Come to our info session on the Physics Careers
Second week of classes: time and place to be announced

Come to our info session on the Physics Major
Sunday August 20, 2017
2:00pm-4:00pm
700 Clark Hall

Frequently asked questions about the Cornell Physics Program (for incoming students) 2017
About Physics at Cornell

Physics forms the intellectual core of the physical sciences. It examines the world through an analytical lens: providing insight into the fundamental building blocks of nature, the emergent behavior of complex systems, and the laws which govern the physical world. In addition to offering an exciting array of courses, Cornell’s Department of Physics features world-class research in a wide variety of specializations: from biophysics and nanoscience, to high energy physics and string theory. Undergraduates in Physics have the opportunity to conduct research in these areas, as well as participate in teaching and community outreach activities.

THE PHYSICS DEPARTMENT

Cornell’s Department of Physics has 40 active professors that specialize in a wide range of research areas: Condensed-Matter (Solid State) Physics, Particle Physics, Astrophysics and General Relativity, Accelerator Physics, and Biological Physics. Emeritus faculty, Administrative Staff, Technical Staff, and Lecturers round out our program. The department has approximately 200 graduate students and ~100 undergraduate majors.

We have close ties to several other departments and are involved in collaborative research with astronomers, biologists, chemists, engineers, material scientists, and medical doctors.

Just as Ezra Cornell founded Cornell as “an institution where any person can find instruction in any study,” the department of physics sees itself as a place where one can learn about all aspects of physics and apply it in any field. We see both teaching and research as forming the core of our mission.

More information about the Department of Physics is at http://www.physics.cornell.edu

COURSES

Cornell offers several types of physics courses:

- General interest courses such as “Why is the Sky Blue?”, and “Physics of Musical Sound”
- Introductory physics courses of interest to students in a range of science and engineering disciplines
- Advanced courses for physics majors and others with a deeper interest in physics.

THE MAJOR

As part of the College of Arts and Sciences, the physics department offers a Bachelors of Arts (BA). A detailed description of the physics major and its requirements can be found in the Cornell Courses of Studies, or at http://www.physics.cornell.edu/academics/undergraduate/

Our program is flexible, and students play an important role in developing a curriculum that fits their needs. To this end, majors may choose to be “inside concentrators” or “outside concentrators”.

Concentrating in physics is the standard path to professional or graduate work in physics and closely related fields, and is also the best choice for students who wish to obtain maximum benefit from rigorous studies in physics.

Concentrating outside of physics provides more flexibility for those who are interested in a variety of careers but whose career interests lie elsewhere. For example, a pre-medical or biophysics student might concentrate in biology; a pre-law student might concentrate in business, history or public policy; and a student planning graduate work in econometrics or on pursuing an MBA might concentrate in economics. Students interested in education careers (and in capitalizing on the critical national shortage of high school physics teachers) might concentrate in education.

Most physics majors incorporate research into their program of study.

To join the major, a student must have a B- average in two introductory physics courses and the associated mathematics courses. Grades of at least C- (or S for S-U only courses) are required in all courses counting toward the physics major.

A chart depicting the required courses for the physics major is shown on the following page -- more detail is found in the Courses of Studies. Many of our courses are offered in two versions: students have enjoyed wide-ranging success from either stream. We encourage students to consult with their instructors and advisors to formulate a plan of study.

THE MINOR

Physics, with its broad range of applications, makes an excellent minor to supplement studies in another area. Students in all colleges and majors are eligible to complete a Physics Minor.

THE SOCIETY OF PHYSICS STUDENTS

Cornell has an active undergraduate physics club, the Society of Physics Students. They have a lounge in Rockefeller B2, a web site http://pages.physics.cornell.edu/sps and a listserv. They sponsor “homework parties,” talks about physics research, and other events. Freshmen play an important role in the club, and you are encouraged to join up.
Physical Sciences Building

Duffield Hall -- Nanofabrication facility
### Concentration

#### Inside Concentrator

**PHYS 4410** (in addition to core lab)  
11 more credits from:  
PHYS3000+, ASTRO 3332, ASTRO 4431-2, or AEP 4340.  
no more than 8 credits from PHYS4490

#### Outside Concentrator

- 15 credits in concentration  
(coherent program of study complementing core)


8 credits must be at 3000+ level

### Mathematics

Students from any college may take courses from any of the Math streams, and can freely mix streams

<table>
<thead>
<tr>
<th>Integral Calculus</th>
<th>Vector Calculus</th>
<th>Intro Diff. Eqns.</th>
<th>Linear Algebra</th>
<th>Complex Analysis*</th>
<th>Diff. Eqns*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engineering</strong></td>
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<tr>
<td>MATH 1910</td>
<td>MATH 1920</td>
<td>MATH 2930</td>
<td>MATH 2940</td>
<td>AEP 4210</td>
<td>AEP 4220</td>
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<tr>
<td><strong>A&amp;S</strong></td>
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<tr>
<td>MATH 1120</td>
<td>MATH 2220</td>
<td>MATH 2930</td>
<td>MATH 2210</td>
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<tr>
<td><strong>Honors</strong></td>
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<tr>
<td>MATH 1220</td>
<td>MATH 2240</td>
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<td>MATH 2230</td>
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<tr>
<td><strong>Other</strong></td>
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<tr>
<td>4+ on AP Calc. BC</td>
<td>MATH 2130</td>
<td>MATH 3230</td>
<td>MATH 2310</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Not required for Outside Concentrators  
AEP courses are a good option for all streams

### Computer Science

No formal CS requirement. Recommend CS 1110 or CS 1112 or ASTRO 3340.
Cornell Undergraduate Physics Minor

### Introductory sequence with Special Relativity (12-13 credit)

**Introductory Mechanics**
- P1112 or 2207 or 1116
  - preq: Integral Calculus

**Special Relativity**
- P2213 or 2208 or 2217
  - preq: Vector Calculus

**Introductory Electricity and Magnetism (Waves)**
- P2214 or 2218
  - preq: Differential Equations

P1116 may simultaneously satisfy both the mechanics requirement and the special relativity requirement.

