PHYSICS

Overview and Contact Information
Consulting with a departmental advisor, the student may design their major curriculum for various purposes. They may take the courses necessary to prepare for graduate study in physics or closely related fields (including engineering), or they may plan a program that, together with courses from other disciplines, prepares them 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
Alexi Arango, Chair
Nicole Amrani, 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:
Katherine Aidala, Professor of Physics
Mark Peterson, Professor of Physics and Mathematics on the Alumnae Foundation
Alexi Arango, Associate Professor of Physics
Kerstin Nordstrom, Assistant Professor of Physics
Spencer Smith, Assistant Professor of Physics

Requirements for the Major
A minimum of 37 credits:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As a prerequisite for PHYS-110:</td>
<td></td>
</tr>
<tr>
<td>MATH-101</td>
<td>Calculus I</td>
<td></td>
</tr>
<tr>
<td>PHYS-110</td>
<td>Force, Motion, and Energy ¹</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-201</td>
<td>Electromagnetism ¹</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-205</td>
<td>Introduction to Mathematical Methods for Scientists</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-210</td>
<td>Waves and Optics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-250</td>
<td>Quantum Mechanical Phenomena</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-231</td>
<td>Techniques of Experimental Physics ²</td>
<td>1</td>
</tr>
</tbody>
</table>

Students must also take two of:
- PHYS-315 Analytical Mechanics
- PHYS-325 Electromagnetic Theory
- PHYS-326 Statistical Mechanics and Thermodynamics

<table>
<thead>
<tr>
<th>Laboratory Work:</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-220 Intermediate Lab in Physics</td>
</tr>
<tr>
<td>or PHYS-308 Electronics</td>
</tr>
<tr>
<td>And 4 additional credits of laboratory work from:</td>
</tr>
<tr>
<td>PHYS-295 Independent Study</td>
</tr>
<tr>
<td>PHYS-295P Independent Study with Practicum</td>
</tr>
<tr>
<td>PHYS-395 Independent Study</td>
</tr>
<tr>
<td>PHYS-395P Independent Study with Practicum</td>
</tr>
<tr>
<td>PHYS-220 or PHYS-308, if you didn’t count it already above</td>
</tr>
<tr>
<td>or laboratory courses offered at other institutions, as arranged on a case-by-case basis. ³</td>
</tr>
</tbody>
</table>

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 (offered in alternate years) 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 materials science might reasonably replace PHYS-315 with CHEM-208.
- 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-295, PHYS-295P, PHYS-395, or PHYS-395P will count towards the major.
- Physics majors are also encouraged to take CHEM-150.
- MATH-203 (Calculus III – multivariate calculus) and MATH-211 (linear algebra), 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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>PHYS-220</td>
<td>Intermediate Lab in Physics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-295</td>
<td>Independent Study</td>
<td>1-4</td>
</tr>
<tr>
<td>PHYS-308</td>
<td>Electronics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-336</td>
<td>Quantum Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-395</td>
<td>Independent Study</td>
<td>1-8</td>
</tr>
</tbody>
</table>

Or a wide range of Five College options

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

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-110</td>
<td>4</td>
<td>PHYS-201</td>
<td>4</td>
</tr>
<tr>
<td>MATH-102</td>
<td>4</td>
<td>MATH-203</td>
<td>4</td>
</tr>
</tbody>
</table>

Sophomore

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-205</td>
<td>4</td>
<td>PHYS-250</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-210</td>
<td>4</td>
<td>PHYS-315</td>
<td>4</td>
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</table>

Junior

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-308 (or elective)</td>
<td>4</td>
<td>PHYS-220 (or elective)</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-326</td>
<td>4</td>
<td>PHYS-336</td>
<td>4</td>
</tr>
</tbody>
</table>

Senior

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-325</td>
<td>4</td>
<td>PHYS-395</td>
<td>1-8</td>
</tr>
<tr>
<td>PHYS-395</td>
<td>1-8 Physics elective</td>
<td></td>
<td></td>
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</tbody>
</table>

Total Credits 54-68

1 Required for the major

For students beginning physics in the first sophomore semester:

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
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<tbody>
<tr>
<td>MATH-101</td>
<td>4</td>
<td>MATH-102</td>
<td>4</td>
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</table>

Sophomore

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-110</td>
<td>4</td>
<td>PHYS-201</td>
<td>4</td>
</tr>
</tbody>
</table>

Junior

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-205</td>
<td>4</td>
<td>PHYS-220 (or elective)</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-210</td>
<td>4</td>
<td>PHYS-250</td>
<td>4</td>
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</table>

