Physics

The major and minor in physics are administered by the Department of Physics: Professor Peterson; Associate Professor Aidala (chair); Assistant Professors Arango, Nordstrom; Visiting Lecturer Smith.

Overview
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 departments.

Contact Info
Sarah Byrne, senior administrative assistant
Katherine Aidala, chair

Requirements for the Major

Credits
- A minimum of 37 credits

Courses
Courses required for the major consist of the following or their equivalents:
- Physics 110, Force, Motion, and Energy
- and 201, Electromagnetism*
- 205, Introduction to Mathematical Methods for Scientists
- 210, Waves and Optics
- 250, Quantum Mechanical Phenomena
- 231, Techniques of Experimental Physics

Students must also take two of:
- 315, Analytical Mechanics
- 325, Electromagnetic Theory
- 326, Statistical Physics and Thermodynamics
- And 8 credits of laboratory work, including at least one of:
  - 220, Intermediate Laboratory in Physics
  - 308, Electronics
  - Independent work (290, 295, 295P, 390, 395, 395P)
  - Other advanced lab work with the permission of the department

In addition, physics majors must take 4 additional credits of independent work or advanced laboratory work. The independent work may include Physics 290, 295, 295P, 395, 395P, or 390; Smith Physics 350; or laboratory courses offered at other institutions, as arranged on a case-by-case basis. Course substitutions for the above requirements will be allowed on a case-by-case basis where it makes sense for a student’s academic goals; for example, a student interested in biomechanics might reasonably replace Physics 250 with Physics 222 and Physics 395 with Biology 395.

*Students who can demonstrate proficiency in one or both introductory courses by taking placement exams administered by the department may begin their physics study at the appropriate level but must still complete 37 credits of college-level physics courses for the major.

Other
- Up to 4 credits of Physics 295P or 395P may be earned through 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.
- Normally, no more than 12 credits of 290, 295, 295P, 390, 395, or 395P will count towards the major.
- 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.

Requirements for the Minor

Credits
- A minimum of 16 credits at or above the 200 level

Courses

Normally, courses for the minor consist of:
- Physics 201 (Physics 110 is a prerequisite)
- Any three of 205, 210, 250, 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 physics department.

For information about the requirements for the minor in education, please consult “Teacher Licensure” in the Other Degree and Certificate Programs chapter and Professor 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.
Getting Started in Physics

Entering students considering a major in physics are strongly urged to take Physics 110 in the first year. While it is possible to complete the major by taking Physics 110 and 201 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.

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, 220, 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:

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

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For students beginning physics in the first sophomore semester:

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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, as is Math 211.

Introductory Courses and Distribution Requirements

Physics 100–150 is a non-calculus 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 110–201 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 201 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 200 or 300-level 4-credit physics course will then count for distribution in physics. Physics 110 and 201 do not cover the full range of topics on the MCAT syllabus; the Physics 100 and 150 sequence has a better coverage of these topics.

Course Offerings

PHYS-100 Foundations of Physics

Fall
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.
Applies to requirement(s): Math & Sciences
M. Peterson
Coreq: PHYS-100L
Credits: 4

PHYS-104 Renewable Energy

Spring
We will examine the feasibility of converting the entire energy infrastructure of the US from one that is dependent on fossil fuels to one that utilizes mostly renewable sources of energy. We will examine the potential scale of energy production and the associated costs, natural resource requirements and land usage needs for both renewables, such as solar, wind and biofuel, and non-renewables, such as coal, natural gas, petroleum and nuclear. By applying extensive use of basic algebra and an elementary understanding of the physical processes underpinning each energy technology, we will arrive at a number of urgent conclusions about the challenges facing our energy infrastructure.
Crosslisted as: Environmental Studies 104
Applies to requirement(s): Math & Sciences
A. Arango
Credits: 4

