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# DEPARTMENT OF PHYSICS

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190 SCIENCE AND ENGINEERING BUILDING

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**Chairperson:** *Andrei Slavin***Professors emeriti:** *Abraham R. Liboff, John M. McKinley, Ralph C. Mobley, Norman Tepley, Paul A. Tipler, W. D. Wallace, Robert M. Williamson***Distinguished professor:** *Michael Chopp***Professors:** *Ken Elder, David Garfinkle, Bradley J. Roth, Andrei Slavin, Gopalan Srinivasan, Uma Devi Venkateswaran, Yang Xia***Associate professors:** *George Martins, Alberto Rojo***Assistant professor:** *Evgeniy Khain***Visiting assistant professor:** *Eugene Surdutovich***Adjunct professors:** *Carl Bleil, Howard J. Dworkin, Adrian Kantrowitz, Jae Ho Kim, Joseph V. Mantese, Harold Portnoy, Hani Sabbah***Adjunct associate professors:** *Stephen L. Brown, Kapila Clara Castoldi, Constantine Demetropoulos, James R. Ewing, Robert A. Knight, S. David Nathanson, Stephen E. Robinson***Adjunct assistant professors:** *Susan M. Bowyer, Kenneth Jenrow, Quan Jiang, Zheng-Gang Zhang***Adjunct instructor:** *Ray A. Carlson***Lecturers:** *Rao Bidthanapally, Sally K. Daniel***Chief Adviser:** *David Garfinkle*

Courses within the Department of Physics are grouped into two categories — pre-professional career programs and experiences in science for students with broad interests in contemporary human culture. The latter are strongly recommended for students planning any of a wide range of careers, including law, business, criminology, art history, music, government, education and journalism. High school students intending to major in physics should refer to the Admissions section of the catalog for specific preparation requirements.

Programs of study lead to the Bachelor of Science degree with majors in physics, medical physics and engineering physics, Bachelor of Arts degree with a major in physics, Master of Science degree in physics, and Doctor of Philosophy degree in biomedical sciences with specialization in medical physics.

The Bachelor of Science in physics is intended for students who plan to become professional scientists. It qualifies students for graduate studies in physical sciences or research positions in government and industry. Students pursuing this degree should consult with faculty members on different available specialties.

The Bachelor of Arts in physics is primarily designed for students who desire a broader, less professionally specialized background in physics. The minor in physics is available for students who want to supplement their work in other fields with an introduction to physics. A secondary teaching minor in physics is available.

The Bachelor of Science in medical physics is based on a group of physics courses plus relevant biology, chemistry and mathematics courses. These students take “Biological Physics” and “Medical Physics.” The degree with the addition of select biology courses, offers an excellent preparation for medical school. Students should consult an adviser in pre-medical studies regarding the selection of these courses.

The Bachelor of Science in engineering physics, which is offered jointly with the School of Engineering and Computer Science, is intended for well-qualified students who seek a broad education in physics and mathematics along with basic preparation in engineering.

## Advising

**Chief adviser:** *David Garfinkle*

Advisers in the various physics fields are professors David Garfinkle (astrophysics and secondary teacher education program), Bradley Roth (medical physics, biophysics), Andrei Slavin (engineering physics, geophysics), and Gopalan Srinivasan (materials physics). Independent research projects are available in each area.

## Requirements for the liberal arts major in physics, B.A. program

To earn the Bachelor of Arts degree with a major in physics, students must complete:

1. PHY 151, 152, 158, 371, 317.
2. An additional 16 credits in physics, with at least 12 credits in courses numbered above 200.
3. MTH 154, 155, 254.
4. Eight additional credits in chemistry, mathematics and physics, but not CHM 300.
5. PHY 400 or PHY 490 either of which fulfills the university general education requirement for the capstone course in the major.

## Requirements for the major in physics, B.S. program

To earn the Bachelor of Science degree with a major in physics, students must complete:

1. 20 required credits in physics (PHY 151, 152, 158, 317, 351, 371).
2. A minimum of 22 elective credits in physics at or above the 200 level, including at least 2 credits of laboratory course work. PHY 361 and 381 are strongly recommended for students planning graduate work in physics.
3. MTH 154, 155, 254 and either MTH 275 (or 256) or APM 255 (or 257).
4. 10 credits of chemistry at a level not below CHM 157, but not CHM 300.
5. PHY 400 or PHY 490 either of which fulfills the university general education requirement for the capstone course in the major.