Senior

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credits</th>
<th>Spring</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-325</td>
<td>4</td>
<td>PHYS-395</td>
<td>1-8</td>
</tr>
<tr>
<td>PHYS-326</td>
<td>4</td>
<td>Physics elective</td>
<td></td>
</tr>
<tr>
<td>PHYS-395 or 308</td>
<td>1-8</td>
<td>PHYS-395 or 308</td>
<td>1-8</td>
</tr>
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</table>

Total Credits 42-56

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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>PHYS-201</td>
<td>Electromagnetism</td>
<td>4</td>
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</table>

Any three of:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>PHYS-205</td>
<td>Introduction to Mathematical Methods for Scientists</td>
<td>12</td>
</tr>
</tbody>
</table>
**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*

S. Smith

*Prereq: MATH-101 or equivalent. Coreq: PHYS-100L.*

*Advisory: Knowledge of calculus as demonstrated by MATH-101 or equivalent.*

**PHYS-132 Engineering for Everyone**

*Not Scheduled for This Year* Credits: 4

Engineers change the world we live in every day by developing and improving nearly every aspect of our lives. In this course, we will study the interaction of technology and society and how the engineering design process helps shape the world we live in. Engineering comprises many disciplines, but one common theme is the engineering design process: research, problem definition, feasibility, conceptualization, prototyping, and testing. In this class, students will learn the engineering design process through application to contemporary technological and societal issues put into practice with pitch presentations, design reviews, prototypes, and written reports.

*Applies to requirement(s): Math Sciences*

K. McTiernan

*Advisory: This course has no prerequisites and is recommended for all students interested in engineering and technology.*

*Notes: Students interested in continuing with the Engineering Nexus are strongly recommended to take the course.*
PHYS-141 Interweaving Themes in Physics and Art
Not Scheduled for This Year. Credits: 4
Physics and Art represent the world in seemingly different ways, however they share many common themes: the guiding role of symmetry, the tension between order and disorder, and the emergence of structure from many simple constituents. We will explore some of the big ideas in physics, including quantum mechanics, relativity, entropy, and chaos theory, by looking at how these underlying themes are represented in the visual arts. Islamic tessellations, Japanese Suminagashi paper marbling, as well works by contemporary artists such as Tara Donovan will guide us toward an intuitive understanding of some of the most exciting ideas in physics without the need for any prior physics background.
Applies to requirement(s): Math Sciences
S. Smith

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
S. Smith
Prereq: 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. Arango
Prereq: Electromagnetism (PHYS-201) and Intro to Math Methods (PHYS-205) or concurrent enrollment in PHYS-205 with permission.

PHYS-220 Intermediate Lab in Physics
Spring. 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. In addition to exploring key physical phenomena crucial to modern understandings and gaining familiarity with modern experimental apparatus and techniques, students complete exploratory projects of various sorts and then extended, multi-week experimental projects, participating in experimental design, construction, debugging and implementation. Students will present and interpret their experimental results and develop follow-up questions which they will answer experimentally. This course will introduce students to scientific communications skills and is speaking- and writing-intensive.
Applies to requirement(s): Meets No Distribution Requirement
Other Attribute(s): Speaking-Intensive, Writing-Intensive
N. Abraham
Prereq: PHYS-201.

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
C. Trimble
Restrictions: This course is limited to Physics majors.; This course is open to juniors and seniors
Notes: 1 meeting (2 hours) for 3 weeks. Credit/no credit grading.

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
N. Abraham

PHYS-290 Advanced Laboratory Practicum
Spring. Credits: 1 - 8
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. In addition to exploring key physical phenomena crucial to modern understandings and gaining familiarity with modern experimental apparatus and techniques, students complete exploratory projects of various sorts and then extended, multi-week experimental projects, participating in experimental design, construction, debugging and implementation. Students will present and interpret their experimental results and develop follow-up questions which they will answer experimentally. This course will introduce students to scientific communications skills and is speaking- and writing-intensive.
Applies to requirement(s): Meets No Distribution Requirement
Other Attribute(s): Speaking-Intensive, Writing-Intensive
K. Aidala
Instructor permission required.
Notes: Repeatable for credit.

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  
Fall. 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  
S. Smith  
Prereq: PHYS-205.  

PHYS-325 Electromagnetic Theory  
Spring. 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  
M. Peterson  

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  
M. Peterson  
Prereq: Quantum Mechanical Phenomena (PHYS-250) and Intro to Math Methods (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): Speaking-Intensive, Writing-Intensive  
M. Gomez  
Prereq: MATH-102 and any chemistry or physics course with grade of C or better.  

PHYS-336 Quantum Mechanics  
Not Scheduled for This Year. 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  
M. Peterson  
Prereq: PHYS-250.  

PHYS-390 Advanced Laboratory Practicum  
Spring. 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  
Instructor permission required.  
Prereq: 16 credits in Physics.  
Notes: Repeatable for credit.  

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.