PHYS-110 Force, Motion, and Energy

Fall and Spring
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.
Applies to requirement(s): Math & Sciences
K. Nordstrom
Prereq: Mathematics 101.; Coreq: PHYS-110L.
Credits: 4
PHYS-150 Phenomena of Physics  
Spring  
This course studies a variety of topics in physics, drawn from the MCAT syllabus, including thermodynamics, acoustics, wave optics, electricity, magnetism, and nuclear phenomena. As in Physics 103/100, the applicable mathematics is geometry, proportion, and dimensional analysis.  
Applies to requirement(s): Math & Sciences  
M. Peterson  
Prereq: Physics 103/100 or Physics 115/110.; Coreq: PHYS-150L.  
Credits: 4

PHYS-201 Electromagnetism  
Fall and Spring  
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.  
Applies to requirement(s): Math & Sciences  
K. Aidala, A. Arango  
Prereq: Physics 115 or 110 and Mathematics 102.; Coreq: PHYS-201L.  
Credits: 4

PHYS-205 Introduction to Mathematical Methods for Scientists  
Fall  
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.  
Applies to requirement(s): Math & Sciences  
S. Smith  
Prereq: Physics 216, 190 or 201.; Coreq: PHYS-205L.  
Advisory: Physics 190/201 or concurrent enrollment  
Credits: 4

PHYS-210 Waves and Optics  
Fall  
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.  
Applies to requirement(s): Math & Sciences  
S. Smith  
Prereq: Electromagnetism (Physics 216/190/201) and Intro to Math Methods (Physics 303/200/205) or concurrent enrollment in Physics 205.  
Advisory: Electromagnetism (Physics 190/201) and Intro to Math Methods (Physics 200/205) or concurrent enrollment in 205  
Credits: 4

PHYS-220 Intermediate Lab in Physics  
Fall  
This lab-based course is an introduction to modern, investigative, experimental physics. The course is intended as a bridge between the structured introductory lab experience and independent research. Students will engage in a semester-long experimental project, participating in experimental design, construction, debugging and implementation. Students will practice presenting and interpreting experimental results and will be encouraged to develop follow-up experimental questions of their own. This course will also introduce students to scientific communication skills, and is speaking- and writing-intensive.  
Applies to requirement(s): Meets No Distribution Requirement  
Other Attribute(s): Speaking-Intensive; Writing-Intensive  
A. Arango  
Prereq: Physics 201.  
Credits: 4

PHYS-221 Topic  
Spring  
Applies to requirement(s): Math & Sciences  
Prereq: Physics 110/115 and permission of instructor.  
Credits: 4

PHYS-222 Comparative Biomechanics  
Spring  
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.  
Crosslisted as: Biological Sciences 322  
Applies to requirement(s): Math & Sciences  
G. Gillis  
Prereq: Physics 110/115 and permission of instructor.; Coreq: PHYS-222L.  
Notes: 12 students per lab  
Credits: 4

PHYS-231 Techniques of Experimental Physics  
Fall and Spring  
Provides training in the techniques employed in the construction of scientific equipment.  
Applies to requirement(s): Meets No Distribution Requirement  
L. McEachern  
Restrictions: This course is limited to physics majors.; This course is open to Juniors and Seniors.  
Notes: 1 meeting (2 hours) for 3 weeks.  
Credits: 1  
Grading: CR/NC Grading only (no letter grading).

PHYS-250 Quantum Mechanical Phenomena  
Spring  
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.  
Applies to requirement(s): Math & Sciences  
S. Smith  
Credits: 4

PHYS-290 Advanced Laboratory Practicum  
Fall  
This course is a hands-on practicum, intended to introduce students to the practice of modern physics research. Depending on student interest, topics include external research seminars by practitioners in the field, training in oral and written scientific communication, presentation and interpretation of research results, scientific modeling, and hands-on experimental skills. Research projects are an integral part of this course; credit will be apportioned in relation to the intensity of the project.  
Applies to requirement(s): Meets No Distribution Requirement  
Other Attribute(s): Speaking-Intensive; Writing-Intensive  
A. Arango  
Instructor permission required.  
Prereq: 4 credits in Physics.  
Credits: 1-8  
Course can be repeated for credit.
PHYS-295 Independent Study  
Fall and Spring  
The department  
Instructor permission required.  
Credits: 1-4  
Course can be repeated for credit.

