

PHYSICS

Faculty

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The physics department provides learning experiences that prepare students to achieve the following outcomes:

- demonstrate knowledge of fundamental principles governing the behavior of physical systems
- apply scientific methodology to identify and solve appropriate physical problems
- demonstrate competence in experimentation
- effectively communicate knowledge of physics orally and in writing
- connect the knowledge and skills gained in the study of physics to holistic concerns of meaningful citizenship, employment and personal development

Majors Offered by the Physics Department

Concordia's Physics department offers three different majors, all with a significant degree of flexibility in the choice of advanced courses, intended to serve students with a wide range of interests.

The traditional **Physics Major** is recommended for those students that intend to go to graduate school in physics or a closely related discipline after college. Although there is a fair amount of flexibility, since one can choose the four advanced physics courses, the table below shows the most recommended courses for those aiming at graduate school in physics, with an emphasis in foundational knowledge.

The **Applied Physics Major** is recommended for those students aiming to go into the workforce after graduation, as well as those who intend to go to grad school in Engineering. Again, there is a high degree of flexibility in the choice of advanced courses and the emphasis is on a practical approach.

The **Physics Major with Astrophysics Emphasis** is addressed to the students who have an interest in the large-scale mysteries of the universe. It can serve both those that intend to go to graduate school and those who want to go into the workforce, depending on the choice of advanced courses and electives.

The Physics department also offers a **Physics Minor**, whose first four semesters are exactly the same as for the Physics Major. After those first four semesters, to obtain the minor it is necessary to take one 4-credit advanced physics course (300 level or above), to choose from the department's offerings.

The Advanced physics courses regularly offered by the department are:

- Classical Mechanics
- Electrodynamics
- Statistical Physics
- Quantum Mechanics
- Techniques for Experimental Physics
- Condensed Matter Physics
- Introduction to General Relativity

- Astrophysics
- Senior Seminar (2 credits)

In addition, depending on staff availability and student demand, other elective advanced courses are occasionally offered (examples include Particle Physics, Quantum Computing, Introduction to Nanosciences, Optics, etc.).

Programs Offered

Majors

- Applied Physics Major (<https://catalog.concordiacollege.edu/arts-sciences/physics/applied-physics-major/>)
- Physics Major (<https://catalog.concordiacollege.edu/arts-sciences/physics/physics-major/>)
- Physics Major with an Astrophysics emphasis (<https://catalog.concordiacollege.edu/arts-sciences/physics/physics-major-concentration-astrophysics/>)

Minor

- Physics Minor (<https://catalog.concordiacollege.edu/arts-sciences/physics/physics-minor/>)

Engineering Dual Degree Programs

Concordia College has partnered with the following universities to create dual degree programs that result in earning a Bachelor of Arts degree with an Applied Science major from Concordia College as well as a Bachelor of Science degree with an engineering major at the partnering institution. More information about Pre-Engineering programs is available at this link (<https://catalog.concordiacollege.edu/pre-professional-programs/pre-engineering/>).

- North Dakota State University Partnership (<https://catalog.concordiacollege.edu/arts-sciences/physics/dual-degree-ndsu/>)
- Valparaiso University Partnership (<https://catalog.concordiacollege.edu/arts-sciences/physics/dual-degree-valparaiso/>)

Physics Education

Students seeking licensure to teach physics must also fulfill the requirements for a major in education (<https://catalog.concordiacollege.edu/arts-sciences/education/education-major/>). For additional information about teaching physics, see the chair of physics or the chair of education.

General Science add-on education endorsement: Students majoring in physics and earning a licensure for teaching may complete an add-on option for grades 5-8 licensure (<https://catalog.concordiacollege.edu/arts-sciences/education/#endorsementooptionstext>).

Courses

PHYS 104 / ESC 104 - Introductory Astronomy: Solar System, 4 credits.

This course is an introduction to our solar system designed for students in all disciplines. Topics include: light and telescopes, a historical overview of astronomy, a study of the components of the solar system and a discussion of the formation of the solar system. Past, present and future space exploration missions are also covered. Three class periods and one laboratory/observing period each week. Prerequisite: high school algebra and geometry or MATH 110 - Precalculus

Frequency: *Not offered on a Regular Basis*

Core designations: Natural Science N

PHYS 106 / ESC 106 - Introductory Astronomy: Stars, Nebulae and Cosmology, 4 credits.

This course is an introduction to the universe beyond our solar system designed for students in all disciplines. Topics include: light and telescopes, the appearance of the sky, negotiating star maps, the physical nature of stars and their formations and life cycles, clusters of stars, gas clouds and laboratory/observing period each week. (PHYS 104, ESC 104 - Introductory Astronomy: Solar System is not a prerequisite.) Prerequisite: high school algebra and geometry or MATH 110 - Precalculus

Frequency: *Alternate Years - 1st Semester*

Core designations: Natural Science N

PHYS 111 - General College Physics I, 4 credits.

