physics for Life Sciences I (4 Credits)
The first part of a two-semester course in general physics specifically oriented towards applications relevant for students in biology and pre-medical programs. The course covers basic mechanics including forces and energy, properties of matter, and thermodynamics done in authentic biological contexts.
Prerequisite: CHEM131; and (MATH136 or MATH140); and (BSCI160 and BSCI161; or BSCI106); and (BSCI170 and BSCI171; or BSCI105).
Credit Only Granted for: PHYS121, PHYS131, or PHYS331.

PHYS132 Fundamentals of Physics for Life Sciences II (4 Credits)
The second part of a two-semester course in general physics specifically oriented towards applications relevant for students in biology and pre-medical programs. The course covers basic statistical physics, electricity and magnetism, and optics done in authentic biological contexts.
Prerequisite: PHYS131; or students who have taken courses with comparable content may contact the department.
Credit Only Granted for: PHYS122, PHYS132, or PHYS332.

PHYS141 Principles of Physics (4 Credits)
The first of a two-semester series in general physics. The first semester covers the fields of mechanics, thermodynamics, and special relativity. This survey course will use calculus and is recommended for chemistry and zoology majors. It also satisfies the requirements of medical and dental schools.
Corequisite: MATH141 or MATH121; or MATH221.
Credit Only Granted for: PHYS141, PHYS161, or PHYS171.

PHYS142 Principles of Physics (4 Credits)
A continuation of PHYS141 covering waves, electricity and magnetism, optics and modern physics.
Prerequisite: PHYS141; or students who have taken courses with comparable content may contact the department.
Credit Only Granted for: PHYS142, (PHYS260 and PHYS261), or PHYS272.

PHYS161 General Physics: Mechanics and Particle Dynamics (3 Credits)
First semester of a three-semester calculus-based general physics course. Laws of motion, force, and energy; principles of mechanics, collisions, linear momentum, rotation, and gravitation.
Prerequisite: Must have completed or be concurrently enrolled in MATH141.
Credit Only Granted for: PHYS141, PHYS161, or PHYS171.
Additional Information: General Education Natural Sciences Lab (DSNL) Course only when taken concurrently with PHYS275.

PHYS165 Introduction to Programming in the Physical Sciences (3 Credits)
Introduction to programming using examples in the physical sciences. Provides instruction in the techniques of upper-level languages such as Fortran, C, and Pascal, as well as an introduction to the object oriented programming techniques used in Python, C++ and Java. Includes strong component of visualization and graphing.
Prerequisite: PHYS171, PHYS141, or PHYS161; or must have scored 3 or higher on AP PHYS exam.

PHYS170 Professional Physics Seminar (1 Credit)
Provides a look at some of the major developments of current interest in physics research and discusses the activities physicists undertake in research, education, industry, government, and other areas of the economy.
Corequisite: MATH140.
Restriction: Must be in Physics program; or must be in Physics-Education program; or permission of instructor.

PHYS171 Introductory Physics: Mechanics (3 Credits)
First semester of a three semester sequence for physics majors and those desiring a rigorous preparation in the physical sciences: kinematics, Newton's laws, energy and work, linear and angular momenta.
Prerequisite: MATH140; or permission of CMNS-Physics department.
Credit Only Granted for: PHYS141, PHYS161, or PHYS171.
Additional Information: General Education Natural Sciences Lab (DSNL) Course only when taken concurrently with PHYS275.

PHYS172 Succeeding in Physics: Applications, Resources and Concepts (1 Credit)
Supplemental instruction and support for students taking PHYS171, especially for students with limited high school physics preparation, or who will benefit from extra review and practice of relevant mathematics and physics concepts and skills.
Corequisite: PHYS171.
Restriction: Permission of CMNS-Physics department.

PHYS174 Physics Laboratory Introduction (1 Credit)
Introduces students to the techniques of data gathering and analysis. This course will lay a foundation for higher-level labs in physics and the physical sciences. Students will learn to use laboratory equipment such as calipers, meters, oscilloscopes, and computer interfaces. Techniques of measurement and error analysis will be presented. Students will be taught to use the computer for data analysis with an emphasis on using spreadsheets.
Corequisite: MATH140.
Recommended: High school physics.

