

STAT 491***Statistics for Scientists I**

Frequency distributions, descriptive statistics, elementary probability; Bernoulli, binomial, and normal distributions; statistical sampling, estimation, and hypothesis testing. Less mathematical treatment than STAT 411. Prerequisite: MATH 127 or MATH 128 or equivalent. 3 credits.

***Duplicate credits cannot be earned in any two of STAT 411 and 491**

STAT 492**Statistics for Scientists II**

Chi-square tests for goodness-of-fit and independence, simple and multiple linear regression, designing an experiment (analysis of variance), multiple comparison. Less mathematical treatment than STAT 412. Prerequisites: STAT 152 and consent of instructor or STAT 467 or STAT 491. 3 credits.

STAT 493**Applied Regression Analysis**

Line fitting; multiple linear and curvilinear regression models; variable selection techniques and examination of residuals, estimation, testing, and prediction; simple, multiple, and partial correlation. Prerequisites: STAT 152 and consent of instructor or STAT 411, STAT 467 or STAT 491. 3 credits.

STAT 495**Nonparametric Statistics**

Survey of nonparametric procedures with emphasis on application; binomial, Mann-Whitney, Wilcoxon, Kruskal-Wallis, Friedman, Kolmogorov-Smirnov, and chi-square tests; measures of association; regression. Comparisons with parametric techniques. Prerequisites: STAT 152 and consent of instructor or STAT 411 or STAT 467 or STAT 491. 3 credits.

STAT 499**Independent Study**

Library research and reports on topics of statistical interest. May be repeated for credit with consent of the Mathematical Sciences Department. Except under special circumstances, total credits limited to six. Prerequisite: STAT 411 or equivalent. 1-3 credits.

Department of Physics and Astronomy

Purpose and Focus

The Bachelor of Science in Physics provides students with preparation for governmental or industrial positions or for graduate studies in physics or related areas. The Bachelor of Science in Applied Physics is designed to introduce the major branches of physics to those seeking double degrees and for those preparing for professions other than physics. The Bachelor of Science in Computational Physics is intended to train students with the state-of-the-art knowledge in physics and scientific computing for either professional positions or graduate studies in computational physics or related areas.

Degree Objectives/Learning Outcomes

At the completion of the physics degree programs, students should have developed rigorous communication, analytical, computing, problem solving, and team-work skills.

Accreditation

Northwest Commission on Colleges and Universities.

Undergraduate Majors

Applied Physics
Computational Physics
Physics

Minor Physics

Includes PHYS 180, 180L, 181, 181L, 182, 182L, 411, and 413 and nine additional credits (three courses) of upper-division physics course work.

No course in which a grade of C- or lower is earned may be applied to any minor in the College of Sciences.

Admission to the Major

Minimum GPA: 2.50

Admission Policies: Students unable to meet the 2.50 GPA requirement may be admitted under contract on a probationary basis, and no students with GPAs less than 2.30 will be admitted.

Transfer Policies: A student transferring from another college or university who declares a major in Physics, Applied Physics, or Computational Physics with a GPA of between 2.30 and 2.50 may become a probationary student. A probationary student must plan a prescribed course of study in physics in consultation with the faculty advisor assigned by the Physics Department. Only after the course of study is signed by the advisor, may the department chair allow the student to register for courses. The student must maintain a GPA of at least 2.50 in the courses taken while on probation. Otherwise, the student will be dropped from the physics program. When the student's overall GPA rises to 2.50, the student is taken off probation. Refer to the College of Sciences section for further requirements.

Department Policies

Academic Policies: For all majors in the programs offered by the Physics Department, a grade of C or higher is required in each of the physics core requirements. In addition, before enrolling in any major requirement courses, the student must have completed all course prerequisites with a grade of C or higher.

Advisement

It is required that all incoming freshmen and transfer students obtain advising from the College of Sciences Advising Center prior to the first semester of classes. As well, those students with any questions regarding degree requirements and graduation applications should contact the Advising Center. All students majoring in Physics, Applied Physics, or Computational Physics will also be assigned a faculty advisor in the Physics Department. Students must meet with their advisor in the Physics Department at least once during the academic year.

Degree Requirements

Applied Physics — B.S.