Topics in mechanics and thermal physics are discussed. Techniques general to all areas of physics are developed. Three class periods and one three-hour laboratory each week. Prerequisite: competence in mathematics (algebra and trigonometry) equivalent to concurrent registration in MATH 110 - Precalculus or a good high school background

Frequency: *Every Year - First Semester*

Core designations: Natural Science N

PHYS 112 - General College Physics II, 4 credits.

This is a continuation of PHYS 111 - General College Physics I. Techniques are expanded, and topics in electricity, optics, and modern physics are added. Three class periods and one three-hour laboratory each week.

Frequency: *Every Year - Second Semester*

Prerequisites: PHYS 111 or PHYS 128

PHYS 115 - Foundations of Modern Physics, 4 credits.

This course develops problem-solving skills by exploring ideas of 21st century physics. Fundamental physical concepts such as energy, momentum, waves, and electromagnetic forces are introduced and used to gain a basic comprehension of topics such as quantum mechanics, wave-particle duality of matter, and special relativity. Three class periods and one two-hour laboratory per week - the laboratory includes a component on professional development and success.

Frequency: *Every Year - First Semester*

Prerequisites: MATH 121 (may be taken concurrently)

PHYS 128 - Physics for Scientists and Engineers, 4 credits.

This is an accelerated introduction to mechanics, waves, and thermal physics. Three class periods and one three-hour laboratory each week.

Frequency: *Every Year - Second Semester*

Prerequisites: MATH 121 (may be taken concurrently) or MATH 122

Core designations: Natural Science N

PHYS 153 - Science of Sound and Music, 4 credits.

Methods, epistemology, strengths and limitations of scientific inquiry are discussed. Physical concepts underlying sound are introduced, including forces, motion, and the character and perception of waves. Acoustic topics include intensity, pitch, tone quality, temperament; sound generation by voices, stringed, brass, reed and percussion instruments; sound recording and reproduction; room and auditorium acoustics. Three seventy minute lecture/demonstration classes and one two-hour laboratory per week.

Frequency: *Not offered on a Regular Basis*

Core designations: Natural Science N

PHYS 211 - Physics for Scientists and Engineers II, 4 credits.

This is a continuation of PHYS 128 - Physics for Scientists and Engineers I. Topics include thermal physics, electricity, magnetism and optics. Three class periods and one three-hour laboratory each week.

Frequency: *Every Year - First Semester*

Prerequisites: MATH 122 (may be taken concurrently)

PHYS 216 - Physical Science II, 1 credits.

This is a continuation of PHYS 215. This course is designed for elementary education majors seeking a concentration in science. Topics include vector addition, motion and forces in two dimensions, conservation of energy, conservation of momentum and waves. One 100-minute class period each week.

Frequency: *Alternate Years - 2nd Semester, 1st or 2nd Half - 2nd Semester*

Prerequisites: SCIE 215 (may be taken concurrently)

PHYS 231 - Introduction to Instrumentation, 2 credits.

This course is an introduction to electronics and experimental instrumentation. Topics include using LabVIEW to interface computers with electronic instrumentation for data acquisition and experiment control; RC and RLC circuits; complex impedance, Operational Amplifiers, and a student-designed project using Arduinos.

Frequency: *1st or 2nd Half - 1st Semester*

Prerequisites: PHYS 211 (may be taken concurrently)

PHYS 233 - Introduction to Computational Physics, 2 credits.

This course introduces some computational tools used by physicists. The main focus will be on programming techniques to solve realistic physical problems. No programming experience is necessary. Required for all physics majors.

Frequency: *1st or 2nd Half - 1st Semester*

Prerequisites: PHYS 211 (may be taken concurrently) and MATH 223 (may be taken concurrently)

PHYS 234 - Introduction to Materials Science, 0-4 credits.

In this course and its accompanying laboratory, we explore the fundamental knowledge about various types of materials, their usage and properties that are essential in engineering design. The important relationships between internal structure and properties ranging from mechanical, thermal, electrical and magnetic in nature will all be studied.

Frequency: *Alternate Years - 2nd Semester*

Prerequisites: (PHYS 224 or PHYS 324) or CHEM 128

PHYS 314 - Classical Mechanics, 4 credits.

Newton's laws are applied in specific situations. Topics include forces, fields, non-inertial reference frames, oscillations, collisions, planetary motions, rigid body dynamics, and an introduction to Lagrangian mechanics. Three 70-minute class periods each week.

Frequency: *Alternate Years - 1st Semester*

Prerequisites: PHYS 128 and MATH 223 (may be taken concurrently)

PHYS 315 - Electrodynamics, 4 credits.

The fields of fixed and moving charges and their effects on other charges are described. The behavior of fields in conducting, dielectric, and magnetic media, and the propagation of electromagnetic waves are studied. Three class periods each week.