PHYS235 The Manhattan Project (3 Credits)
Introduction to some critical ideas of nuclear physics and a review of some key historical developments starting at the end of the 19th century. Chronological development of nuclear physics from the discovery of radioactivity by Becquerel in 1896 through to the discovery of fission in Germany in 1938 followed by an examination of the programs to develop nuclear weapons in the United States, Britain and Germany. Extensive study of political, ethical, scientific, military, social, and economic issues surrounding the Manhattan Project.
Recommended: Students should be comfortable standard high school algebra II.
Credit Only Granted for: PHYS199M or PHYS235.
Formerly: PHYS199M.

PHYS260 General Physics: Electricity, Magnetism and Thermodynamics (3 Credits)
Second semester of a three-semester calculus-based general physics course. Electrostatics, magnetism, induction, DC and AC circuits; Maxwell's Equations, heat, and thermodynamics.
Prerequisite: PHYS161 and MATH141.
Corequisite: PHYS261.
Credit Only Granted for: PHYS142, PHYS260, or PHYS272.

PHYS261 General Physics: Mechanics, Vibrations, Waves, Heat (Laboratory) (1 Credit)
Lab includes experiments on mechanics, vibrations, waves, and heat. Engineering majors are expected to take PHYS260 and PHYS261 in the same semester.
Prerequisite: PHYS161.

PHYS265 Introduction to Scientific Programming (3 Credits)
Introduction to scientific programming with python. Basic data types, sequences, input/output, and program control flow structures. Evaluation and plotting of mathematical functions and data. Statistical interpretation of data, and fitting of data to models. Introduction to numerical methods including integration, solutions of ordinary differential equations, and linear algebra. Extensive use of the numpy, matplotlib, and scipy packages.
Prerequisite: PHYS171, PHYS141, or PHYS161; or must have scored 3 or higher on AP PHYS C Mechanics exam.
Credit Only Granted for: PHYS165 or PHYS265.
Formerly: PHYS165.

PHYS270 General Physics: Waves, Optics, Relativity and Modern Physics (3 Credits)
Third semester of a three-semester calculus-based general physics course. Waves, sound, electromagnetic waves, optics, special theory of relativity, and modern physics.
Prerequisite: PHYS261, MATH241, and PHYS260.
Corequisite: PHYS271.

PHYS271 General Physics: Electrodynamics, Light, Relativity and Modern Physics (Laboratory) (1 Credit)
Lab includes experiments on ac circuits, magnetism, light and modern physics. PHYS270 and PHYS271 (lab) must be taken in the same semester.
Prerequisite: PHYS261.
Corequisite: PHYS270.

PHYS272 Introductory Physics: Fields (3 Credits)
Second semester of a calculus based general physics course. Universal gravitation, electric and magnetic fields and potentials, simple circuits, Maxwell's equations in integral form. Continues the application of mathematics to conceptual models, now with more abstract components.
Prerequisite: PHYS161 or PHYS171; and MATH141; and must have completed or be concurrently enrolled in MATH241.
Credit Only Granted for: PHYS142, PHYS260, or PHYS272.

PHYS273 Intermediate Oscillations and Waves (3 Credits)
Classical physics at an intermediate level, introducing mathematical tools such as complex variables, linear differential equations, and Fourier series and transforms. Physics of mechanical and electrical oscillators, including damped and driven systems; coupled oscillators and normal modes; the classical wave equation and its Fourier solutions; wave reflection and transmission at boundaries; Maxwell's equations in differential form; electromagnetic waves, and physical optics.
Prerequisite: MATH241 and PHYS272; and must have completed or be concurrently enrolled in one of the following: (PHYS274, MATH243, MATH246 or equivalent).

PHYS274 Mathematical Methods for Physics I (3 Credits)
A first course in mathematical methods for physics. Topics include linear algebra, curvilinear coordinates and vector analysis.
Prerequisite: MATH241 and PHYS272.

