PHYSICS

Overview and Contact Information

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.

See Also

- Engineering (http://catalog.mtholyoke.edu/areas-study/engineering)
- Dual-Degree in Engineering (http://catalog.mtholyoke.edu/other-programs/other-degree-certificate-programs)

Contact Information

Katherine Aidala, Chair
Sarah Byrne, Academic Department Coordinator

206 Kendade Hall
413-538-2238
https://www.mtholyoke.edu/acad/physics

Faculty

This area of study is administered by the Department of Physics:
Mark Peterson, Professor of Physics and Mathematics on the Alumnae Foundation, On Leave 2016-2017

Katherine Aidala, Associate Professor of Physics

Alexi Arango, Assistant Professor of Physics

Kerstin Nordstrom, Assistant Professor of Physics

Anat Burger, Visiting Lecturer in Physics

Requirements for the Major

A minimum of 37 credits:

PHYS-110	Force, Motion, and Energy [1]	4
PHYS-201	Electromagnetism [1]	4
PHYS-205	Introduction to Mathematical Methods for Scientists	4
PHYS-210	Waves and Optics	4
PHYS-250	Quantum Mechanical Phenomena	4
PHYS-231	Techniques of Experimental Physics [2]	1
Students must also take two of:		8
PHYS-315	Analytical Mechanics	
PHYS-325	Electromagnetic Theory	
PHYS-326	Statistical Mechanics and Thermodynamics	
Laboratory Work:		
PHYS-220	Intermediate Lab in Physics	4
or PHYS-308	Electronics	
And 4 additional credits of laboratory work from:		4
PHYS-290	Advanced Laboratory Practicum	
PHYS-295	Independent Study	
PHYS-295P	Independent Study with Practicum	
PHYS-390	Advanced Laboratory Practicum	
PHYS-395	Independent Study	
PHYS-395P	Independent Study with Practicum	
PHYS-220 or PHYS-308, if you didn't count it already above		
Physics 350 at Smith College		
or laboratory courses offered at other institutions, as arranged on a case-by-case basis. [3]		
Total Credits		37

1 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

2 PHYS-231 should be taken during the junior or senior year

3 As arranged on a case-by-case basis

4 PHYS-336 is offered in alternate years. PHYS-336 is recommended, as is MATH-211.

Additional Specifications

- 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 PHYS-250 with PHYS-222 and PHYS-395 with BIOL-395.
- Up to 4 credits of PHYS-295P or PHYS-395P may be earned through summer research, following college guidelines for awarding PHYS-295P/PHYS-395P credit. Note that PHYS-295P and PHYS-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 PHYS-295P or PHYS-395P.
- Normally, no more than 12 credits of PHYS-290, PHYS-295, PHYS-295P, PHYS-390, PHYS-395, or PHYS-395P will count towards the major.
- Physics majors are also encouraged to take CHEM-101 and/or CHEM-201 (General Chemistry I and II).
- MATH-203 (Calc III – multivariate calculus), MATH-211 (linear algebra), and PHYS-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.
- For advising purposes, several Plans of Study (http://catalog.mtholyoke.edu/areas-study/chemistry/#planofstudytext), showing recommended sequences of course-taking to complete the major are available.

Sample Plans of Study for the Physics Major

Courses with a footnote 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:

PHYS-220	Intermediate Lab in Physics	4
PHYS-222	Comparative Biomechanics	4
PHYS-295	Independent Study	1-4
PHYS-308	Electronics	4
PHYS-336	Quantum Mechanics	4
PHYS-395	Independent Study	1-8

Or a wide range of Five College options

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

First Year

Fall	Credits	Spring	Credits
PHYS-110[1]	4	PHYS-201[1]	4
MATH-102	4	MATH-203	4
	8		8

Sophomore

Fall	Credits	Spring	Credits
PHYS-205[1]	4	PHYS-250[1]	4
PHYS-210[1]	4	PHYS-315	4
	8		8

Junior

Fall	Credits	Spring	Credits
PHYS-325	4	PHYS-308	4
PHYS-326	4	PHYS-336	4
	8		8

Senior

Fall	Credits	Spring	Credits
PHYS-395	1-8	PHYS-395	1-8
Physics elective	Physics elective		
	1-8		1-8