Advanced placement or transfer credit can be used to satisfy these requirements.

### Intermediate Level Physics (3 courses, 9 credits)

**P3316**
- preq: Special Relativity (P1116 or P2216), Waves coreq: Linear Algebra

**P3310, or P3330, or P3360, or P4410 or ASTRO 4410 or experimental research as P4490**
- 1 or more physics courses at the 3000+ level to meet the requirement of 3 courses, 9 credits

Students in majors that require physics courses at the 3000 level or higher, such as Applied and Engineering Physics, Astronomy, or Mathematics, may not use courses to satisfy both their major and the physics minor.

No more than 3 credits of Physics 4490 may count towards the minor.

Admission to the minor requires a B- or better in 2 introductory physics courses, and in their mathematics prerequisites. A C- or better is required in all courses used for the minor.

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### More information about Concentrations

1. The Concentration must complement the Core. The narrative behind this can vary. Some examples include:
   a. Astronomy: Applying physical concepts to study astrophysical phenomena.
   b. Public Policy: Working on issues such as nuclear proliferation, sustainability, or science policy requires a technical background.

2. The Concentration must have internal coherence.

3. There are no set courses. The student should develop a sensible program of study in consultation with their advisor and the director of undergraduate studies. Two students with the same concentration may have very different course sets. For example a life sciences concentrator may be interested in applying physics to medical instrumentation. Such a student may use the biology and chemistry classes needed for medical school as their concentration. Another life science student may be interested in biophysics research, and hence focus on courses which develop biophysics lab skills.

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### Partial list of Courses with Physics Content

**Physics** — The physics department offers a full range of undergraduate and graduate classes. As a supplement to their introductory sequence, freshmen may enjoy PHYS 1117 Concepts of Modern Physics. Upperclassmen interested in becoming research physicists would benefit from supplementing the core with PHYS 3341 Statistical Physics (typically taken in the fall of your senior year), PHYS 4444 Quantum Mechanics (typically taken in the spring of your junior or senior year). Other advanced courses include: Lab courses (PHYS 3310/3360/4410), PHYS 4444 Particle Physics, PHYS 4445 Solid-State Physics, PHYS 4466/4485/4496 Accelerator Physics, PHYS 4468 Computational Physics, and PHYS 4489 Quantum Information Processing. Students often perform research for course credit by taking PHYS 4490. Advanced undergraduate students occasionally enroll in graduate courses (typically, but not limited to, PHYS 6572 or 6599).

**Applied Physics** — Cornell's applied physics department offers a number of courses which complement those offered by physics. These include AEP 1100 Lasers and Photonics, AEP 1200 Nanoscience, AEP 3240 Maple Supplement to Mathematical Physics, AEP 3330 Mechanics of Particles and Solid Bodies, AEP 4280 Statistical Thermodynamics, AEP 4340 Continuum Physics, AEP 4440 Quantum and Nonlinear Optics, AEP 4840 Fusion, and the AEP courses listed below under “Biology.”

**Astronomy** — Introductory astronomy courses particularly appropriate to physics majors: ASTRO 2211 Extragalactic, ASTRO 2212, Solar, ASTRO 2223 Special Topics, ASTRO 2290 Relativity. Any astronomy course labelled 3000+ should also be considered (many have no astronomy prerequisites).

**Applied Mathematics** — Physics heavily draws on applied mathematics such as Calculus, Differential Equations, Complex Analysis, and Differential Geometry. In addition to looking at courses offered by the Mathematics department, students may find it useful to look at the courses offered by Theoretical and Applied Mechanics. Please see an advisor for help on selecting mathematics courses.

**Abstract Mathematics** — Students with an interest in abstract mathematics should consider taking courses in real analysis and abstract algebra. Other major branches of abstract mathematics include Differential Geometry, Topology, and Group Theory.

**Biotechnology** — Physics is important in understanding micro and macro biology, and has application in areas such as bioinformatics. Physics is also a major part of biotechnology. Biology related courses some physics flavor include: AEP 2520/3520 Physics of Life, AEP 4700/5710 Biophysical methods, BIEE 3310 Bio-Fluid Mechanics, BIEE 4500 Biostatistics, BIEE 4900 Biocatalysis, BIEE 5000 Biomedical Engineering, BME 5300 Biomedical Instrumentation, BICMB 4960 Bioacoustic Signals in Animals and Man. Introductory Biology is naturally incorporated into a well-rounded science education.

**Communication/Writing** — Technical writing skills are essential to success in physics. General technical writing courses: ENGL 2880/2890, ENGRC 3350/3500, BIEE 4950, BIEE 4980, COMM 2630. Science journalism courses: COMM 3520/3530.

**Computers** — Computer skills are essential for success in most areas of physics. Physics students are encouraged to consider an introductory computer science course such as CS 1112, as well as more targeted courses such as PHYS 4480 Computational Physics, AEP 4380 Computational Engineering Physics, CS 3220 Scientific Computing, CS 3260 Engineering Computing, and MATH 4250/60 Numerical Analysis.

**Chemistry** — Quantum physics forms the basis of most chemical processes. Chemistry related courses with some physics flavor include: CHEM 3890/3900, CHEM 4840 Microchemical/Microfluidic Systems. Introductory chemistry (CHEM 2070/80/90), and organic chemistry (CHEM 3980-3060) are naturally incorporated into a well-rounded science education.