PHYS275 Experimental Physics I: Mechanics and Waves (2 Credits)
A first course for physics majors and interested engineering students introducing the methods of experimental science. Students learn to identify various statistical data distributions, carry out rigorous uncertainty analysis, and test whether a given theoretical model adequately describes the observed phenomena. These concepts are applied to sophisticated physical systems that exhibit complex behavior and can yield remarkably precise and accurate results. Experiments are chosen from the areas of mechanics and waves.
Prerequisite: Must have completed or be concurrently enrolled in PHYS171 or PHYS161.
Additional Information: General Education Natural Sciences Lab (DSNL) Course only when taken concurrently with PHYS171 or PHYS161.

PHYS276 Experimental Physics II: Electricity and Magnetism (2 Credits)
Second course in the three semester introductory sequence. Methods and rationale of experimental physics. Experiments chosen from the fields of electricity and magnetism including electrostatics, magnetostatics, magnetic induction, AC circuits.
Prerequisite: PHYS272 and PHYS275.

PHYS298 Special Topics in Physics (1-3 Credits)
Special topics in physics.
Repeatable to: 6 credits if content differs.

PHYS299 Special Problems in Physics (1-6 Credits)
Research or special study to complement courses taken elsewhere which are not fully equivalent to those in departmental requirements. Credit according to work done.
Prerequisite: Permission of CMNS-Physics department.

PHYS299Q Quantum Steampunk Science-Fiction Workshop (3 Credits)
Steampunk is a science-fiction genre in which futuristic technologies populate Victorian-era settings. Recently, steampunk has come to life in the scientific field of quantum thermodynamics. Thermodynamics, the study of energy, grew out of the Industrial Revolution. Two centuries later, quantum physics is transforming computing and cryptography. Quantum science is now revolutionizing 19th-century thermodynamics in quantum thermodynamics, which features quantum engines, automata, and more. Quantum thermodynamics inspired the growing subgenre of quantum steampunk. In this course, you will read science fiction, write quantum steampunk short stories, receive feedback, and critique classmates' writing. In parallel, you will learn about quantum physics, technologies, and thermodynamics.
Cross-listed with: ARHU270, CMSC298Q, ENME299Q.
Credit Only Granted for: ARHU270, ARHU298Q, CHEM298Q, CMSC298Q, ENME299Q or PHYS299Q.

PHYS313 Electricity and Magnetism I (4 Credits)
A first course in electricity and magnetism at an advanced level. Electrostatics; solutions to the Laplace and Poisson equations in cartesian and spherical coordinates; electric fields in matter; and magnetostatics. Study of boundary value problems and extensive use of vector calculus.
Prerequisite: MATH241, PHYS273, and one of the following: PHYS274, MATH240, MATH243, MATH246, or equivalent courses.

PHYS318 Topics in Contemporary Physics (3 Credits)
A survey of topics of current research and public interest. Intended for the non-physics or non-science major. Topics covered will include lasers, quantum liquids, cosmology, elementary particles and geophysics.
Prerequisite: PHYS122 or PHYS111; or permission of CMNS-Physics department.

PHYS331 Physics for Life Sciences I (4 Credits)
The first part of a two-semester course in general physics specifically oriented towards applications relevant for students in biology and pre-medical programs. The course covers basic mechanics including forces and energy, properties of matter, and thermodynamics done in authentic biological contexts.
Prerequisite: CHEM131; and (MATH131 or MATH136); and (BSCI160 and BSCI161; or BSCI106); and (BSCI170 and BSCI171; or BSCI105). Or students who have taken courses with comparable content may contact the department.
Credit Only Granted for: PHYS121, PHYS131 or PHYS 331.

PHYS332 Physics for Life Sciences II (4 Credits)
The second part of a two-semester course in general physics specifically oriented towards applications relevant for students in biology and pre-medical programs. The course covers basic statistical physics, electricity and magnetism, and optics done in authentic biological contexts.
Prerequisite: PHYS331; or PHYS131; or students who have taken courses with comparable content may contact the department.
Credit Only Granted for: PHYS122, PHYS132, or PHYS332.

