Physics

The major and minor in physics are administered by the Department of Physics: Professors Hudgings, Peterson (*chair*), Sutton; Assistant Professors Aidala, Arango; Visiting Assistant Professor Burciaga.

Contact Persons

Cynthia Morrell, *senior administrative assistant*
Mark Peterson, *chair*

Consulting with a departmental advisor, the student may design her major curriculum for various purposes. She may take the courses necessary to prepare for graduate study in physics or closely related fields (including engineering), or she may plan a program that, together with courses from other disciplines, prepares her for advanced work in medicine, environmental engineering, or other physical sciences or branches of engineering, as well as for secondary school teaching, technical writing, or technical positions in industry. Students interested in geophysics, astrophysics, materials science, biophysics, physical chemistry, and other similar programs can work out special majors in consultation with faculty in the appropriate department.

Requirements for the Major

Credits

- A minimum of 36 credits
- 28 at the 300 level

Courses

Courses required for the major consist of the following or their equivalents:

- Physics 115, Force, Motion, and Energy *and* 216, Electromagnetism*
- 231, Techniques of Experimental Physics
- 301, Waves and Particles
- 302, Quantum Mechanical Phenomena
- 303, Introduction to Mathematical Methods for Scientists
- 315, Analytical Mechanics
- 325, Electromagnetic Theory
- 326, Statistical Physics and Condensed Matter

* Students who can demonstrate proficiency in one or both of these courses by taking placement exams administered by the department may begin their physics study at the appropriate level but must still complete 36 credits of college-level physics courses for the major.

Other

- At least 12 credits of independent research or advanced laboratory work must be taken in addition to the courses listed above. The 12 credits will normally be accrued through some combination of the following options: Physics 308, up to 6 credits of the Smith physics department's Advanced Lab (Smith Physics 350), up to 6 credits of Physics 295 or 395 for academic year independent research, or up to 4 credits of Physics 295P or 395P for summer research, following college guidelines for awarding 295P/395P credit. Note that 295P and 395P credit must be arranged with the department before the summer research experience begins; typically, a single eight to ten-week summer research program will account for no more than 2 credits of 295P or 395P. Potential variations on the lab requirement, such as taking an advanced physics lab course at another institution, will be considered on a case-by-case basis.
- Physics majors are also encouraged to take Chemistry 101 and/or 201 (General Chemistry I and II).
- Math 203 (Calc III – multivariate calculus), Math 211 (linear algebra), and Physics 324, while not required, are recommended for those students planning to take advanced physics courses or to pursue graduate study. Math 302 (complex analysis) and Math 333 (differential equations) are also recommended for students planning to pursue graduate study in physics or engineering.

- Students planning to pursue graduate study in physics are encouraged to take at least one graduate-level course in physics at UMass.

Getting Started in Physics

Entering students considering a major in physics are strongly urged to take Physics 115 in the first year. While it is possible to complete the major by taking Physics 115 and 216 as late as the second year, such a program is not recommended because this delay limits the student's opportunities for advanced electives or honors work.

Sample Programs of Study

Courses in italics are required for the major.

Some combination of 295 and 395 totaling at least 4 credits is required. The recommended programs are based on the assumption that the student will undertake an independent project leading to honors in the fourth year. It is important for students to take mathematics courses which teach the specific skills needed for physics. Both integral and differential calculus are necessary for mathematical manipulation of formulas in the introductory physics courses.

Elective courses include: Physics 211, 222, 295, 308, 324, 336, 395 or a wide range of Five College options.

For students beginning physics in the first semester of the first year:

	Semester I	Semester II
Fy	*Physics 115* Math 202	*Physics 216* Math 203
Soph	*Physics 301* *Physics 303*	*Physics 302* *Physics 315*
Jr	Physics 308 *Physics 325*	Physics 324 or 336 *Physics 326*
Sr	Physics 395 Physics elective	Physics 395 Physics elective

For students beginning physics in the second semester of the first year:

	Semester I	Semester II
Fy	Math 101	Math 202 *Physics 115*
Soph	*Physics 216* *Physics 303*	*Physics 315* *Physics 295* (or 324)
Jr	*Physics 301* Physics 308	*Physics 302* Physics elective (222, 295, 324 or 395)
Sr	*Physics 325* Physics 395	*Physics 326* Physics 395

For students beginning physics in the first sophomore semester:

	Semester I	Semester II
Fy	Math 101	Math 202
Soph	*Physics 115*	*Physics 216*
Jr	*Physics 301* *Physics 303*	*Physics 302* *Physics 315*
Sr	Physics 308 *Physics 325* Physics 395	*Physics 326* Physics 395

(Physics 231 should be taken during the junior or senior year; note that Physics 324 and 336 will be offered in alternate years. Both 324 and 336 are recommended. Chemistry 101 or 201 and Math 211 should be taken in Semester I or II of any year.)