**Earth and Atmospheric Sciences** — Physics can be applied to understanding the Earth and its Atmosphere. Of particular interest to physics students are EAS4470 Physical Meteorology and EAS 4480 Inverse Methods in Natural Sciences.

**Education** — PHYS 4484 Teaching and Learning Physics, EDUC 4104/50 Learning and Teaching, PHYS 4485/66 Teaching Exp. I/II.

**Electrical Engineering** — ECE courses of interest to Physics students include: ECE 4300 Lasers, ECE 4350 Microwave Devices, ECE 4370 Fiber.

**Food Science** — FDSC 2000 Physicochemical and Biological Aspects of Food, FDSC 4230 Physical Principles of Food Preservation, NS 3310 Physiological and Biochemical Bases of Human Nutrition.


**History, Art History, and Archaeology** — HIST 2810/2820 Science in the Western Civilization, HIST 3290 Physical Sciences in the Modern Age HIST 4581/4610/6810/7110 Seminars, ARTH 6252 Research Methods in Archaeology, ARKEO 4570 Geophysical Field Methods.

**Law** — LAW 6742 Patent Law

**Material Science** — Physics can be applied to understanding the properties of materials. Possible courses include: ENGRD 2610 Mechanical Properties of Materials, CEE 3710/20 Structural Modeling, MSE 4100 Physical Metallurgy, MSE 4890 Colloids.
Discussion of “Suggested Prerequisites”

The mathematics prerequisites in the courses of study (also shown on the previous chart) list the courses which will guarantee that you will have seen the relevant mathematics. Some students choose to take their physics courses without taking all of the suggested prerequisite mathematics. Depending on your mathematical aptitude and your personality, you may have success at this, and your instructors have the ability to waive/modify the prerequisites. For a typical student following the prerequisites as closely as possible will help guarantee your success.

Some common variations include:

- Students in the Honors math stream are required to take Linear Algebra (MATH 2230) before Vector Calculus (MATH 2240). They can request to take Vector Calculus as a corequisite with P2217.

- Students sometimes receive permission to treat the prerequisites as corequisites [for example, taking MATH 1910 at the same time as P1112, or MATH 2220 at the same time as P2217.]

Other variations are possible, and students should consult with their advisors, course instructors, and the Physics Director of Undergraduate Studies. You must talk with your course instructor if you wish to take a course without the suggested prerequisites.

Students are free to switch between the various streams -- or to take some courses from one stream and other courses from another. The one caveat is that switching into the honors mathematics stream is discouraged, and requires permission from the Mathematics department.

Survey courses of interest

**P1117 -- Concepts of Modern Physics** -- A 1 credit survey of modern physics topics. Requires no prerequisites. Intended to be a fun and exciting course to expose students to topics they typically would not encounter until an advanced course in physics. Syllabus varies by semester, but has included symmetry and conservation laws, quantum theory, unification of forces, the Standard Model, and big-bang cosmology.

**AEP1100 -- Lasers and Photonics** -- A 3 credit course on lasers, photonics, and laser technology [taught through the school of engineering, but open to all students.] Requires no prerequisites. Contains a strong laboratory component in which students build and operate a nitrogen laser and participate in experiments involving holography, laser processing of materials, optical tweezers, and fiber optics.

**AEP1200 -- Introduction to Nanoscience and Nanoengineering** -- A 3 credit course on nanotechnology [taught through the school of engineering, but open to all students.] Requires no prerequisites. Contains a strong laboratory component. Students learn techniques for designing and manipulating materials on the sub-micron scale.

**MATH1600 -- Totally Awesome Mathematics** -- A 2 credit team-taught survey course which introduces students to the breadth of mathematics. Requires one semester calculus [AP credit suffices]. Syllabus varies by semester, but has included encryption and number theory, non-Euclidean geometry, knots and surfaces, combinatorics of polyhedra, Heisenberg Uncertainty Principle and signal processing, unsolvable problems, and noncomputable functions.

See also ENGR11xxx and ASTRO22xx
Senior Lecturer and Teaching Support Specialist, Phil Krasicky demonstrates that in free-fall the apparent weight of a book is zero.
### Sample Schedules -- Preparation for Physics Grad School

<table>
<thead>
<tr>
<th>Preparation:</th>
<th>Interests/Goals:</th>
<th>Semester:</th>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 year AP Calculus AP Physics/Good HS physics</td>
<td>Physics Graduate School</td>
<td>1. Fall Freshman</td>
<td>M1910, CS 1110/1112</td>
</tr>
<tr>
<td>1 year AP Calculus AP Physics/Good HS physics</td>
<td>Physics Graduate School</td>
<td>2. Spring Freshman</td>
<td>P1116, M1920 CS 1110/1112</td>
</tr>
<tr>
<td>1 year AP Calculus AP Physics/Good HS physics</td>
<td>Physics Graduate School -- Possible Math Graduate School</td>
<td>3. Fall Sophomore</td>
<td>M2210</td>
</tr>
<tr>
<td>Late Start -- discovered physics in Sophomore year</td>
<td>Physics Graduate School</td>
<td>4. Spring Sophomore</td>
<td>M1120</td>
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<td>5. Fall Junior</td>
<td>M2220</td>
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<td>6. Spring Junior</td>
<td>M4200</td>
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<td>7. Fall Senior</td>
<td>M4200</td>
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<td>8. Spring Senior</td>
<td>M4200</td>
</tr>
</tbody>
</table>

| | | 1. Fall Freshman | P1116, M1920 CS 1110/1112 |
| | | 2. Spring Freshman | P2217, M2930 |
| | | 3. Fall Sophomore | P2218, M2940 |
| | | 4. Spring Sophomore | P3316, P33x0, M2940 |
| | | 5. Fall Junior | P3317, P3327, AEP4210 |
| | | 6. Spring Junior | P3318, P4443, AEP4220 |
| | | 7. Fall Senior | P3341, P4410, P3317 |
| | | 8. Spring Senior | P4444 |