## Requirements for the major in medical physics, B.S. program

To earn the Bachelor of Science degree with a major in medical physics, students must complete:

1. PHY 151, 152, 158, 317, 318, 325, 326, 341, 347, 351, 371, 372 and 381.
2. MTH 154, 155, 254, STA 226 and APM 255 (or 257).
3. CHM 157 and 158 plus 4 additional credits at a level not below CHM 157 (CHM 201 may be taken for credit, but not CHM 300).
4. BIO 111, 205 and 207.
5. PHY 400 or PHY 490 either of which fulfills the university general education requirement for the capstone course in the major.

## Secondary Teacher Education Program (STEP): Physics

The Secondary Teacher Education Program (STEP) at Oakland University is an extended program of study leading to certification. Students in this program may complete the requirements for a B.A. degree in physics as listed below or may complete the requirements for the B.S. degree, which requires 14 additional credits. Generally, eligibility for admission to the STEP requires a GPA of 3.00 in both the major and minor, and an overall GPA of 2.80. No single major or minor course grade may be below 2.0.

Second undergraduate degree candidates completing major and/or minors may be required to complete additional course work at Oakland University beyond the stated minimums.

1. PHY 151, 152, 158, 317 and 371 (16 credits).
2. 12 credits chosen from: PHY 325, 331, 341, 351, 361, 366, 372, 381, 421.
3. Four laboratory credits chosen from: PHY 306, 318, 347, 418, 487, 490.
4. MTH 154, 155 and APM 255 (or 257) (11-12 credits).
5. CHM 157 and 158 (10 credits).
6. Four credits of biology at or above the level of BIO 111, but not BIO 300.
7. Four credits of earth science: PHY 106, 307 or 308.
8. Four credits relating science, technology, and society: AN 300; ENV 308, 312; PHY 115, 127.
9. PHY 400 or PHY 490, either of which fulfills the university general education requirement for the capstone course in the major.

A program in STEP must include either a 20-28 credit secondary teaching minor or an integrated science endorsement. Furthermore, STEP Physics majors must also complete a sequence of undergraduate course work in education to include SED 300, FE 345, RDG 538 and SED 427.

Extended study including SED 428, 455 and SE 501 is also required. Further details on program and admission requirements and procedures can be found in the School of Education and Human Services portion of the catalog and by consulting advisers in the department of Physics and the School of Education and Human Services Advising Office (363 Pawley Hall, 248-370-4182).

## Secondary Teacher Education Program (STEP): Endorsement in Integrated Science

Students pursuing the STEP Physics major are eligible to pursue an Integrated Science endorsement. Students who complete both the STEP Physics major and the STEP Integrated Science program will be recommended for certification by Oakland University to teach the following subjects at the secondary level: Biology, Chemistry, Earth Science, Life Science, Physical Science and Physics. This program may be substituted for a secondary teaching minor. Students must complete the STEP Physics major and also have taken the following courses:

BIO 111, BIO 113, CHM 157, CHM 158, CHM 234, ENV 308, PHY 101/151, PHY 102/152, PHY 104, GEO 106/PHY 106.

STEP Physics majors should note that many of the courses listed above may have already been taken in the process of completing the STEP Physics major.

A cumulative grade point average of 3.00 is required in courses in the program, with no single course grade below 2.0. Second undergraduate degree candidates completing the program may be required to take additional courses at Oakland University beyond the stated minimums. Students must consult with the STEP Physics adviser.

## Requirements for the major in engineering physics, B.S. program

**Coordinators:** Andrei Slavin (Physics), Hoda Abdel-Aty-Zohdy (Engineering)

The program in engineering physics is offered jointly by the College of Arts and Sciences and the School of Engineering and Computer Science. This program blends the pure and applied, the theoretical and practical aspects of scientific knowledge into a meaningful educational experience. Through the university's cooperative education program, engineering physics students may opt to combine a relevant work experience with their formal education. To earn the degree of Bachelor of Science with a major in engineering physics, students must complete a minimum of 128 credits, demonstrate writing proficiency (see *Undergraduate degree requirements*) and meet the following requirements:

1. MTH 154, 155, 254 and APM 255;
2. CHM 143;
3. PHY 151, 152, 158, 317, 351, 361 and 371, plus one of the following: PHY 331, 366, 381 or 472;
4. EGR 120, 141, 240, 250, 260, 280; ECE 276, 327; PHY 490 or EGR 491;
5. Professional options. (The following two options are offered as typical. Select 12 credits from one of these. Students with different interests can construct different options in consultation with the program coordinators.)