Total Credits: 50-64

[1] *Required for the major*

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

First Year

Fall	Credits	Spring	Credits
MATH-102	4	MATH-102	4
		PHYS-110[1]	4
	4		8

Sophomore

Fall	Credits	Spring	Credits
PHYS-201[1]	4	PHYS-308	4
PHYS-205[1]	4	PHYS-315	4
	8		8

Junior

Fall	Credits	Spring	Credits
PHYS-210[1]	4	PHYS-250[1]	4
PHYS-395	1-8	Physics elective	
	5-12		4

Senior

Fall	Credits	Spring	Credits
PHYS-325	4	PHYS-395	1-8
PHYS-326	4	Physics elective	
	8		1-8

Total Credits: 46-60

[1] *Required for the major*

For students beginning physics in the first sophomore semester:

First Year

Fall	Credits	Spring	Credits
MATH-101	4	MATH-102	4
	4		4

Sophomore

Fall	Credits	Spring	Credits
PHYS-110[1]	4	PHYS-201[1]	4
	4		4

Junior

Fall	Credits	Spring	Credits
PHYS-205[1]	4	PHYS-250[1]	4
PHYS-210[1]	4	PHYS-310	2
	8		6

Senior

Fall	Credits	Spring	Credits
PHYS-325	4	PHYS-308	4
PHYS-326	4	PHYS-395	1-8
PHYS-395	1-8		
	9-16		5-12

Total Credits: 44-58

[1] *Required for the major*

- PHYS-231 should be taken during the junior or senior year
- PHYS-336, offered in alternate years, is recommended, as is MATH-211.

Requirements for the Minor

A minimum of 16 credits:

Normally, courses for the minor consist of: [1]

PHYS-201	Electromagnetism	4
Any three of:		12
PHYS-205	Introduction to Mathematical Methods for Scientists	
PHYS-210	Waves and Optics	
PHYS-250	Quantum Mechanical Phenomena	
PHYS-308	Electronics	
Total Credits		16

[1] Other combinations of courses are also possible with permission of the department chair. Courses must be at or above the 200 level in Physics

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. Further information about the minor in education (http://catalog.mtholyoke.edu/areas-study/psychology-education/#minortext) and the Teacher Licensure program (http://catalog.mtholyoke.edu/areas-study/psychology-education/#teacherlicensuretext) is available in other sections of the catalog, and consult 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.

Additional information about the Licensure Program, including application materials, can be found on the Teacher Licensure Program website (https://www.mtholyoke.edu/acad/teach).

Course Advice

Getting Started in Physics

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

Introductory Courses and Distribution Requirements

PHYS-100–PHYS-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.

PHYS-110–PHYS-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 PHYS-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. PHYS-110 and PHYS-201 do not cover the full range of topics on the MCAT syllabus; the PHYS-100 and PHYS-150 sequence has a better coverage of these topics.

Course Offerings

PHYS-100 Foundations of Physics
Fall. Credits: 4
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
K. Nordstrom
Coreq: PHYS-100L.

PHYS-104 Renewable Energy
Spring. Credits: 4
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: ENVST-104
Applies to requirement(s): Math Sciences
A. Arango

PHYS-110 Force, Motion, and Energy
Fall and Spring. Credits: 4
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. Aidala, A. Burger
Prereq: MATH-101 or equivalent. Coreq: PHYS-110L.
Advisory: Knowledge of calculus as demonstrated by Math 101 or equivalent.

PHYS-150 Phenomena of Physics
Spring. Credits: 4
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 100, the applicable mathematics is geometry, proportion, and dimensional analysis.
Applies to requirement(s): Math Sciences
K. Nordstrom
Prereq: PHYS-100 or PHYS-110. Coreq: PHYS-150L.

PHYS-201 Electromagnetism
Fall and Spring. Credits: 4
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
A. Arango
Prereq: PHYS-110 and MATH-102. Coreq: PHYS-201L.

PHYS-205 Introduction to Mathematical Methods for Scientists
Fall. Credits: 4
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
A. Arango
Prereq: PHYS-190 or PHYS-201 (or concurrent enrollment with permission). Coreq: PHYS-205L.