PHYS371 Modern Physics (3 Credits)
Physics of the early 20th century. Special relativity; particle-wave duality; Compton scattering; the Bohr model; the Schroedinger equation; atomic and nuclear physics phenomena. Includes introductory thermodynamics and the kinetic theory of gases.
Prerequisite: PHYS273; and 1 course from (PHYS274, MATH243, or MATH246).
Credit Only Granted for: PHYS371 or PHYS420.
Additional Information: Intended primarily for physics and astronomy majors.

PHYS373 Mathematical Methods for Physics II (3 Credits)
A second course in mathematical methods for physics. Topics include introduction to ordinary differential equations, partial differential equations, and complex analysis.
Prerequisite: PHYS273 and PHYS274.

PHYS375 Experimental Physics III: Electromagnetic Waves, Optics and Modern Physics (3 Credits)
Third course in the three-semester introductory sequence. Methods and rationale of experimental physics. Experiments chosen from the areas of electromagnetic waves, optics and modern physics.
Prerequisite: PHYS276 and PHYS273.

PHYS386 Experiential Learning (3-6 Credits)

PHYS389 Undergraduate Thesis Research (1-6 Credits)
Independent directed research and study on a topic selected by the student in consultation with his or her advisor. Final written thesis and oral defense will be expected.
Prerequisite: Permission of CMNS-Physics department.
Restriction: Must be in a major within CMNS-Physics department.
Repeatable to: 6 credits.

PHYS398 Independent Studies Seminar (1-16 Credits)
Credit according to work done. Enrollment is limited to students admitted to the independent studies program in physics.

PHYS399 Special Problems in Physics (1-3 Credits)
Selected advanced experiments. (Will be given with sufficient demand.)
Prerequisite: PHYS405; and permission of CMNS-Physics department.

PHYS401 Quantum Physics I (4 Credits)
Introduces some quantum phenomena leading to wave-particle duality. Schroedinger theory for bound states and scattering in one dimension. One-particle Schroedinger equation and the hydrogen atom.
Prerequisite: PHYS371; and (PHYS313 or PHYS373).

PHYS402 Quantum Physics II (3 Credits)
Applications of quantum mechanics to atomic, molecular, and solid state systems. Addition of angular momenta, multiparticle states, perturbation theory and other approximation techniques, scattering, and symmetries.
Prerequisite: PHYS401.

PHYS404 Introduction to Statistical Thermodynamics (3 Credits)
Introduction to basic concepts in thermodynamics and statistical mechanics.
Prerequisite: PHYS371 or PHYS420.

PHYS405 Advanced Experiments (3 Credits)
Advanced laboratory techniques. Selected experiments from many fields of modern physics. Emphasis on self-study of the phenomena, data analysis, and presentation in report form.
Prerequisite: PHYS375.
Restriction: Must be in a major within CMNS-Physics department.

PHYS406 Experimental Research Development (3 Credits)
Part I of a two-semester, independent, experimental research project supervised by a faculty mentor. The student participates significantly in experimental design, set-up, and collection and analysis of real, physical data, including the evaluation of experimental uncertainties. The student maintains a lab notebook and completes an end-of-semester progress report.
Prerequisite: PHYS375.
Restriction: Permsission of CMNS-Physics department.
Additional Information: The student is expected to work on the project for approximately 9 hours per week in a standard semester or a total of 135 hours in a non-standard semester. PHYS406 may not be used to satisfy an advanced physics elective.

PHYS407 Undergraduate Experimental Research (3 Credits)
Students develop and complete an independent, experimental research project with a professor in the Physics Department. The project should be a continuation of work done in PHYS499A. To obtain permission, students must submit a proposal describing the experimental work to be completed and this proposal must be approved by their faculty mentor, the associate chair for undergraduate education and the chair of the laboratory committee. Students must maintain a lab notebook, give an oral presentation and complete a written report on their research that includes data and error analysis.
Prerequisite: PHYS499 and PHYS375; and permission of CMNS-Physics department.
Restriction: Must be in a major within CMNS-Physics department; and senior standing.