**Solid state physics and technology option**

ECE 384 and PHY 472, plus one of the following design electives: ECE 378, 426, 437, 470, 487.

**Applied mechanics option**

PHY 366, ME 322 or 361, plus one of the following design electives: ME 456, 461, 482, 486, 487.

**Technical electives**

6. Choose 6-8 credits from MTH 275; APM 263; PHY 318, 331, 366, 372, 381, 418, 472, 482; ECE 352, 378, 384; ME 331, 361 or any 400-level ECE, ME or ISE course.
7. Free electives (6-8 credits), which may be used to satisfy writing requirement. For limitations on free electives see the School of Engineering and Computer Science policy on free electives.
8. Average grade of at least 2.0 in courses taken to meet program requirements.

Students in this program are not required to complete the college distribution requirement of the College of Arts and Sciences. For further information about this program, see the section of this catalog for the School of Engineering and Computer Science, Engineering Physics program. Note: either PHY 400 or 490 satisfies the university general education requirement for the capstone course in the major.

## Departmental honors

Departmental honors may be awarded to students on the basis of high academic achievement and either independent research or meritorious service to the Department of Physics.

## Requirements for the liberal arts minor in physics

To earn a minor in physics, students must complete a minimum of 20 credits in physics, including PHY 101-102 or 151-152, 158 and at least 8 credits in physics courses numbered 300 or above.

## Requirements for the secondary teaching minor in physics

To earn a secondary teaching minor in physics, students must complete PHY 101-102 or 151-152, 158 and 10 credits in physics courses numbered 300 or above, including PHY 371. Non-science majors i.e., other than biology, chemistry and physics majors, must complete an additional 4 credits in science for a total of 24 credits. In addition SED 427, Methods of Teaching Secondary Students, is required.

## Course Offerings

The department offers selected courses from this catalog as warranted by student needs and availability of faculty. Specific offerings for each term may be found in the Schedule of Classes.

**PHY 101                      General Physics I (4)**

Mechanics, heat, mechanical waves and sound. Calculus is not required. Students must attend three general education laboratory sessions during the semester. *Satisfies the university general education requirement in the natural science and technology knowledge exploration area.*

Prerequisite: recommended MTH 012 or equivalent.

**PHY 102            General Physics II (4)**

Electricity and magnetism, light, relativity, atomic and nuclear physics. *Satisfies the university general education requirement in the knowledge applications integration area. Prerequisite for knowledge applications integration: completion of the general education requirement in the natural science and technology knowledge exploration area.*

Prerequisite: recommended PHY 101.

**Each of the following courses is designed for non-science majors and minors:**

**PHY 104            Astronomy: The Solar System (4)**

The sun, planets, space travel, the search for extraterrestrial life. Offered fall only. *Satisfies the university general education requirement in the natural science and technology knowledge exploration area.*

**PHY 105            Astronomy: Stars and Galaxies (4)**

Nature and evolution of stars, the Milky Way and other galaxies, cosmology. Offered winter only. *Satisfies the university general education requirement in the natural science and technology knowledge exploration area.*

**PHY 106            Earth Science/Physical Geography (4)**

The earth: its structure, history, and the geography of its surface. Topics include: the theory of continental drift, rocks and minerals, earthquakes, volcanoes, mountains, rivers, deserts, weather, climate, the geomagnetic field, and the earth's resources. Identical with GEO 106.

*Satisfies the university general education requirement in the natural science and technology knowledge exploration area.*

**PHY 115            Energy (4)**

Basic physical principles of energy, sources, transmission and distribution. Political, economic and ecological considerations. *Satisfies the university general education requirement in the natural science and technology knowledge exploration area.*

Prerequisite: high school algebra.

**PHY 120            The Physics of Everyday Life (4)**

Concepts of physics taught with reference to specific everyday observations or devices such as automobiles, televisions, radios and microwave ovens. Topics include the laws of motion, fluids, heat, thermodynamics, waves, electric and magnetic fields, optics and nuclear physics. *Satisfies the university general education requirement in the natural science and technology knowledge exploration area.*

**PHY 127            Human Aspects of Physical Science (4)**

Primarily for the student wishing to explore the interaction of the physical and social sciences. Format varies to reflect the impact of physics on contemporary life, particularly on politics, economics and behavior, as well as environment and well-being.

Prerequisite: high school algebra.

**PHY 131            The Physics of Cancer, Stroke, Heart Disease, and Headache (4)**

The physical basis for a variety of diseases and disorders, as well as diagnostic and therapeutic techniques will be discussed by a number of medical physics faculty and guest lecturers.