Requirements for the Minor

Credits

- A minimum of 16 credits above the 100 level

Courses

Normally, courses for the minor consist of:

- Physics 216 (Physics 115 is a prerequisite)
- Any three of 301, 302, 303, and 308, although other combinations of courses are also possible with permission of the department chair.

Teacher Licensure

Students interested in pursuing licensure in the field of physics can combine their course work in physics with a minor in education. In some instances, course work in the major coincides with course work required for licensure; in other cases, it does not. For specific course requirements for licensure within the major of physics, please consult your advisor or the chair of the mathematics department.

For information about the requirements for the minor in education, please consult "Teacher Licensure" in the Other Degree and Certificate Programs chapter and Ms. Lawrence in the psychology and education department. Licensure also requires a formal application, as well as passing scores on the Massachusetts Test of Educator Licensure (MTEL) in both the literacy component and the subject matter component. Copies of the test objectives for the MTEL are available in the physics department and in the Department of Psychology and Education. Licensure application information and materials are available in the Department of Psychology and Education.

Introductory Courses and Distribution Requirements

Physics 103f–204s is a noncalculus introductory course sequence in physics, appropriate for students in the life sciences and for students with a general, nonprofessional interest in physics. This sequence satisfies the physics requirements of medical school.

Physics 115–216 is a calculus-based introductory course sequence in physics, appropriate for students intending to major in a physical science. To major in physics, a student must complete Physics 216 by the end of her sophomore year. A student with excellent preparation in physics may take a departmental placement exam to place out of one or both of these introductory courses. Any 300-level 4-credit physics course will then count for distribution in physics.

Physics 115 and 216 do not cover the full range of topics on the MCAT syllabus; the Physics 103 and 204 sequence has a better coverage of these topics.

Course Offerings

103f Foundations of Physics
This course studies a variety of topics in physics unified by the physical notions of force, energy, and equilibrium. Mathematics is used at the level of geometry, proportion, and dimensional analysis. Topics, drawn from the MCAT syllabus, include geometrical optics, time, oscillation, statics, elasticity, conservation of energy, and fluids.
Meets Science and Math II-B requirement
M. Peterson
4 credits

105f Science in the Media
(First-year seminar) Popular coverage of science ranges in depth and accuracy, and many scientists do not see the importance of communicating their work, or their excitement, to the general public. Scientific breakthroughs contribute to everyone's quality of life, but the process is poorly understood by many, leading to misunderstandings and misgivings that can affect public policy. This course will look at newsworthy results from current scientific research, exploring topics to better understand the science, ideas such as scientific consensus and repeatability, and examining the tension that may exist between the scientists and the public. Topics will be pulled largely from the physical sciences.
Meets Science and Math II-C requirement
K. Aidala
Prereq. fy; 4 credits

115fs Force, Motion, and Energy
Studies the mechanics of material objects. Topics include Newton's laws, projectile motion, circular motion, momentum, kinetic and potential energy, angular momentum, gravitation, and oscillations. This course is appropriate for students intending to major in a physical science.
Meets Science and Math II-B requirement
K. Aidala, The department
Prereq. Mathematics 101; 4 credits

204s Phenomena of Physics
This course studies a variety of topics in physics, drawn from the MCAT syllabus, in-

cluding thermodynamics, acoustics, wave optics, electricity, magnetism, and nuclear phenomena. As in Physics 103f, the applicable mathematics is geometry, proportion, and dimensional analysis.
Meets Science and Math II-B requirement
M. Peterson
Prereq. Physics 103 or 115; 4 credits

211s Gender in Science
(Same as Gender Studies 241) This course examines explanations for the underrepresentation of women in science, technology, engineering, and math (STEM) with an eye to identifying how to increase the participation of women in science. The course will address questions about gender differences in cognition and ability, the role of stereotyping, as well as the "leaky pipeline" issue, that is, the rate and timing of the departure of women from scientific fields. Course readings will explore the psychology of gender, as it relates to STEM. In addition, we will read research from physical scientists, reports from professional organizations such as the American Physical Society, and reports from congressional committees.
Does not meet a distribution requirement
K. Aidala
4 credits

216fs Electromagnetism
Topics include: electromagnetism, emphasizing fields and energy; electrostatics; electric circuits; magnetism; induction; and electromagnetic radiation. Additional topics chosen according to the interests of the class and instructor.
Meets Science and Math II-B requirement
A. Arango, The department
Prereq. Physics 115; Mathematics 202; 4 credits