| | | 1. Fall Freshman | P1116, M1920 CS 1110/1112 |
| | | 2. Spring Freshman | P2217, M2930 |
| | | 3. Fall Sophomore | P2218, M2940 |
| | | 4. Spring Sophomore | P3316, P33x0, P4490 |
| | | 5. Fall Junior | P3317, P3327, AEP4210 |
| | | 6. Spring Junior | P3318, P4443, AEP4220 |
| | | 7. Fall Senior | P3341, P4410, P3317 |
| | | 8. Spring Senior | P4444 |

| | | 1. Fall Freshman | M2210 |
| | | 2. Spring Freshman | M1120 |
| | | 3. Fall Sophomore | M2220 |
| | | 4. Spring Sophomore | M2230 |
| | | 5. Fall Junior | M4200 |
| | | 6. Spring Junior | M4200 |
| | | 7. Fall Senior | M4200 |
| | | 8. Spring Senior | M4200 |

Sample schedules illustrate breadth of option -- they by no means are inclusive. Many of the courses can be taken in different orders (e.g., P3316, P3318 and P3327 can be taken in any order after P2218). Students may substitute non-honors versions of courses (for example P3314 for P3318). Past students have succeeded in physics graduate school with the lower level course, but students with ambitions to attend the best schools should take the honors classes.

**Blue** courses could be substituted for any other physics course numbered 3000+

(Not all courses are offered every semester, and some have prerequisites.)

P4410 and P4490 can be taken multiple times for credit.

Some GRE topics are covered in PHYS 3317, so may have to do some self-study to excel at GRE in October of senior year.

Very hard math

Please speak with mathematics advisor about course suggestions for math graduate school.

[Should at least include 2 algebra courses and geometry/topology.]
## Sample Schedules -- Professional School

<table>
<thead>
<tr>
<th>Preparation:</th>
<th>1/2 year AP Calculus standard HS physics</th>
<th>1 year AP Calculus Standard HS physics</th>
<th>1/2 year AP Calculus standard HS physics</th>
<th>No Calculus, discovered physics in Sophomore year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interests/Goals:</td>
<td>High School Physics Teaching -- Prep for Masters of Arts in Teaching</td>
<td>Medical School / MD-PhD</td>
<td>1 year masters of engineering program</td>
<td>Medical School / MD-PhD</td>
</tr>
<tr>
<td>Concentration:</td>
<td>Education</td>
<td>Life Sciences</td>
<td>Physics</td>
<td>Life Sciences</td>
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</thead>
<tbody>
<tr>
<td>Course</td>
<td>P2213, M1920, Psych101</td>
<td>P2213, M2220, BioG</td>
<td>P2213, M1920</td>
<td>P2213, M2220</td>
<td>P2213, M2220</td>
<td>P2213, M2220</td>
<td>P2213, M2220</td>
<td>P2213, M2220</td>
</tr>
<tr>
<td>Course</td>
<td>P2214, M2930</td>
<td>P2214, M2210, Chem</td>
<td>P2214, M2930</td>
<td>P2214, M2930</td>
<td>P2214, M2930</td>
<td>P2214, M2930</td>
<td>P2214, M2930</td>
<td>P2214, M2930</td>
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<tr>
<td>Course</td>
<td>P3316, P2216, M2940</td>
<td>P3316, P2216, Chem</td>
<td>P3316, P33x0, M2940</td>
<td>P3316, P33x0, M2940</td>
<td>P3316, P33x0, M2940</td>
<td>P3316, P33x0, M2940</td>
<td>P3316, P33x0, M2940</td>
<td>P3316, P33x0, M2940</td>
</tr>
<tr>
<td>Course</td>
<td>P3317, AEP4210 EDUC3110</td>
<td>P3317, OrgChem</td>
<td>P3317, P3323, AEP3210</td>
<td>P3317, P3323, AEP3210</td>
<td>P3317, P3323, AEP3210</td>
<td>P3317, P3323, AEP3210</td>
<td>P3317, P3323, AEP3210</td>
<td>P3317, P3323, AEP3210</td>
</tr>
<tr>
<td>Course</td>
<td>P33x0, EDUC4410, EDUC5030</td>
<td>P3314, OrgChem</td>
<td>P3314, P33x0, AEP3220</td>
<td>P3314, P33x0, AEP3220</td>
<td>P3314, P33x0, AEP3220</td>
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</tr>
<tr>
<td>Course</td>
<td>P3323, P120x, EDUC4040</td>
<td>P3323, AdvBio</td>
<td>P3341, P4410</td>
<td>P3341, P4410</td>
<td>P3341, P4410</td>
<td>P3341, P4410</td>
<td>P3341, P4410</td>
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<tr>
<td>Course</td>
<td>P3314, EDUC4050</td>
<td>P33x0</td>
<td>P4443</td>
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</tbody>
</table>

| Comments: | Please contact Cornell Teacher Education to learn about certification, and the 1 year Masters of Arts in Teaching program. | Please contact Cornell Health Careers Advising to learn more about preparation for Medical School. | Please contact Cornell Applied and Engineering Physics to learn more about preparation for the one year Masters of Engineering Program. | Please contact Cornell Health Careers Advising to learn more about preparation for Medical School. |

Sample schedules illustrate breadth of option -- they by no means are inclusive.

- **Green** -- preparation for professional program (but not used for concentration) -- substitutes may be available
- **Blue** -- concentration -- may be substituted for other appropriate courses

Many of the courses can be taken in different orders.