- 1) English Composition 6 credits
ENG 101 and ENG 102
- 2) English Literature 3 credits
ENG 231 or 232
- 3) Constitutions 3-6 credits
- 4) Mathematics 3 credits
MATH 181
- 5) Distribution Requirement
(Life & Physical Sciences & Analytical Thinking)
Humanities and Fine Arts 9 credits
Social Science 9 credits
- 6) Multicultural (see notes)
International (see notes)
- 7) Degree Requirements:
Physics Core Requirements 36 credits
PHYS 180, PHYS 180L, PHYS 181, PHYS 181L, PHYS 182, PHYS 182L, PHYS 411, PHYS 413, PHYS 414, PHYS 421, PHYS 422, PHYS 423, PHYS 424, PHYS 493, six additional credits of upper-division physics courses.

Related Core Requirements 20-33 credits
CHEM 121, CHEM 122, MATH 181, MATH 182, MATH 283, six credits of upper-division MATH or upper-division CS courses, ten additional credits of science, mathematics, or engineering courses. (Credits used to satisfy a minor in science, mathematics, or engineering may also satisfy part of these requirements.)

Minor or Approved Program 18-27 credits
Any accepted minor in the College of Science or the College of Engineering or an equivalent program formally approved by the Physics Department faculty.

Electives 20 credits
Total: 124 credits

Computational Physics — B.S.

- 1) English Composition 6 credits
ENG 101 and ENG 102
- 2) English Literature 3 credits
ENG 231 or 232
- 3) Constitutions 3-6 credits
- 4) Mathematics 3 credits
MATH 181
- 5) Distribution Requirement
(Life & Physical Sciences & Analytical Thinking)
Humanities and Fine Arts 9 credits
Social Science 9 credits
- 6) Multicultural (see notes)
International (see notes)
- 7) Degree Requirements:
Physics Core Requirements 39 credits
PHYS 180, PHYS 180L, PHYS 181, PHYS 181L, PHYS 182, PHYS 182L, PHYS 300, PHYS 404, PHYS 411, PHYS 413, PHYS 421, PHYS 423, PHYS 467, PHYS 481, and PHYS 493 (in computational physics).

Related Core Requirements 40 credits
CS 135, CS 202, MATH 181, MATH 182, MATH 283, MATH 365, MATH 466, and fifteen additional credits of science, mathematics, computer science, or engineering courses with at least six of them in upper-division courses (numbered 300 or higher).

Electives 15 credits
Total 124 credits

Notes:

1. The Physics Department recommends that students take PHYS 422 and PHYS 424 for the six additional credits of upper-division physics courses needed in the Physics Core Requirement.
2. Every student must complete a multicultural course and a international course. Courses satisfying other requirements may simultaneously satisfy the multicultural and international requirements except one course cannot satisfy both the multicultural and the international requirements.

Physics — B.S.

- 1) English Composition 6 credits
ENG 101 and ENG 102
- 2) English Literature 3 credits
ENG 231 or 232
- 3) Constitutions 3-6 credits
- 4) Mathematics 3 credits
Math 181
- 5) Distribution Requirement
(Life & Physical Sciences & Analytical Thinking)
Humanities and Fine Arts 9 credits
Social Science 9 credits
- 6) Multicultural (see notes)
International (see notes)
- 7) Degree Requirements:
Physics Core Requirements 48 credits
PHYS 180, PHYS 180L, PHYS 181, PHYS 181L, PHYS 182, PHYS 182L, PHYS 411, PHYS 413, PHYS 414, PHYS 421, PHYS 422, PHYS 423, PHYS 424, PHYS 467, PHYS 481, PHYS 493, six additional credits of upper-division physics courses.

Related Core Requirements 30-33 credits
CHEM 121, CHEM 122, MATH 181, MATH 182, MATH 283,
six credits of upper-division MATH or upper-division CS
courses, ten additional credits of science, mathematics, or
engineering courses.

Electives 16 credits
Total: 124 credits

Astronomy

AST 100C

Topics in Astronomy: White Dwarfs, Neutron Stars, and Black Holes

Traces the history of a star's evolution from its birth in interstellar gas and dust to its end as a placid white dwarf, fiery nova or supernova, or mysterious black hole. Emphasis upon the archetypical Crab Nebula and its rotating neutron star. Recommended for non-science majors. Prerequisite: Consent of instructor. 1 credit.