PHYS-308 Electronics  
Spring  
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.  
Applies to requirement(s): Math & Sciences  
T. Herd  
Prereq: Physics 216/190/201.  
Notes: Meetings combine lecture and hands-on lab  
Credits: 4

PHYS-315 Analytical Mechanics  
Spring  
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.  
Applies to requirement(s): Math & Sciences  
S. Smith  
Prereq: Physics 200 (formerly Phys-303) or 205.  
Credits: 4

PHYS-325 Electromagnetic Theory  
Fall  
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.  
Applies to requirement(s): Math & Sciences  
S. Smith  
Advisory: Intro to Math Methods (Physics 200/205)  
Credits: 4

PHYS-326 Statistical Mechanics and Thermodynamics  
Fall  
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.  
Applies to requirement(s): Math & Sciences  
K. Nordstrom  
Prereq: Quantum Mechanical Phenomena (Physics 302/250) and Intro to Math Methods (Physics 303/200/205).  
Advisory: Intro to Math Methods (Physics 303/200/205) and Quantum Mechanical Phenomena (Physics 302/250) or permission from department  
Credits: 4

PHYS-328 From Lilliput to Brobdingnag: Bridging the Scales Between Science and Engineering  

Not Scheduled for This Year  
The performance of many engineered devices is dependent on macroscopic factors (pressure, temperature, flow, conductivity). As a result, engineers often model devices macroscopically considering atomistic level details only through fixed parameters. These parameters do not always capture the full atomistic level picture. More accurate multi-scale approaches for modeling macroscopic properties use basic atomistic level chemistry at key points in larger scale simulations. This course is an introduction to such approaches focusing on fuel cells as a concrete example. Basic scientific principles will be developed along side of basic engineering principles through project/case studies.  
Crosslisted as: Chemistry 328  
Applies to requirement(s): Meets No Distribution Requirement  
Other Attribute(s): Speaking-Intensive; Topics Course  
K. Aidala  
Prereq: Math 102 and Physics 216.  
Credits: 4

PHYS-336 Quantum Mechanics  
Spring  
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.  
Applies to requirement(s): Math & Sciences  
N. Abraham  
Prereq: Physics 302/250.  
Notes: Physics 324 or 336 will normally be offered in alternating years  
Credits: 4

PHYS-390 Advanced Laboratory Practicum  
Fall  
This course is a hands-on practicum, intended to introduce students to the practice of modern physics research. Depending on student interest, topics include external research seminars by practitioners in the field, training in oral and written scientific communication, presentation and interpretation of research results, scientific modeling, and hands-on experimental skills. Research projects are an integral part of this course; credit will be apportioned in relation to the intensity of the project.  
Applies to requirement(s): Meets No Distribution Requirement  
Other Attribute(s): Speaking-Intensive; Writing-Intensive  
A. Arango  
Instructor permission required.  
Prereq: 16 credits in Physics.  
Credits: 1-8  
Course can be repeated for credit.

PHYS-395 Independent Study  
Fall and Spring  
The department  
Instructor permission required.  
Credits: 1-8  
Course can be repeated for credit.

PHYS-396 Advanced Laboratory Techniques  
Instructor permission required.

PHYS-396MS Advanced Laboratory Techniques: 'Scanning Probe Microscopy'  
Spring  
Students will be introduced to scanning probe microscopy and pursue projects on a variety of materials systems. This will be a hands-on course with weekly meetings to discuss progress and challenges.  
Applies to requirement(s): Meets No Distribution Requirement  
Other Attribute(s): Speaking-Intensive; Topics Course  
K. Aidala  
Credits: 4
Instructor permission required.
Credits: 1-4
Course can be repeated for credit.

**PHYS-396SC  Advanced Laboratory Techniques: 'Next Generation Solar Cells and LEDs'**

*Spring*
Students will be introduced to solar cell and LED fabrication and characterization techniques, and pursue projects on a variety of materials systems. This will be a hands-on course with weekly meetings to discuss progress and challenges.

*Applies to requirement(s):* Meets No Distribution Requirement
*Other Attribute(s):* Speaking-Intensive; Topics Course
*A. Arango*
Instructor permission required.
Credits: 1-4
Course can be repeated for credit.

**See Also**
- Engineering
- Dual Degree Engineering