All students are encouraged to try the honors version of the courses (ex P3318 in place of P3314)

Physics can be used as an entry point for other professional programs (ex. Law, Business) and for directly entering workforce.
### Description of Courses

For full descriptions, please see the Courses of Studies

#### Introductory Courses (Credit may only be received for one from each category)

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
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<tbody>
<tr>
<td>Physics I: Mechanics</td>
<td>P1112: Calculus based, strong introduction to physics, typical entry point for majors</td>
</tr>
<tr>
<td></td>
<td>P1116: Calculus based, mathematically sophisticated, very strong introduction to physics, entry point for majors with very good backgrounds, <em>includes special relativity.</em></td>
</tr>
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<td></td>
<td>P2207: Calculus based, life sciences focus, less mathematically sophisticated than P1112, wider range of topics, typically taken by life sciences majors</td>
</tr>
<tr>
<td></td>
<td>P1101: Algebra based, self-paced, same topics as P2207, not appropriate for physics majors</td>
</tr>
<tr>
<td>Physics II: Electricity and Magnetism</td>
<td>P2213: Strong introduction to electro/magnetostatics, circuits, and thermodynamics.</td>
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<tr>
<td></td>
<td>P2217: More mathematically sophisticated than P2213, covers electromagnetism and circuits.</td>
</tr>
<tr>
<td></td>
<td>P2218: More mathematically sophisticated than P2214. Wave mechanics, thermodynamics, and statistical mechanics</td>
</tr>
<tr>
<td>Collectivity</td>
<td>P2216: Half semester course on special relativity for students who have not taken P1116</td>
</tr>
<tr>
<td>Special Relativity</td>
<td>P1117: One credit course which introduces concepts of modern physics. Intended for Freshmen</td>
</tr>
<tr>
<td>Modern Physics</td>
<td>P3316: Basics of Quantum Mechanics: motivates quantum mechanics and give introduction to formalism</td>
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<tr>
<td></td>
<td>P3317: Applications of Quantum Mechanics: Overview of quantum phenomena</td>
</tr>
<tr>
<td>Intermediate Courses</td>
<td>P3314: Introduction to Lagrangian mechanics</td>
</tr>
<tr>
<td></td>
<td>P3318: Honors version</td>
</tr>
<tr>
<td>Laboratory Courses</td>
<td>P3310: Intermediate Experimental Physics -- Select experiments on a range of physics topics</td>
</tr>
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<td>P3310: Modern Experimental Optics -- Experiments in Ray Optics and Geometric Optics</td>
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<td>P3360: Electronic Circuits -- Practical Electronics</td>
</tr>
<tr>
<td></td>
<td>P4410: Advanced Experimental Physics -- Select experiments on a range of physics topics -- may be taken for credit multiple times</td>
</tr>
<tr>
<td>Advanced Courses (partial list)</td>
<td>P4490: Independent Study in Physics</td>
</tr>
<tr>
<td></td>
<td>P4455: Geometric Concepts</td>
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<td>P4481: Quantum Information</td>
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<td>P4480: Computational Physics</td>
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<td>P4444: Introduction to Particle Physics</td>
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<td>P4445: Introduction to General Relativity</td>
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<td>P4445: Introduction to Solid-State Physics</td>
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<td></td>
<td>P4456: Introduction to Accelerator Physics and Technology [Also see 4487 and 4488]</td>
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Frequently Asked Questions

Where can I get advice about my physics program of study?

Do not hesitate to contact your instructors, academic advisor, or the physics director of undergraduate studies. We highly recommend getting advice from multiple sources, and to not rely upon information from other students.

Appointments with the Physics Director of Undergraduate Studies can be made by contacting the Undergraduate and Events Coordinator, at (607) 255-7562 or by contacting the Physics DUS by email at physicsdus@cornell.edu.

Up to date contact information can be found on the web at http://www.physics.cornell.edu/undergraduate/

When should I start taking physics courses?

As seen by the sample schedules on page 8-9, you have flexibility in which semester you begin taking physics. The only notable issue with a late start is that some portions of the GRE involve topics from P3317. Thus students with a late start who are interested in graduate school may either need to study those topics on their own, or delay applying to graduate schools (ie. take a “gap year”). Our typical advice is to just study the topics on your own, but everyone is unique.

Those who are aiming for other careers -- such as working in industry, teaching, law, or medicine, will find that there are essentially no repercussions to a late start.

What preparation do I need to begin taking physics classes?

Mathematics is the language of physics. We recommend that students do not take PHYS 1112 or PHYS 1116 until they have credit for an integral calculus course (MATH 1910, 1120, 2220 or AP Calculus BC with a score of 4+). Students should not take PHYS 2213 or PHYS 2217 until they have credit for vector calculus (MATH 1920, 2220, 2240 or 2130).

Individual course instructors may waive these prerequisites.

What is the difference between P1112 and P1116?

These two courses cover nearly the same physical concepts. P1116 uses more sophisticated mathematics than P1112.

Physics 1116 has about 40-80 students in it, while Physics 1112 has from 150-300 depending on the term. [These break into smaller groups of no more than 20 for recitations and labs.] Both courses have excellent instructors, great TA’s, and share the same labs. They are both very stimulating. P1112 tends to have more focus on applications, while P1116 is more abstract.

P1116 includes a module on special relativity. Students who take P1112 and want to learn about special relativity can take the half-semester course P2216.

Should I take P1112 or P1116?

You should fold many things into this decision. First, do you have the required mathematical background? P1116 requires the ability to apply sophisticated mathematics (calculus, vectors) to problem. Second, are you looking for a challenge? P1116 problem sets are much harder than those in P1112.