Prerequisite: high school algebra.

**SCI 100            Physical Sciences in Life, the World and Beyond (4)**

Interdisciplinary physical science course for non-science majors to enhance their scientific literacy and experience the scientific approach to problem solving in active-learning classrooms and hands-on and computer laboratories. Modules on the science of everyday life, science of the microscopic world, and the earth and beyond. Offered each semester. *Satisfies the university general education requirement in the natural science and technology knowledge exploration area.*

Prerequisite: MTH 012 with a grade of 2.0 or higher or placement in a higher level mathematics course.

The following courses are designed primarily for the physics major and for majors in the other sciences and engineering:

**PHY 151            Introductory Physics I (4)**

Classical mechanics and thermodynamics. For science, mathematics and engineering students. Students must attend three general education laboratory sessions during the semester. *Satisfies the university general education requirement in the natural science and technology knowledge exploration area.*

Prerequisite: recommended MTH 154.

**PHY 152            Introductory Physics II (4)**

Sound, light, electricity and magnetism. *Satisfies the university general education requirement in the knowledge applications integration area. Prerequisite for knowledge applications integration: completion of the general education requirement in the formal reasoning knowledge foundation area or the natural science and technology knowledge exploration area.*

Prerequisite: recommended PHY 151. Corequisite: recommended MTH 155.

**PHY 158            General Physics Laboratory (2)**

Elementary experiments in mechanics, heat, sound, electricity and optics.

Prerequisite: recommended PHY 101 or 151. Co-requisite: recommended PHY 102 or PHY 152.

**PHY 290            Introduction to Research (2 or 4)**

Independent study and/or research in physics for students with no research experience. May be repeated for additional credit.

Prerequisite: written agreement of a physics faculty supervisor.

**PHY 304            Astrophysics I (4)**

Application of elementary physics to the study of planets, stars, galaxies and cosmology.

Prerequisite: recommended PHY 102 or 152, and MTH 254.

**PHY 305            Astrophysics II (4)**

Continuation of PHY 304.

Prerequisite: recommended PHY 304.

**PHY 306            Observational Astronomy (2)**

A lecture/laboratory course using the Oakland University observatory and providing basic training in astronomical techniques.

Prerequisite: recommended PHY 158 or 104 or 105 and permission of instructor.

**PHY 307            Geophysics (4)**

The application of physics concepts to the study of the earth, gravity and its anomalies, geomagnetism, earth-sun energy, geochronology and seismic wave propagation.

Prerequisite: recommended PHY 102 or 152, PHY 106 and MTH 254.

**PHY 308            Physical Oceanography (4)**

Physical oceanography and meteorology; composition and structure of the atmosphere and oceans. Interactions of sea water with the atmosphere, the continents and man.

Prerequisite: recommended PHY 102 or 152, and MTH 254.

**PHY 317            Modern Physics Laboratory (2)**

Optics and atomic physics experiments.

Prerequisite: recommended PHY 158. Corequisite: recommended PHY 371.

**PHY 318 Nuclear Physics Laboratory (2)**

Nuclear physics experiments.

Prerequisite: recommended PHY 158. Corequisite: recommended PHY 372.

**PHY 325 Biological Physics (4)**

Applications of physics to biology, including biomechanics, fluid dynamics, statistical mechanics, diffusion, bioelectricity, biomagnetism, feedback and control.

Prerequisite: recommended PHY 102 or 152, and MTH 155.

**PHY 326 Medical Physics (4)**

Applications of physics to medicine, including signal analysis, imaging, x-rays, nuclear medicine and magnetic resonance imaging.

Prerequisite: recommended PHY 102 or 152, and MTH 155.

**PHY 331 Optics (4)**

Geometrical optics, optical instruments, wave theory of reflection, refraction, interference, diffraction and polarization of light.

Prerequisite: recommended PHY 102 or 152, and MTH 155. Corequisite: recommended MTH 254.

**PHY 341 Electronics (4)**

Electronics for scientists, circuit theory, transistors, power supplies, linear amplifiers, oscillators.

Prerequisite: recommended PHY 158 and MTH 155, and either PHY 102 or 152. Concurrent enrollment in PHY 347.

**PHY 347 Electronics Laboratory (2)**

Circuits and electronics experiments.

Corequisite: PHY 341.

**PHY 351 Intermediate Theoretical Physics (4)**

Topics and techniques common to intermediate physics courses. Includes analytical and numerical (computer) solution techniques, DIV, GRAD, CURL and Fourier analysis.