PHYS-210 Waves and Optics
Fall. Credits: 4
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
A. Burger
Prereq: Electromagnetism (PHYS-190/PHYS-201) and Intro to Math Methods (PHYS-303/PHYS-200/PHYS-205) or concurrent enrollment in PHYS-205 with permission.
Advisory: Electromagnetism (Physics 190/201) and Intro to Math Methods (Physics 200/205) or concurrent enrollment in 205

PHYS-220 Intermediate Lab in Physics
Not Scheduled for This Year. Credits: 4
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: PHYS-201.

PHYS-221 Topic
Not Scheduled for This Year. Credits: 4
Applies to requirement(s): Math Sciences
Prereq: PHYS-110/PHYS-115 and permission of instructor.

PHYS-222 Comparative Biomechanics
Not Scheduled for This Year. Credits: 4
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: BIOL-322
Applies to requirement(s): Math Sciences
G. Gillis
Prereq: PHYS-110/PHYS-115 and permission of instructor. Coreq: PHYS-222L.
Notes: 12 students per lab

PHYS-231 Techniques of Experimental Physics
Fall and Spring. Credits: 1
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

PHYS-250 Quantum Mechanical Phenomena
Spring. Credits: 4
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
A. Burger
Prereq: PHYS-205 and PHYS-210.

PHYS-290 Advanced Laboratory Practicum
Not Scheduled for This Year. Credits: 1 - 8
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
K. Aidala, A. Arango
Instructor permission required.

PHYS-295 Independent Study
Fall and Spring. Credits: 1 - 4
The department
Instructor permission required.

PHYS-295P Independent Study with Practicum
Fall and Spring. Credits: 1 - 4
The department
Instructor permission required.

PHYS-308 Electronics
Spring. Credits: 4
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
K. Aidala
Prereq: PHYS-150 or PHYS-201.
Notes: Meetings combine lecture and hands-on lab

PHYS-315 Analytical Mechanics
Spring. Credits: 4
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
K. Nordstrom
Prereq: PHYS-205.

PHYS-325 Electromagnetic Theory
Fall. Credits: 4
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
A. Burger
Prereq: Intro to Math Methods (PHYS-303/PHYS-200/PHYS-205).

PHYS-326 Statistical Mechanics and Thermodynamics
Fall. Credits: 4
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 (PHYS-302/PHYS-250) and Intro to Math Methods (PHYS-303/PHYS-200/PHYS-205) or permission from department.

PHYS-328 From Lilliput to Brobdingnag: Bridging the Scales Between Science and Engineering
Fall. Credits: 4
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: CHEM-328
Applies to requirement(s): Meets No Distribution Requirement
Other Attribute(s): Writing-Intensive
M. Gomez
Prereq: MATH-102 and PHYS-201.

PHYS-329 Advanced Physics

PHYS-336 Quantum Mechanics
Spring. Credits: 4
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: PHYS-250.
Notes: Physics 324 or 336 will normally be offered in alternating years

PHYS-390 Advanced Laboratory Practicum
Not Scheduled for This Year. Credits: 1 - 8
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
K. Aidala, A. Arango
Instructor permission required.
Prereq: 16 credits in Physics.

PHYS-395 Independent Study
Fall and Spring. Credits: 1 - 8
The department
Instructor permission required.

PHYS-395P Independent Study with Practicum
Fall and Spring. Credits: 1 - 8
The department
Instructor permission required.

PHYS-396 Advanced Laboratory Techniques
Instructor permission required.

PHYS-396MS Advanced Laboratory Techniques: 'Scanning Probe Microscopy'
Not Scheduled for This Year. Credits: 1 - 4
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
K. Aidala
Instructor permission required.

PHYS-396SC Advanced Laboratory Techniques: 'Next Generation Solar Cells and LEDs'
Not Scheduled for This Year. Credits: 1 - 4
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
A. Arango
Instructor permission required.

PHYS-396US Advanced Laboratory Techniques: 'Quantitative Ultrasound'
Not Scheduled for This Year. Credits: 1 - 4
Students will be introduced to quantitative ultrasound imaging. This will be a hands-on course utilizing experimental methods to study the application of ultrasound as a diagnostic tool. We will meet weekly to discuss progress and challenges.
Applies to requirement(s): Meets No Distribution Requirement
Other Attribute(s): Speaking-Intensive
T. Herd
Instructor permission required.