To get additional information, please talk to the professors [P1116: James Alexander (jpa6) -- P1112: Fall: Julia Thom (jt297)] and look at the two texts in the bookstore.
P1112 is traditionally taught from Young and Freedman’s “University Physics”, while P1116 is traditionally taught from Kleppner and Kolenkow’s “An Introduction to Mechanics.” One can get a good feel for the differences in the courses by comparing the books.

If you are still undecided, register for both classes. Attend them for the first week. By that time it should be clear which is the correct course for you. Please do not forget to drop one of the courses before the add-drop date!!

I eventually want to attend graduate school in physics. Do I need to take P1116?

No. Both P1112 and P1116 are great introductions to Mechanics. They cover the same physical concepts. Some physics majors succeed at graduate school after taking physics 1112 - 2213 - 2214. Many start with P1112 then transfer into the honors stream in a following course (for example taking P2217 after P1112).

Each student’s program is unique, and we encourage students to find the correct course for them. Students come in with different backgrounds, interests, and goals -- all of which need to be taken into account in choosing a course of study.

Can I switch between P1116 and P1112 partway through the semester?

Yes. Every year several students start out in P1116, then switch to P1112 – and a smaller number switch in the opposite direction. We encourage students to attend both lectures (and try both homeworks) in order to rapidly make a decision. The sooner you make the switch the better. Homework and laboratory grades may be directly transferred. You should consult with your instructors to find out how exam grades will be dealt with.

Will I get a lower grade if I take P1116?

We actively try to set the grades so that if you keep up with the class, then you will not penalized for taking P1116. Occasionally students end up falling behind in P1116, and end up with grades that are lower than they would have received in P1112.

If I do poorly in P1116 should I take P2217?

If you receive a C+ or lower in P1116 we typically recommend that you follow up with P2213. If you do well in P2213 then you can once again consider if P2214 or P2218 is a better course for you.

All of our courses are challenging and engaging. You close no doors by taking the “majors” versions.

If I do very well in P1112 should I take P2217?

If after P1112 you feel that you are ready for a more intense physics experience, then by all means take P2217. We recommend that you talk with the instructor to get advice on making the transition.

How do I enroll for PHYS 1117?

PHYS 1117 is our “teaser course” which discusses some of the most exciting areas of physics at a level understandable by an incoming freshman.

It is aimed at physics students.

I have taken AP Physics or Higher Level IB physics. What courses do these count for?

Typically the best course of action for students who have taken AP or IB courses and are interested in pursuing a physics major is to enroll in P1116. This is an exciting and challenging course which gives a different perspective on mechanics than the one they have seen in AP or IB physics. Students who go this route will not receive any Cornell credit for their AP or IB physics courses.

Students who score a 4 or 5 on AP Physics C Mechanics may opt to receive credit for P1112.

Students who score a 5 on AP Physics 1 (2) may opt to receive credit for PHYS 1101 (1102).

Students who score a 5 on AP Physics 1(2), together with a 5 on AP Math BC may opt to receive credit for PHYS 2207 (2208).

Students who score a 6-7 on Higher Level IB Physics may opt to receive credit for P1112.

AP/IB Credit for P1112 should be used to enter P2213, and credit for P2213 should be used to enter P2214. An incoming student wishing to enter the honors stream should begin with P1116.

What are the recommended introductory mathematics courses for the major, and when should I take them?

The physics major is flexible, so you should talk to your advisor to find out which courses are best for you. There are three possible
mathematics sequences. Students have succeeded in physics with each set of courses.

For the majority of physics majors, the recommended course sequence is the one designed for engineers: Math 1910 - 1920 - 2930 - 2940. The chart on page 3 shows which math courses are prerequisites for which physics course.

One reason why the engineering sequence is often appropriate for physics majors is that it presents the material in the order that we use it. It also is very practical -- focussing on how to use the mathematics.

The engineering sequence typically involves fewer proofs than the other mathematics sequences.

Students may alternatively take the Arts and Science sequence Math 1120-2220-2210. This sequence covers fewer topics in slightly more depth -- for example, there will be slightly more discussion of abstract vector spaces in the linear algebra course. Proofs are discussed, but much of the emphasis is on applications. Typically students taking this sequence will complete the courses out of order, beginning Math 2220 before Math 2210.

Given that much of the material in the two sets of courses are so similar, the major difference between the Arts and Science sequence and the Engineering sequence is that there is no exact equivalent to Math 2930 (a course on differential equations, which is listed as a prerequisite for P2214/P2218). Although not an exact match, Math 3230 is a viable alternative to Math 2930. There is, however, nothing wrong with taking courses from the Arts and Science stream, and supplementing them with Math 2930.

Although not recommended, students who are particularly adept mathematically may be able to learn the necessary mathematics within their physics courses, skipping the prerequisite.

Students with a strong interest in abstract mathematics should consider taking Math 1220 - 2230 - 2240. These courses emphasize proofs and abstract reasoning rather than computational techniques. Students taking this route should be aware that they will be learning concepts in a slightly different order than others in their physics classes, and that they will not spend as much time learning practical techniques for using mathematics. These students should be prepared to learn mathematical techniques in their physics courses.

The honors mathematics sequence is certainly the hardest of the three, but for some students may be the most rewarding.

What are the recommended advanced mathematics courses for the major, and when should I take them?

We recommend that students wishing to take our most advanced physics classes enroll in AEP4210 and AEP4220 -- or an equivalent set of classes from the mathematics department on differential equations and complex analysis.

[Typical choice would involve MATH 3230, 4200, 4220, or 4180.] Beyond this, your exploration of mathematics should be driven by your interests.

What are the computer science requirements for the physics major?

