Faculty: Ms. Mader, Chairperson; Mr. DeYoung, Mr. Gonthier*, Ms. Hampton, Mr. Remillard.

The Department of Physics offers several majors. The course structure allows students to tailor their programs to their main interests. Opportunities for research participation are available to all students at all class levels during both the academic year and the summer. Students are presently engaged in:

- nuclear physics experiments on the Hope accelerator
- theoretical astrophysics investigations
- theoretical nuclear physics investigations
- heavy ion physics experiments at national laboratories
- surface analysis using alpha particle beams from the Hope accelerator
- chemical analysis using proton beams from the Hope accelerator
- superconductivity
- microwave science
- electrochemistry
- nanoscale science

Laboratories provide students with opportunities to test fundamental concepts and apply theory in practical applications. In addition, research programs and internships enable students to work along side faculty members and working professionals. In the department, the primary physics research laboratories are: a 1.7 million volt Van de Graaff pelletron tandem accelerator, a nuclear physics laboratory, a superconductivity/microwave laboratory, and an electrochemistry/nanoscale laboratory. There is extensive computer support. Students and faculty are also involved in research programs at national laboratories and NASA Goddard Space Flight Center. Students are strongly encouraged, as early as possible, to become involved in one of the research programs of the faculty members. Summer stipends for such activity are often available.

MAJOR PROGRAMS

The department offers several majors designed to meet a variety of students' needs. Students with a possible interest in engineering should also see that section.

PHYSICS

Program for students interested in post-graduate professional work in physics, astronomy, medicine, biophysics, chemical physics, materials physics, radiation physics, environmental physics, medical physics:

Bachelor of Arts Degree — A minimum of 27 credits from physics courses numbered 121 and higher including 8 credits from courses numbered 340 or higher. Courses required are 121 and 122, 141, 142, 270, 280, 281, and 382. Also two semesters of PHYS 080 (Seminar) are required. The mathematics requirement is MATH 232. An additional laboratory course, designated for science majors, in chemistry, biology, or geology is required. Computer programming competence is expected by the beginning of the junior year. This requirement may be satisfied by CSCI 160 (preferred), 225 or 283, or by demonstrating programming competence on a problem chosen by the department.

Bachelor of Science Degree — A minimum of 36 credits in physics including 121 and 122, 141, 142, 270, 280, 281, and two semesters of 382. In addition, three courses selected from PHYS 342, 361, 362, 372, and 380 are required. Two semesters of PHYS 080 (Seminar) are required. In addition, 24 credits of courses in mathemat-

*Sabbatical Leave, Fall Semester 2008

ics, computer science, and science are required, including MATH 232 and a laboratory science course, designated for science majors, in chemistry, biology, or geology. Computer programming competence is expected by the beginning of the junior year. This requirement may be satisfied by CSCI 160, 225, 241, or by demonstrating competence on a problem chosen by the department. For those planning graduate work, MATH 334, 361 or 370, and other physics courses, engineering courses (especially 345), and research are recommended.

Honors Designation: In order to encourage students to go beyond the minimum requirements for graduation, students completing additional requirements will have an Honors Designation added to their transcripts. Students must fulfill the requirements for a B.S. in physics, and take an additional 6 credits of physics. Physics 342, 361, 362, and 372 must all be taken. In addition, one summer and two semesters (for one credit each term) of research work must be done with a Hope faculty member, and the research work must be documented in written form and submitted to the *Journal of Undergraduate Research* or another appropriate peer-reviewed journal. An additional semester of a laboratory based science majors course outside of physics is required, and a mathematics course beyond the required calculus sequence is required. The minimum GPA in physics courses is 3.6.

ENGINEERING PHYSICS

Students wishing to combine elements of physics and engineering in their major should consider the Bachelor of Science in Engineering Physics. This major (minimum of 36 credits) combines elements from both areas and is designed in consultation with the chairperson and requires prior approval from the department.

DUAL MAJORS

In case of a dual major, the physics courses required are those listed above. The additional mathematics and science requirements shall be established by agreement between the student and the department. Recent dual majors have included physics-mathematics, physics-computer science, physics-geology, physics-chemistry, and physics-philosophy.