***222s Comparative Biomechanics**
(Same as Biological Sciences 322) The main objective of this course is to explore organismal structure and function via an examination of the basic physical principles that guide how living things are constructed and how organisms interact with their environment. We will use the combined approaches of the biologist and engineer to study the impact of size on biological systems, address the implications of solid and fluid mechanics for animal design, survey different modes of animal locomotion, and learn how biologists working in diverse areas (e.g., ecology, development, evolution, and physiology) gain insight through biomechanical analyses.
Meets Science and Math II-B requirement
G. Gillis
Prereq. Physics 115 and permission of the instructor; 2 meetings (75 minutes), 1 lab (3 hours) with 12 per lab; 4 credits

231fs Techniques of Experimental Physics
Provides training in the techniques employed in the construction of scientific equipment.
Does not meet a distribution requirement
L. McEachern
Prereq. jr, sr, major; 1 meeting (2 hours) for 3 weeks; 1 credit

295fs Independent Study
Does not meet a distribution requirement
The department
Prereq. soph; 1-4 credits

301f Waves and Optics
A comprehensive treatment of wave phenomena, particularly light, leading to an introductory study of quantum mechanics. Topics include wave propagation, polarization, interference and interferometry, diffraction, and special relativity.
Meets Science and Math II-B requirement
J. Burciaga
Prereq. Physics 216 and either: 303 or concurrent enrollment in 303; 4 credits

302s Quantum Mechanical Phenomena
This course provides an introduction to quantum mechanics. The Uncertainty Principle, Schroedinger's Equation, and the hydrogen atom are studied in depth, with emphasis on angular momentum, electron spin, and the Pauli Exclusion Principle.
Meets Science and Math II-C requirement
The department
Prereq. Physics 301; 4 credits

303f Introduction to Mathematical Methods for Scientists
Topics include infinite series, complex numbers, partial differentiation, multiple integration, selected topics in linear algebra and vector analysis, ordinary differential equations, and Fourier series. The course includes a brief introduction to Mathematica and

Matlab, in addition to a traditional emphasis on analytic solutions.
Does not meet a distribution requirement
A. Arango
Prereq. Physics 216 or concurrent enrollment; 4 credits

***308f Electronics**
This course is a study of electrical circuits and components with emphasis on the underlying physical principles; solid-state active devices with applications to simple systems such as linear amplifiers; feedback-controlled instrumentation; and analog and digital computing devices.
Meets Science and Math II-B requirement
K. Aidala
Prereq. Physics 216; 2 meetings (3 hours: hands-on lecture and lab combined); fall 2011 offered at Smith; 4 credits

315s Analytical Mechanics
Newton's great innovation was the description of the world by differential equations, the beginning of physics as we know it. This course studies Newtonian mechanics for a point particle in 1, 2, and 3 dimensions, systems of particles, rigid bodies, and the Lagrangian and Hamiltonian formulations.
Does not meet a distribution requirement
The department
Prereq. Physics 303; 4 credits

324s Methods of Applied Mathematics
(Same as Mathematics 324) This course is an introduction to theories and techniques important to applied mathematics. Topics include special functions, calculus of variations, theory of functions of a complex variable, solution of partial differential equations, integral transform methods, and Green's functions. While the focus of the course is on analytical techniques, we will develop numerical approaches to problem solving.
Does not meet a distribution requirement
The department
Prereq. Physics 216, 303; Physics 324 or 336 will normally be offered in alternating years; 4 credits

325f Electromagnetic Theory
This course presents the development of mathematical descriptions of electric and magnetic fields; study of interactions of fields with matter in static and dynamic situations; mathematical description of waves; and development of Maxwell's equations with a few applications to the reflection and refraction of light and microwave cavities.
Does not meet a distribution requirement
J. Burciaga
Prereq. Physics 301, 315, or 324; 4 credits

326f Statistical Mechanics and Thermodynamics
This course presents thermodynamic and statistical descriptions of many-particle systems. Topics include classical and quantum ideal gases with applications to paramagnetism; black-body radiation; Bose-Einstein condensation; and the Einstein and Debye solid; the specific heat of solids.
Does not meet a distribution requirement
The department
Prereq. Physics 301; 2011-12 - may be team taught with Chem 308. if so, this course WILL have 4th hour but no lab requirement; 4 credits

***329fs Topics in Advanced Physics**
Topics chosen according to the interests of the students and the instructor.
Does not meet a distribution requirement
The department
Prereq. Physics 216; 4 credits

336s Quantum Mechanics
This course is an introduction to formal quantum theory: the wave function and its interpretation, observables and linear operators, matrix mechanics and the uncertainty principle; solutions of one-dimensional problems; solutions of three-dimensional problems and angular momentum; and perturbative methods.
Does not meet a distribution requirement
The department
Prereq. Physics 302; Physics 324 or 336 will normally be offered in alternating years; 4 credits

395fs Independent Study
Does not meet a distribution requirement
The department
Prereq. jr, sr, permission of department; 1-8 credits