PHYS410 Classical Mechanics (3 Credits)
Classical mechanics at a more advanced level, including its Newtonian, Lagrangian, and Hamiltonian formulations. Conservative and non-conservative forces; the calculus of variations; central force motion; non-inertial frames of reference; rigid body rotations; and selected advanced topics.
Prerequisite: PHYS265 and PHYS273; and (MATH243 or MATH246).

PHYS411 Intermediate Electricity and Magnetism (4 Credits)
Foundations of electromagnetic theory, with extensive applications of the methods. Thorough treatment of wave properties of solutions of Maxwell's equations.
Prerequisite: PHYS313 or PHYS373.

PHYS412 Intermediate Electricity and Magnetism I (4 Credits)
The first semester of a two semester course with emphasis on electrostatics and magnetostatics, boundary value problems, fields in matter, electrodynamics, and Maxwell's equations.
Prerequisite: PHYS373.

PHYS413 Electricity and Magnetism II (3 Credits)
The second semester of a two semester course with emphasis on electromagnetic waves, potentials and gauge invariance, and relativistic electrodynamics
Prerequisite: PHYS313 or PHYS412.
Credit Only Granted for: PHYS411 or PHYS413.

PHYS420 Principles of Modern Physics (3 Credits)
A survey of atomic and nuclear phenomena and the main trends in modern physics. Appropriate for students in engineering and other physical sciences.
Prerequisite: MATH246. And PHYS271 and PHYS270; or PHYS273.
Credit Only Granted for: PHYS371 or PHYS420.

PHYS428 Physics Capstone Research (2-4 Credits)
Individual, focused research under the guidance of a faculty member. Discussion, presentations and, if appropriate, research group projects involved. Student must submit final research paper for completion of course. Paper may also serve as thesis required for High Honors in Physics. Not intended as a general "reading course" (see PHYS499).
Restriction: Must be in a major within CMNS-Physics department; and senior standing or higher; and permission of instructor.
Repeatable to: 4 credits.

PHYS429 Atomic and Nuclear Physics Laboratory (3 Credits)
Classical experiments in atomic physics and more sophisticated experiments in current techniques in nuclear physics.
Prerequisite: PHYS405.

PHYS431 Introduction to Solid State Physics (3 Credits)
Classes of materials; introduction to basic ideal and real materials' behavior including mechanical, electrical, thermal, magnetic and optical responses of materials; importance of microstructure in behavior. One application of each property will be discussed in detail.
Prerequisite: PHYS271, PHYS270, and MATH241.
Cross-listed with: ENMA460.
Restriction: Junior standing or higher; and must be in the Engineering: Materials Science program or Physics program.
Credit Only Granted for: ENMA460 or PHYS431.
Additional Information: Materials Engineering students take ENMA460 and Physics students take PHYS431.

PHYS441 Topics in Nuclear and Particle Physics (3 Credits)
A survey of concepts in particle and nuclear physics, with a topical emphasis on the impact of the Weak Interaction and the discovery of Parity Violation.
Prerequisite: PHYS401 or PHYS402.
Corequisite: PHYS402.

PHYS444 Computing Beyond the Standard Model of Particle Physics (3 Credits)
An exploration of the computing languages and techniques used to analyze large data sets in Large Hadron Collider physics with some discussion of applications in unrelated fields.
Prerequisite: PHYS371 and PHYS373; or permission of instructor.

PHYS456 Making Physics Experiments (3 Credits)
Laboratory course emphasizing practical skills used for making Physics experiments within the broader context of the maker movement and the maker culture. Design, fabrication, hands-on skills, repair, and safety. Practical skills not otherwise covered in traditional coursework (e.g.: carpentry, electronics disassembly/assembly, soldering, etc.).
Prerequisite: PHYS276; or permission of instructor.
Restriction: Permission of Physics Department.
Credit Only Granted for: PHYS499X or PHYS456.
Formerly: PHYS499X.