STUDENTS PREPARING FOR SECONDARY EDUCATION

A Bachelor of Arts degree with a major in physics will require 30 credits (certification requirement) in physics and completion of the education requirements. A listing of the requirements can be found on the education Web site. Students interested in teaching physics at the secondary level should begin working with the Department of Education as early as possible.

PHYSICS MINOR

A minor in physics consists of 20 credits. Physics 121, 122, 141, 142, 270, and at least one 300-level course are required. The remaining courses are to be chosen by the student in consultation with the department chairperson. The exact courses will depend upon the intended major program of the student. Approval of the courses by the department chairperson is required.

ENGINEERING

The fields of physics and engineering are closely related. Similar principles and science concepts are found in both. One is more focused on application and one tends more to the abstract. Students unsure of their specific career goals are encouraged to read about the engineering program elsewhere in this catalog.

HEALTH PROFESSIONS — Medicine, Dentistry, Physical Therapy, Veterinary Medicine

Students considering one of the health professions may enroll either in Physics 105, 106, 107, 108, or Physics 121, 122, 141, 142. Consultation with your advisor about the appropriate course is strongly advised. Students who may pursue graduate work in the sciences should take Physics 121, 122, 141, 142.

PREREQUISITE POLICY

Many courses in the department have prerequisites listed. A grade of C- or better is required in these prerequisite courses. If this is not the case, then it is the view of the department that the prerequisite has not been fulfilled and the course may not be taken without written permission of the instructor and the department chairperson.

SCIENCE MAJOR ORIENTED COURSES

080. Seminar — All students interested in physics and engineering are encouraged to attend departmental seminars. Registered students are required to attend at least 80 percent of the seminars presented. The purpose of the seminars is twofold. One is the presentation of fields of current interest and questions of concern for researchers so that students can learn the content of and approaches to research. The other is to provide students contemplating further study at the graduate level with opportunities to discuss with speakers the programs at their institutions. In this manner, students can make better informed decisions on the course of their further education. Prerequisite for registration: junior standing. *Zero Credits Both Semesters*

105. College Physics I — This is an algebra-based course which provides a rigorous examination of the following physical phenomena and systems: 1) mechanics (forces, kinematics of motion, conservation of energy and momentum, collisions, and rotational systems), 2) oscillating systems and springs and 3) selected topics from molecular physics and heat (physics of solids and fluids, thermal physics and thermodynamics). Corequisite: Physics 107. Prerequisite: Mathematics 123 (A Study of Functions) or the equivalent. *Three Credits Remillard Fall Semester*

106. College Physics II — A continuation of College Physics I, Physics 105. This course is algebra-based with an accompanying laboratory. It provides a rigorous examination of the following physical phenomena and systems: 1) electricity and magnetism, 2) geometric optics, 3) physical optics and waves and 4) atomic and nuclear physics. Corequisite: Physics 108. Prerequisites: Physics 105 and Mathematics 123 (A Study of Functions) or the equivalent.

Three Credits Remillard Spring Semester

107. College Physics Laboratory I — The laboratory is designed to accompany Physics 105. Basic laboratory skills are developed. Students use modern instrumentation methods to explore and analyze scientific measurements. This laboratory is a great introduction to the use of computers in the collection and analysis of data. Students will be able to study quantitatively, and in detail, many of the mechanical systems which are presented in Physics 105. Corequisite: Physics 105.

One Credit Mader Fall Semester

108. College Physics Laboratory II — A continuation of Physics 107, College Physics Laboratory I. The laboratory accompanies Physics 106. The topics of electricity and magnetism, electrical circuits, optics, radiation and quantum effects are explored. Physical phenomena are studied and measured at a more advanced level, including techniques currently employed in modern physics. A major goal of the

course is to develop skills in the measurement of physical phenomena. Corequisite: Physics 106. Prerequisite: Physics 107. *One Credit Mader Spring Semester*

111. Introduction to Physics — This course is an introduction to the field and practice of physics for those intending or considering a major in physics. It focuses on the topic of spectroscopy in atomic spectra, stellar astrophysics, molecular spectroscopy, and proton induced x-ray emission. Students will also learn laboratory skills, writing skills, problem-solving skills, and presentation skills. Prerequisite: concurrent enrollment in Mathematics 131 or 125, or permission of the instructor.
Two Credits Mader Fall Semester