AST 103

Introductory Astronomy: The Solar System

Beginning level survey that discusses the nearby objects of our solar system, the formation and evolution of planetary bodies and the exploration of space. A minimum of mathematics is required. Recommended for non-science majors. 3 credits.

AST 104

Introductory Astronomy: Stars and Galaxies

Survey course at the beginning level which discusses stellar systems and galaxies. Topics include stellar evolution, formation of galaxies, and cosmology. A minimum of mathematics is required. Recommended for non-science majors. 3 credits.

AST 105

Introductory Astronomy Laboratory

Laboratory exercises in astronomy presented in the tradition of the amateur astronomer. Instruction includes observation of celestial objects as well as laboratory exercises to investigate the physical nature of astronomical objects. Instruction on the use of telescopes and the process of the scientific method presented. Recommended for non-science majors. Prerequisite: AST 103 or AST 104, or concurrent registration in one of these courses. 1 credit.

AST 190

Projects in Observational Astronomy

Project-oriented course to develop skills in observational astronomy. The material and experience gained quite helpful to those people interested in education or in astronomy. The use of high quality equipment such as cameras, photometers, telescopes, and heliostats emphasized. Laboratory course recommended for non-science majors. Prerequisite: AST 105. 3 credits.

AST 301

Introduction to Astrophysics

Introduction to modern astrophysics. Discussion of matter and electromagnetic radiation, the physical processes in stars, galaxies, active galactic nuclei, and the large-scale structure of the Universe. Emphasis on applying physical principles

and problem-solving techniques to astronomical situations. Prerequisite: PHYS 180. 3 credits

AST 470

Special Topics in Astrophysics

Advanced astrophysics. Material alternates among three topics: solar system astrophysics, stellar structure and evolution, and galactic dynamics. Emphasis on current areas of interest. Prerequisites: PHYS 180, PHYS 181, PHYS 182, and PHYS 411. 3 credits.

Physics

PHYS 120

Introduction to Einstein's Spacetime

Algebra-based exploration of Einstein's theory of Special Relativity covering time dilation, length contraction, the addition of velocities, the Lorentz transformation, the Twin Paradox, Minkowski space-time diagrams, and other topics time permitting. Beauty and consistency of Special Relativity emphasized. 3 credits.

PHYS 151/151L-152/152L

General Physics I, II

General physics intended primarily for students in liberal arts, medicine, and the biological sciences. Lecture and laboratory exercises in mechanics, heat, electricity, magnetism, optics, and modern physics. Three hours lecture and three hours laboratory. Prerequisite: MATH 128 or equivalent, or placement test. PHYS 151/151L is prerequisite for PHYS 152/152L. 4 credits each.

PHYS 180

Physics for Scientists and Engineers I

Lecture in Newtonian mechanics. Rectilinear motion, particle dynamics, work and energy, momentum and collisions, rotational mechanics, oscillations, wave motion, and gravitation. Prerequisite: MATH 181. 3 credits.

PHYS 180L

Physics for Scientists and Engineers Lab I

Laboratory exercises in Newtonian mechanics. Rectilinear motion, particle dynamics, work and energy, momentum and collisions, rotational mechanics, oscillations, wave motion, and gravitation. Corequisite: PHYS 180. 1 credit.

PHYS 181

Physics for Scientists and Engineers II

Lecture in electromagnetism. Coulomb's law, electric and magnetic fields, Gauss' law, potential, capacitance, current and resistance, electromotive force, inductance, motion of charged particles, introduction to Maxwell's equations, and electromagnetic waves. Prerequisites: PHYS 180 and MATH 182. 3 credits.

PHYS 181L

Physics for Scientists and Engineers Lab II

Laboratory exercises in electromagnetism, Coulomb's law, electric and magnetic fields, Gauss' law, potential, capacitance, current and resistance, electromotive force, inductance, motion of charged particles, introduction to Maxwell's equations, and electromagnetic waves. Corequisite: PHYS 181. 1 credit.