Frequency: *Alternate Years - 1st Semester*

Prerequisites: PHYS 211 and MATH 223 (may be taken concurrently)

PHYS 316 - Statistical Physics, 4 credits.

The behavior of matter at macroscopic and microscopic levels is discussed. Techniques of statistical mechanics are used to describe the behavior of ideal gases, heat engines, heat transfer, and magnetic effects. Three class periods each week.

Frequency: *Alternate Years - 2nd Semester*

Prerequisites: (PHYS 225 or PHYS 324) and MATH 223

PHYS 317 - Optics, 4 credits.

This course is an introduction to geometrical optics, lenses, mirrors, ray tracing, and aberrations, followed by a detailed discussion of physical optics, electromagnetic character of light, reflection, interference, diffraction and lasers. Three class periods and a two-hour laboratory each week.

Frequency: *Alternate Years - 2nd Semester*

Prerequisites: PHYS 211

PHYS 324 - Modern Physics, 4 credits.

This course and required laboratory develop the theories of Special Relativity and Quantum Mechanics. These disciplines are applied to models of atoms, nuclei and elementary particles.

Frequency: *Every Year - Second Semester*

Prerequisites: PHYS 115 and PHYS 211 and MATH 223 (may be taken concurrently)

PHYS 327 - Techniques for Experimental Physics, 4 credits.

A laboratory-intensive exploration of advanced methods in experimentation. Emphasis is on topics in quantum physics: energy spectroscopy of photons and particles, nuclear reactions, and optical spectroscopy. Other areas to be explored are optical diffraction and electromagnetic waves. Two two-hour lecture/laboratory sessions each week.

Frequency: *Alternate Years - 2nd Semester*

Prerequisites: (PHYS 225 (may be taken concurrently) or PHYS 324)

PHYS 356 - Condensed Matter Physics, 4 credits.

This course provides a theoretical introduction and an overview of the fundamental applications of solid state physics. It includes theoretical description of crystal and electronic structure, lattice dynamics, and physical properties of materials (metals, semiconductors, dielectrics, magnetic materials and superconductors).

Frequency: *Not offered on a Regular Basis*

Prerequisites: PHYS 324

PHYS 357 - Astrophysics, 4 credits.

This course is a rigorous introduction to modern astrophysics. Topics include geometry of the celestial sphere, astronomical instrumentation, structure and evolution of stars and galaxies, and modern cosmology.

Frequency: *Alternate Years - 1st Semester*

Prerequisites: (PHYS 324 or CHEM 128) and MATH 223 (may be taken concurrently) and (ESC 104 or ESC 106)

PHYS 380 - Special Topics, 0-4 credits.

Courses covering various topics of interest in this particular discipline are offered regularly. Contact department or program chair for more information.

Frequency: *Not offered on a Regular Basis*

Repeatable: Yes

PHYS 390 - Academic Internship, 1-8 credits.

Frequency: *Every Semester*

Repeatable: Yes

PHYS 419 - Introduction to General Relativity, 4 credits.

This course is an introduction to Einstein's theory of gravitation, and will focus on physical consequences of the solutions of Einstein's equation for particular geometries. Among the applications to be studied are black holes and gravitational waves. Required for physics majors with a concentration in astrophysics.

Frequency: *Alternate Years - 1st Semester*

Prerequisites: PHYS 324 and MATH 311 (may be taken concurrently)

PHYS 429 - Quantum Mechanics, 4 credits.

One of the great intellectual accomplishments of the modern era, quantum physics presents a radical new picture of the material world. This course covers the principles and techniques of basic quantum mechanics, including the uncertainty principle, Schrödinger's equation, matrix mechanics, and perturbation theory. Three class periods each week.

Frequency: *Alternate Years - 2nd Semester*

Prerequisites: (PHYS 224 or PHYS 324) and MATH 223 and MATH 311 (may be taken concurrently)

PHYS 430 - Senior Seminar, 2 credits.

This course uses the seminar format to assist students to improve their scientific communication skills. Students will learn about the writing and presentation standards in physics, work on a senior thesis paper under the supervision of the instructor, and present the thesis for criticism and discussion. Prerequisites: senior standing and any major in physics.

Frequency: *Every Year - First Semester*

PHYS 480 - Independent Study, 1-4 credits.

This course provides an opportunity for individual students to conduct in-depth study of a particular topic under the supervision of a faculty member. Contact the department or program chair for more information.

Frequency: *Every Semester*

Repeatable: Yes

PHYS 487 - Directed Research, 1-4 credits.

This course provides an opportunity for individual students to conduct research in a specific area of study, completed under the direction of a faculty mentor. Specific expectations of the research experience to be determined by the faculty. Repeatable for credit. Prerequisite: consent of instructor.

Frequency: *Not offered on a Regular Basis*

Repeatable: Yes