PHYS457 Introduction to Quantum Computing (3 Credits)
An introduction to the concept of a quantum computer, including algorithms that outperform classical computation and methods for performing quantum computation reliably in the presence of noise. As this is a multidisciplinary subject, the course will cover basic concepts in theoretical computer science and physics in addition to introducing core quantum computing topics.
Prerequisite: 1 course with a minimum grade of C- from (MATH240, PHYS274); and 1 course with a minimum grade of C- from (CMSC351, PHYS373).
Restriction: Permission of CMNS-Physics department; or permission of CMNS-Computer Science department. Cross-listed with CMSC4 57.
Credit Only Granted for: PHYS457 or CMSC457. Additional infor mation: No previous background in quantum mechanics is required.

PHYS467 Introduction to Quantum Technology (3 Credits)
Investigates the basic concepts/building blocks of quantum computers, quantum key distribution, quantum networks, and quantum sensors. Examines what is needed to form a working qubit and different hardware platforms that implement them (for example, trapped ions, superconducting microwave circuits, color centers, and neutral atoms.) Conceptual and computational familiarity with complex numbers, vector spaces, bases, matrices, eigenvectors, and eigenvalues will be assumed, as well as quantum states/wave functions, and quantum measurement. Familiarity with spin-1/2 systems, and Pauli matrices is highly recommended.
Prerequisite: MATH141 and MATH240 or equivalent; and one of the following: PHYS360, PHYS401, PHYS457, or ENEE491; or permission of instructor.
Cross-listed with: ENEE492.
Credit Only Granted for: PHYS467 or ENEE492.

PHYS474 Computational Physics (3 Credits)
Introduction to computational physics. Overview of some of the most widely used methods of computational physics and computational methods, including data analysis and statistical methods, visualization, numerical solutions of ordinary and partial differential equations (classical equations of motion, Poisson's equation, time independent and time dependent Schrodinger equations) and Monte Carlo simulations. In addition to giving the students a basic working knowledge of these particular techniques, the goal is to make them proficient in scientific computing and programming in general, so that they will be prepared to tackle other computational and data analysis problems that they may encounter in the future. This course will use the programming language Python.
Prerequisite: PHYS373; and (PHYS165, CMSC106, or CMSC131).
Recommended: PHYS401 (strongly recommended).
Additional Information: Students will need a laptop for this course to run specific software; however, arrangements will be made for those who need them. Students will need to load the Python 3 language on your computer, which will be done in the first week of class. The class will use the "Anaconda" environment/distribution, which is available for Mac/Windows/Linux. Contact the department for more information.

PHYS476 Introduction to Applied Machine Learning (3 Credits)
Introduces machine learning techniques that are becoming pertinent in the technology industry. Focus on hands-on work using popular high-level libraries. Students are expected to have a background in functional programming, linear algebra, calculus, and mathematical modeling.
Prerequisite: PHYS165, PHYS274, and PHYS276; or interested students with backgrounds in functional programming, linear algebra and statistics, should contact the instructors to request permission.

PHYS485 Electronic Circuits (3 Credits)
Theory and application to experimental physics of modern semiconductor analog and digital circuits. Emphasis on understanding passive and active elements in practical circuits. Topics span the range from simple transistor circuits to microcomputers.
Prerequisite: PHYS272 and PHYS276.
Restriction: Must be in a major within CMNS-Physics department.

PHYS487 Computerized Instrumentation (3 Credits)
Concentration on computer interfaces to measurement devices. Includes a review of basic electronic circuits and measurement devices. Extensive work with arduinos, making use of a variety of measurement probes. Includes introduction to the C++ programming language, the Segger development environment, and real-time operating systems (RTOS) used in advanced physics experiments.
Prerequisite: PHYS276 or Permission of Instructor.
Restriction: Departmental Permission.

PHYS499 Special Problems in Physics (1-16 Credits)
Research or special study. Credit according to work done.