PHYS 182

Physics for Scientists and Engineers III

Lecture in fluid mechanics, thermodynamics, and optics. Sound, temperature and thermometry, heat, gases, intermolecular forces, kinetic theory, entropy, nature of light, geometrical optics, physical optics including diffraction and interference, introduction to modern developments. Prerequisites: PHYS 180 and MATH 182. 3 credits.

PHYS 182L

Physics for Scientists and Engineers Lab III

Laboratory exercises in fluid mechanics, thermodynamics, and optics. Sound, temperature and thermometry, heat, gases, intermolecular forces, kinetic theory, entropy, nature of light, geometrical optics, physical optics including diffraction and interference, introduction to modern developments. Corequisite: PHYS 182. 1 credit.

PHYS 191

Directed Study

Individual projects under the direction of a faculty member. Department approval must be obtained prior to registration. Prerequisite: Three credits of physics. 1-3 credits.

PHYS 250

Special Relativity

In-depth introduction to the space time of special relativity with emphasis on coherence brought about by the union of three-dimensional Euclidean space time to form a four-dimensional space. Prerequisites: PHYS 180 or consent of instructor. 3 credits.

PHYS 300

Introduction to Physics and Scientific Computing

Basic concepts and methods in solving scientific problems in physics and other disciplines computationally. Emphasis on problems not commonly solvable by analytical means. Hands-on experience with real-life problems in physics and scientific computing. Prerequisites: PHYS 152, PHYS 152L or PHYS 180, PHYS 180L. 3 credits.

PHYS 350

Introduction to General Relativity

Physics in and around black holes is used as a vehicle for learning about the implications of general relativity. Prerequisites: PHYS 250 or consent of instructor. 3 credits.

PHYS 404

Computational Techniques in Physics

Application of numerical methods to simulation of physical systems, including topics in classical mechanics, electrostatics, quantum mechanics, scattering, nonlinear dynamics and chaos. Prerequisites: PHYS 181, PHYS 182 and experience with high-level programming language. 3 credits.

PHYS 411

Modern Physics I

Those aspects of quantum and statistical mechanics and relativity necessary to describe the changes in the physicist's world view

wrought by revolutionary theories early in the last century. Prerequisites: PHYS 181, PHYS 181L, PHYS 182, PHYS 182L. 3 credits.

PHYS 412

Modern Physics II

Continuation of the survey of twentieth-century developments in physics. Topics include simple molecular quantum mechanics, quantum statistics, solids, superfluids and superconductors, nuclear processes and models, and elementary particle physics. Prerequisite: PHYS 411. 3 credits.

PHYS 413

Intermediate Laboratory I

Experimental investigation of a variety of phenomena involving the properties of electrons and their interactions with fields and matter, including selected quantum and wave mechanical effects. Experiments designed to reinforce theory learned in previous courses and to develop laboratory techniques. Corequisite: PHYS 411. 3 credits.

PHYS 414

Intermediate Laboratory II

Further experimental investigations of phenomena in classical and modern physics. Emphasis on problem solving, experimental technique, data analysis, and independent work. Students encouraged to alter or extend the experiments and engage in projects. Prerequisite: PHYS 413. 3 credits.

PHYS 421-422

Electricity and Magnetism I, II

Electrostatics, magnetic fields, and electromagnetism. Maxwell's equations, theory of metallic conduction, motion of charged particles, radiation. Prerequisite: PHYS 181, PHYS 421 is prerequisite for PHYS 422. 3 credits each.

PHYS 423-424

Mechanics I, II

Newtonian mechanics. Mathematical formulation of the dynamics of a particle and systems of particles, including applications to atomic physics. Mechanics of continuous media using Fourier series. Introduction to generalized coordinates and the methods of Lagrange and Hamilton. Prerequisite: PHYS 180. PHYS 423 is prerequisite for PHYS 424. 3 credits each.

PHYS 426

Physics of Solids

Structure of crystalline solids. Mechanical, thermal, and electric properties of conducting and non-conducting solids. Prerequisite: PHYS 411. 3 credits.

PHYS 431

Nuclear and Elementary Particle Physics

Survey of basic nuclear concepts and structure. Interactions between nuclear radiations and matter, nuclear reactions and decay, nuclear force, sub-atomic structure and models, symmetries and conservation laws. Prerequisite: PHYS 411. 3 credits.