112. Introduction to Modern Physics — This course is an introduction to modern physics for the student who enters Hope College with advanced placement but weaknesses in the area of modern physics. The material covered includes interference and diffraction, wave nature of light, particle nature of light, wave nature of matter, introduction to quantum mechanics, and atomic and nuclear structure. Prerequisites: Advanced Placement credit for Physics 122 and concurrent enrollment in Mathematics 132. *Two Credits DeYoung Fall Semester*

121. General Physics I — The course is calculus-based and designed for students desiring professional science careers. It provides a rigorous examination of the following physical phenomena and systems: forces, conservation of momentum, energy (kinetic, potential, chemical, and thermal), fields, thermodynamics, and statistical mechanics. Corequisite: Physics 141. Mathematics 131 (Calculus I) or 126 must accompany or precede. *Three Credits DeYoung, Hampton Spring Semester*

122. General Physics II — A continuation of General Physics I, Physics 121. The course is calculus-based with an accompanying laboratory. It is designed for students desiring professional careers in science. The course provides a rigorous introduction to the following topics: 1) electricity and magnetism, 2) geometric optics, 3) physical optics and waves, 4) atomic and nuclear physics. Corequisite: Physics 142. Prerequisite: Physics 121 (permission of instructor required if Physics 121 grade is below C-). Mathematics 132 must accompany or precede this course.
Three Credits DeYoung, Hampton Fall Semester

141. Physics Laboratory I — The laboratory is designed to accompany Physics 121. Basic laboratory skills are developed. The use of modern instrumentation in physical measurements is explored. Students gain experience in using computers to analyze scientific measurements. Topics covered include forces, conservation of momentum, conservation of energy, oscillation systems, and rotational motion. Corequisite: Physics 121. *One Credit DeYoung Spring Semester*

142. Physics Laboratory II — A continuation of Physics 141, Physics Laboratory I. The laboratory accompanies Physics 122. Physical phenomena are studied and measured on a more advanced level. Topics in electrostatics, radioactivity, modern physics, optics, electricity and magnetism, resonance, and electrical circuits are explored. A major goal of the course is to develop skills in the measurements of physical phenomena. Corequisite: Physics 122. *One Credit DeYoung Fall Semester*

241. Electronics I — An introduction to digital and analog electronics. This course is cross listed as ENGS 241. A full description may be found there.

242. Electronics II — Advanced applications of analog and digital electronics. This course is cross listed as ENGS 242. A full description may be found there.

270. Modern Physics — A first course in the quantum physics of atoms, molecules, solids, nuclei, and particles. Topics include special relativity, the structure of the nucleus, the Schroedinger wave equation, one electron atoms, angular momentum,

spectra, transition rates, and quantum statistics. Applications to atoms, molecules, nuclei, conductors, semiconductors, superconductors, and elementary particles will be discussed. Experiments as well as theory will be examined. Prerequisites: Physics 122 and Mathematics 132, or permission of instructor.

Four Credits Mader Spring Semester

280. Introduction to Mathematical Physics and Engineering — Mathematical methods applicable to physical systems are studied. These include effective use of MAPLE, modeling with ordinary differential equations, vector calculus, Fourier Analysis, and common differential equations. Special attention is given to physical examples from multiple areas to show the generality of the techniques. Corequisite: Mathematics 232. *Two Credits DeYoung Spring Semester*

281. Intermediate Laboratory — This course focuses on developing experimental skills. These include experiment planning, research, analysis, error propagation, writing, and presenting. A series of short exercises are done first to develop the background in these areas and then experiments are done where these skills must be correctly applied. Typical laboratory experiments will include the Cavendish experiment, index of refraction of a gas with an interferometer, and determining the ellipticity of a large outdoor courtyard. Prerequisite: Physics 270.

Two Credits Remillard Fall Semester

290. Independent Studies — With departmental approval freshmen or sophomores may engage in independent studies at a level appropriate to their ability and class standing, in order to enhance their understanding of physics. Students may enroll each semester. Permission of the instructor is required.