Prerequisite: recommended PHY 102 or 152, and MTH 155.

**PHY 361 Mechanics I (4)**

Applications of Newton's laws to particles, systems of particles, harmonic oscillators, central forces, accelerated reference frames and rigid bodies.

Prerequisite: recommended PHY 102 or 152, and MTH 254.

**PHY 366 Vibrations and Waves (4)**

Oscillations; mechanical waves in one, two and three dimensions; sound.

Prerequisite: recommended PHY 152, MTH 155.

**PHY 371 Foundations of Modern Physics (4)**

Introduction to relativity, kinetic theory, quantization and atomic physics. Additional topics chosen from physics of molecules, solids, nuclei and elementary particles.

Prerequisite: recommended PHY 102 or 152, and MTH 155; concurrent enrollment in PHY 317.

**PHY 372 Nuclear Physics (4)**

Radioactivity, interaction of radiations with matter, accelerators, nuclear reactions, fission and fusion.

Prerequisite: recommended PHY 102 or 152, and MTH 155; concurrent enrollment in PHY 318.

**PHY 381 Electricity and Magnetism I (4)**

Maxwell's equations and the experimental laws of electricity and magnetism. Potential theory, boundary conditions on the electromagnetic field vectors, field energy. Dielectrics, conductors and magnetic materials.

Prerequisite: recommended PHY 351 and MTH 254. APM 255 (or 257).

**PHY 400 Undergraduate Seminar (3)**

Weekly colloquia describing research at the forefront of physics. Requires a written report. *Satisfies the university general education requirement for the capstone experience. Satisfies the university general education requirement for a writing intensive course in the major. Prerequisite for writing intensive: completion of the university writing foundation requirement.*

Prerequisite: permission of instructor.

**PHY 405 Special Topics (2, 4 or 6)**

Prerequisite: permission of department.

**PHY 418 Modern Optics Laboratory (2)**

Experiments illustrating geometric and physical optics principles, lasers, fiber optics, holography and spectroscopy. Equipment used ranges from simple to sophisticated lasers, interferometers, digital cameras and a Raman spectrometer.

Prerequisite: recommended PHY 317, 371 and PHY 331 or permission of instructor.

**PHY 421 Thermodynamics (4)**

The zeroth, first and second laws of thermodynamics with applications to pure substances. Introduction to the kinetic theory of gases and to statistical mechanics.

Prerequisite: recommended PHY 361 and APM 255 (or 257).

**PHY 431 Lasers and Applications (4)**

Interaction of radiation and atomic systems, basic principles and properties of laser light, types of lasers, applications in physics, optical communication, industry and medicine.

Prerequisites: recommended PHY 331 or PHY 371 or permission of instructor.

**PHY 445 Medical Instrumentation (2)**

Detailed examination of the scientific instrumentation used in modern medical diagnostic and therapeutic practice.

Prerequisite: recommended approval of department, PHY 371, 381 and 347.

**PHY 470 Relativity (4)**

Special relativity in mechanics and electromagnetism. Introduction to general relativity and gravitation.

Prerequisite: recommended PHY 361 or 371 or 381.

**PHY 472 Quantum Mechanics I (4)**

Principles of non-relativistic quantum mechanics, Schrodinger wave equation, expectation values of energy, position, momentum and angular-momentum operators, spin, perturbation theory, identical particles. With applications to atomic systems.

Prerequisite: recommended PHY 351, 361, 371 and APM 255 (or 257).

**PHY 482 Electricity and Magnetism II (4)**

Multipole fields, solutions of Laplace and Poisson equations, electromagnetic waves in insulators and conductors, radiation and the derivation of the laws of optics from Maxwell's equations.

Prerequisite: recommended PHY 381, APM 255 (or 257) and MTH 256.

**PHY 487                    Electricity and Magnetism Laboratory (2)**

Experiments in electricity and in magnetism, including coupled circuits, bridges, creation and detection of electric and magnetic fields, the geomagnetic field, spectrum analysis, transmission lines and microwaves.

Corequisite: PHY 381.

**PHY 490                    Independent Research (3-6)**

Independent study or research project carried out under the direction of a faculty member. May be repeated for additional credit. Requires a written report. *Satisfies the university general education requirement for the capstone experience. Satisfies the university general education requirement for a writing intensive course in the major. Prerequisite for writing intensive: completion of the university writing foundation requirement.*

Prerequisite: junior standing and written agreement with a physics faculty member.