PHYS 441**Mathematical Physics**

Application of selected mathematical techniques to problems in physics. Prerequisite: PHYS 181. 3 credits.

PHYS 442**Mathematical Physics II**

Application of selected mathematical techniques to problems in physics. Prerequisites: PHYS 181, PHYS 441. 3 credits.

PHYS 451**Modern Scientific Instrumentation**

Electronics for scientists, including circuit design and construction using analog and digital integrated circuits. Introduction to machining, glassblowing, and fabrication techniques. Prerequisites: PHYS 181, PHYS 181L, PHYS 182, PHYS 182L, PHYS 422. 3 credits.

PHYS 461**Light and Physical Optics**

Survey of geometric optics and optical instruments. Selected topics in physical optics including interference, diffraction and polarization, with applications; the nature of light. Prerequisite: PHYS 182. 3 credits.

PHYS 462**Modern Optics and Photonics**

Laser principles and applications. Non-linear optics, image formation, optical transfer function, and Fourier optics. Introduction to quantum optics. Prerequisite: PHYS 461. 3 credits.

PHYS 467**Thermodynamics**

Fundamentals of thermodynamics, including equations of state, laws of thermodynamics, and entropy. Principles and methods of temperature measurement, calorimetry and heat transfer. Prerequisite: PHYS 182. 3 credits.

PHYS 468**Statistical Mechanics**

Principles and applications of statistical mechanics. Quantum statistics of ideal gas and simple solids. Transport theory, irreversible processes and fluctuations. Prerequisite: PHYS 467. 3 credits.

PHYS 481**Quantum Mechanics I**

Introduction to the Schroedinger Equation and the interpretation of its solutions, the uncertainty principles, one-dimensional problems, harmonic oscillator, angular momentum, the hydrogen atom. Prerequisites: PHYS 422 and PHYS 424. 3 credits.

PHYS 482**Quantum Mechanics II**

Introduction to the matrix formulation of quantum mechanics, spin, coupling of angular momenta and applications. Time dependent perturbation theory and approximation methods and techniques discussed. Prerequisite: PHYS 481. 3 credits.

PHYS 483**Special Topics in Physics**

Special topics in physics such as, but not limited to, relativity, plasma physics, hydrodynamics, and particle physics. May be repeated to a maximum of six credits. Prerequisite: PHYS 182. 3 credits.

PHYS 485**Condensed Matter Physics**

Properties of condensed matters and their applications in materials science. Structures of classical and quantum liquids. Correlations in lower dimensional systems. Localization and magnetism. Superconductivity and superfluidity. Polymers and liquid crystals. Prerequisite: PHYS 481. 3 credits.

PHYS 491**Independent Study**

Independent study of a topic in physics not specifically included in the regular course offerings. Grade depends on requirements outlined in a written contract between student and instructor agreed upon prior to beginning the course. Prerequisites: PHYS 180, PHYS 180L, PHYS 181, PHYS 181L, PHYS 182, PHYS 182L and consent of instructor. 1-3 credits.

PHYS 493**Special Problems**

Laboratory or research work on a project that demonstrates the student's ability to apply his or her knowledge of physics. A 30-minute talk on the project required. Prerequisites: Nine credits of upper-division physics courses and consent of instructor. 1-3 credits.

Sciences**SCI 101****First Year and Transfer Science Major Orientation**

Orientation for first time freshmen and transfer students. Confers training in use of library and other research resources. Provides strategies for preparing for science coursework at the collegiate level. S/F grading only. 1 credit.

SCI 410L**Standardized Test Lab**

Laboratory review of basic sciences for standardized tests required for application to Health Science Professional School. Practice examinations administered on Saturday's. Prerequisites: BIOL 196, 197, CHEM 121, 122, 241, 242, PHYS 151, 152. Three credit laboratory course. 3 credits.

SCI 499**Training in Science Leadership**

Seminar course designed to develop and hone leadership skills. Students acquire skills required for proctoring examinations, tutoring of undergraduate students, teaching undergraduate students, and supervising student evaluation of teaching. Students receive education regarding ethics that are essential for responsibilities. Prerequisites: Sophomore or higher standing, cumulative GPA of 3.00 or higher. 3 credits.