One can complete the physics major without taking any computer science courses. However, students will find that they are well served by taking an introductory programming course. The typical suggestion is either CS 1112: Introduction to Computing using Matlab, or CS 1110: Introduction to Computing using Python. There are more specialized computer courses that may also be worth considering. For example, ASTR3340: Symbolic & Numerical Computing, PHYS 4480: Computational Physics, AEP 4380: Computational Engineering Physics, CS 3220: Scientific Computing, CS 3200: Engineering Computation, and MATH 4250/60 Numerical Analysis.

Students with prior programming experience may be able to take CS 1132 or 1133.

Both Matlab and Python are great languages for scientific computing.

Does a Cornell physics major have room in their schedule for courses other than physics and math?

Yes! One of the strengths of Cornell’s physics program is that it provides an excellent physics education as part of a more general liberal arts education.
Does the physics degree require me to take courses in any area other than physics and math?

Yes, in order to receive a BA from the college of Arts and Sciences you need to fulfill a number of requirements, including appropriate language and writing courses, a set nine distribution courses, and a breadth requirement. Four of the distribution courses would typically be satisfied by courses required for the physics major.

In choosing their course of study, students should keep in mind that a well-rounded science education involves learning about sciences beyond physics, and a well-rounded education involves learning about more than science. The distribution requirements of the College of Arts and Sciences help guide students towards taking a broad range of courses, but students should consider going beyond these requirements, and to explore broadly. Areas which may be of particular interest to students interested in a complete science education are Chemistry, Biology, and computer science.

Can I double major?

Yes, many students do double majors in physics and a second field. We encourage students to think carefully about such a decision. We feel that it often limits your possibilities without necessarily offering you much benefit. We encourage students to instead considering concentrating in their other field of interest if a coherent program can be devised.

If a student wishes to pursue a double major they should consult with advisors in both department. Any courses used to satisfy a requirement of another major may be used in satisfaction of the physics major only if the student is concentrating in physics.

As an Arts and Science student, may I take courses offered by the College of Engineering, or some other colleges?

Yes. You will however need at least 100 credits of Arts courses to receive a BA in physics.

Can I study abroad?

Yes. The caveat is that you will likely need to find an institution where you can take some physics courses while abroad. The physics curriculum is fairly standardized, so this is not typically too difficult.

Can I take graduate level courses?

Yes, every year we have about 5-6 undergraduate students (typically seniors) who opt to take graduate level courses in various fields. Their motivation vary. Keep in mind that if you choose to go to graduate school you will have ample opportunities to take graduate courses then. On the other hand, for some areas of study taking graduate courses earlier helps you become a productive researcher earlier.

The graduate physics courses that our undergraduate students took recently included PHYS 6562, 6572, 7645, 7651, 7652, 7680, 7683.

Can I get involved in research?

Yes! We find that almost all of our undergraduates work in a research lab sometime during their tenure at Cornell.

How do I get involved in research?

Most students find their research positions by knocking on doors. Expect to have some rejections, but rest assured that there is a position out there for you. If after knocking on six doors you are still having no luck, then talk with the director of undergraduate studies.

When can I start research?

Some students start research as early as their Freshman year. Some wait until as late as their Senior year. For most students, however, the ideal time to start research is during their Sophomore or Junior year.

Do I get paid for research? Do I get class credit?

Most students receive class credit for research conducted during the school year. It is fairly typical for students to be paid for research undertaken during the summer.

Can I do research at another institution?

Yes. Students often take advantage of an NSF sponsored program known as “Research Experience for Undergraduates” which provides paid summer research positions at various locations throughout the United States. These positions are only open to US citizens and resident aliens.
Can I get involved in teaching or tutoring?

Yes. There are several ways to get involved in teaching.

Those interested in a career in teaching should look into Cornell Teacher Education. Physics teachers are currently in short supply, and this is one way to make a difference.

The physics department has an “undergraduate teaching assistant” program, where undergraduates help out in our recitations. This is a great way to hone your physics knowledge while helping your peers. We offer these teachers the opportunity to take a course on “teaching and learning physics”.

The Learning Skills Center has a tutoring center, which hires undergraduate tutors.

The college of engineering hires undergraduate facilitators for their “Academic Excellence Workshop” courses.

If you wish to offer private tutoring, the physics department would be happy to add your name to a list we maintain.

The Society for Physics Students organizes a number of outreach events which give you the opportunity to help teach K-12 students. For example, one year they worked for an extended period with the Northern Lights Learning Center, a home-school network.

What is the difference between AEP and Physics, and how are they related?

In addition to having a Department of Physics within its College of Arts and Sciences, Cornell has a Department of Applied and Engineering Physics within its College of Engineering.

The Applied and Engineering Physics program is very similar to the Physics program. The main difference comes from the non-physics courses. Physics students are required to take a set of Distribution courses specified by the College of Arts and Sciences. Applied and Engineering Physics students instead must take the Engineering Common Curriculum. Typically the Physics student will have more flexibility in his/her program. On the other hand, some students prefer the more structured program in Applied and Engineering Physics.

Can I switch between the colleges?

Yes. If you are in good standing you may apply to change colleges.

What do Physics students do after they graduate?

About half our our students go to graduate school, the other half enter the workforce. Their job titles include: Engineer, Software Engineer, Consultant, Research Assistant, Lab Assistant, Assistant Researcher, Scientist, Analyst, Financial Analyst, Hydrologist, CAD Technician, Regional Sales Manager, Secondary School Teacher, and Assistant. They work in publishing, software, semiconductors, medical, aerospace, finance, government, and teaching. Not only are physicists in demand, but among people whose highest degree is a Bachelor, they are the sixth-highest-earning group of graduates. [Median salary of $98,800 after at least 10 years in the workforce.]

Are there co-op or internship programs for Physics students?