One or Two Credits Mader Both Semesters

295. Studies in Physics — A lecture and/or laboratory course in a physics area of current interest. *Two to Four Credits Mader Both Semesters*

342. Electricity and Magnetism — A course in classical electromagnetism with the development and application of Maxwell's equations as the central focus. Topics include electromagnetic fields, boundary value problems, dielectric and magnetic materials, radiation, and energy and momentum of the electromagnetic field. Prerequisites: Physics 280 and Mathematics 232. *Four Credits Remillard Spring Semester*

352. Optics — Topics covered concern both geometrical and physical optics. The approach involves matrix formulation, computer formulation, Fourier analysis as it relates to Fresnel and Frauenhofer diffraction, interference, polarization matrices and holography. The relevance of these topics to modern day optical information processing and physical devices is considered. Prerequisite: Physics 280. Alternate years.

Three Credits DeYoung Spring Semester, Even Years

361. Analytical Mechanics — This course covers Newtonian mechanics, linear and nonlinear oscillations, calculus of variations, Lagrangian and Hamiltonian dynamics, and motion in noninertial frames of reference. The course builds upon the topics covered in general physics and makes extensive use of the methods learned in Introduction to Mathematical Physics. The course acquaints students with mathematical and computer techniques in solving complex problems. These more formal methods empower students with skills necessary to make the transition from introductory to advanced physics and engineering. Prerequisites: Physics 280, Mathematics 232 and programming competence. *Four Credits Hampton Fall Semester*

362. States of Matter — The prominent states of matter are examined from classical and quantum mechanical points of view. An overview of thermodynamics and statistical mechanics is given. Effects of Bose-Einstein and Fermi-Dirac statistics

are detailed for gases, liquids and solids. Slightly degenerate perfect gases, electrons in metals and Bose-condensation, viewed as a first order phase transition, are discussed. Applications are made to such systems as plasmas, semiconductors, white dwarfs, and neutron stars. Special emphasis is given to superfluids, superconductors, and the Josephson effect. Alternate years. Corequisite: Physics 280. Prerequisites: Physics 270 and Mathematics 232.

Four Credits Gonthier Spring Semester, Odd Years

372. Quantum Theory — A detailed study of the mathematical and physical foundations of quantum mechanics. Topics include the Schroedinger wave equation, one-dimensional potentials, operator methods in quantum mechanics, the Heisenberg representation of operators, the three-dimensional Schroedinger equation, angular momentum, the hydrogen and helium atoms, matrix methods in quantum mechanics, time independent and time dependent perturbation theory, radiation of atoms, and scattering theory. Prerequisites: Physics 270, 280 and Mathematics 232. Alternate years. *Four Credits Gonthier Fall Semester, Odd Years*

380. Mathematical Physics and Engineering II — This is a continuation of Physics 280, Introduction to Mathematical Methods in Physics and Engineering. Additional mathematical methods, primarily for physics, are considered, including complex analysis, numerical methods, probability and statistics, additional special functions, and more partial differential equations. Prerequisite: Physics 280.

Two Credits DeYoung Fall Semester

382. Advanced Laboratory — This laboratory builds on the skills learned in Physics 280 and combines experiments from both classical and modern physics. Extensive use of the computer is made in the analysis of data from experiments. Detailed error analysis of each experiment is required. In any given semester the selected topics are drawn from experiments such as gamma detection, Millikan oil drop, alpha spectroscopy, accelerator operation, Cavendish, Rutherford scattering, and neutron activation. Two hours of lecture and seven hours of laboratory. Required for physics majors and may be taken more than once for credit. Prerequisites: Physics 270 and 281, and Mathematics 232. *Two Credits Gonthier Spring Semester*

490. Research — With departmental approval juniors or seniors may engage in independent studies at a level appropriate to their ability and class standing, in order to enhance their understanding of physics. Students may enroll in each semester.

One or Two Credits Remillard Both Semesters

495. Advanced Studies in Physics — A lecture or seminar in an area of special interest or experience. Department chairperson's approval required.

Three or Four Credits Mader Spring Semester