The College of Arts and Sciences at Cornell does not have a formal co-op program. Many students find research experiences during the summer. Others find internships or summer jobs through Cornell’s excellent offices of career services. Physics students are encouraged to use all three career services offices:

http://as.cornell.edu/academics/careers
http://www.career.cornell.edu/
http://www.engineering.cornell.edu/resources/career_services/index.cfm
A bicycle travels a distance \( D \) up a gentle hill at steady speed \( v_1 \) and then continues down the other side of the hill the same distance \( D \) at steady speed \( v_2 \). Derive an algebraic expression for the bicycle's average speed \( v_{av} \) for the entire trip in terms of \( v_1 \) and \( v_2 \). Please simplify your expression if possible. Does \( v_{av} \) depend on the distance \( D \)? [HINT: The answer is not \( (v_1 + v_2)/2 \).]

A baseball is given an initial velocity with magnitude \( v_0 \) at an angle \( \theta \) above the surface of an incline, which is in turn inclined an an angle \( \phi \) above the horizontal. (a) Calculate the distance, measured along the incline, from the launch point to where the baseball strikes the incline. (b) What angle gives the maximum range?

The International Space Station (ISS) orbits the Earth in an approximately circular orbit at a height of about 240 miles (384 km) above the Earth's surface. What is the speed of the space station in its orbit (in km/s)? What is the space station's orbital period (in hours)?

A passenger with mass 85 kg rides in a Ferris wheel in which the seats travel in a circle of radius 35 m. The Ferris wheel rotates at constant speed, and makes one complete revolution every 25 s. Calculate the magnitude and direction of the net force exerted on the passenger by the seat when she is (a) one-quarter revolution past her lowest point and (b) one-quarter revolution past her highest point.

A car's maximum acceleration when speeding up is \( a \), and can brake at a maximum deceleration \( d \). What is the minimum time that it will take the car to traverse a distance \( L \), given that it must start AND end at rest?

You are standing on the top of a hill whose downward slope makes an angle \( \theta \) with the horizontal. Ignoring air resistance, at what angle should you throw a rock such that it travels the maximum horizontal distance away from you before hitting the slope?

Consider two planets in space with mass \( M \) and \( m \), which orbit in a circular manner around each other with a period \( T \). The planets experience an attractive force between each other of magnitude \( F \). What is the distance \( D \) between the planets, in terms of \( M \), \( m \), \( F \), and \( T \)?

A circular loop of rope of length \( L \) and mass \( M \) sits on a frictionless table. The loop is spun around its center with an angular velocity \( \omega \). Find the tension in the rope.

Style of problems, and timing of syllabus may vary by instructor.
Advice From Past Students

*If* you can handle them, take the advanced versions of the upper level courses (Analytical Mechanics over Intermediate Mechanics; Advanced E&M over Intermediate E&M, etc.). You learn so much more that it's more than worth the extra effort.

*Melisa Sologuren*

Keep in mind that if you take grad level classes at Cornell, you may be retaking them at grad school. *If* you really like Particle Physics, go ahead and take 646, but if you have ANY interest in taking a non-physics class, do that first! Chances are, you won't ever be able to again. How many schools offer Introduction to Wines? or Roman Experience? Or culinary classes? *I* assure you that the grad school you choose will have particle physics classes

*Andrew Long*

Take advantage of the incredible resources that Cornell has to offer while you're still there. Register for spring classes that aren't necessarily related to what you think you'll be doing in grad school, or in a future career. One of the best professors *I* had at Cornell taught a class on Shakespeare that *I* took my second semester senior year.

*Michael Hartinger*
Beyond Coursework

Throughout your undergraduate career (even before becoming a physics major) there are many ways to be involved with Cornell Physics Department: join the Society for Physics Students; conduct scientific research in a world-class laboratory; help teach your peers; and get involved with community outreach.

Society for Physics Students

The Society of Physics Students is a professional association explicitly designed for students. Membership, through collegiate chapters, is open to anyone interested in physics. The only requirement for membership is that you be interested in physics. Besides physics majors, SPS members include majors in chemistry, computer science, engineering, geology, mathematics, medicine, and other fields.

Cornell’s society for physics students is currently revamping its web site. The SPS lounge is in Rockefeller B2, and it runs a list-serv. More information: [http://pages.physics.cornell.edu/sps](http://pages.physics.cornell.edu/sps)

Research

Most Cornell physics majors participate in research at some point in their undergraduate career -- some even as freshmen. This could be as a paid/unpaid position during the school year or over the summer. Often students will get course credit for their efforts.

Most students find their research positions by approaching faculty members: nearly all labs have undergraduates working in them. Some positions are posted at [http://www.physics.cornell.edu/resources/research-outreach-and-teaching-opportunities/](http://www.physics.cornell.edu/resources/research-outreach-and-teaching-opportunities/) and [http://as.cornell.edu/research](http://as.cornell.edu/research)

Students often also take advantage of nationally advertised Research Experience for Undergraduate (REU) programs which gives them further breadth by allowing them to conduct research during the summer at other institutions.

Teaching

As part of the Physics Teachers Education Coalition (PhysTEC), Cornell runs a program where undergraduate learning assistants work with graduate student teaching assistants to help facilitate recitation sections for introductory physics courses. For more information on this program, contact Professor Rob Thorne -- ret6@cornell.edu.

Outreach

Members of the Cornell physics department feel strongly about the importance of science literacy and sharing our knowledge with those outside of our community. We do this through programs aimed at K-12 students, K-12 teachers, and the general community.

Undergraduate students are encouraged to get involved in these rewarding activities. Outreach is organized by the society for physics students, individual faculty members, and several major centers. Of particular note are the programs of the education programs of the Cornell Center for Material Science [http://www.ccmr.cornell.edu/education/] and the Laboratory for Elementary Particle Physics [http://www.lns.cornell.edu/Education/].