

THE PHYSICS AND CHEM/PHYS CONCENTRATIONS

2016–2017 version

Physicists at Harvard are engaged in the quantitative study of the way the world works, from its beginnings in the earliest moments of the big bang, to the strange properties of light and matter in extreme conditions, to the bizarre relativistic and quantum mechanical regime of the world's tiniest objects. Physicists use their quantitative understanding to build tools that regularly transform our everyday life, and that are also central not only to the study of physics itself, but to all other sciences.

The Harvard Physics Department has a large and very active undergraduate program, graduating roughly 50 concentrators each year (including those in the Chemistry and Physics concentration, also administered by the department). The hallmark of the undergraduate program is its flexibility, as roughly 40 percent of Harvard physics graduates go on to graduate school in physics or a closely related field; the rest pursue a wide range of careers including medical school and law school, as well as immediate employment in technology, software, teaching, finance, and consulting.

Concentrators are required to take a reasonably small number of courses, and the core courses are given in both semesters. This makes the concentration very flexible, and many students choose joint concentrations such as Physics-Mathematics, Physics-Astronomy, and Physics-History of Science, in addition to the special Chemistry and Physics concentration. Additional flexibility is provided by the Physics options in Biophysics, Applied Physics, and Teaching. The faculty are enthusiastic about both undergraduate students and physics. Almost all faculty teach in the undergraduate program, although not every year. They take pride in their teaching and continually develop new materials and courses.

Many undergraduates participate in research through the Physics 90r course which allows course credit for research supervised by faculty members. The department also supports a number of students doing independent research during the summer. Although no thesis is required for the concentration, undergraduate research is strongly encouraged, and virtually all of the experimentalist faculty have undergraduates working in their labs.

The department establishes a community of physics students. The active Society of Physics Students (SPS) chapter organizes a “buddy” system that teams first-year students with upper division concentrators, produces a booklet of advice for new concentrators, has weekly meetings, and organizes numerous events for students and professors. There are many other opportunities for faculty-student interactions, both formal and informal. These activities include study nights, lunches, dinners, and weekly presentations by faculty of their research. The famous “puppet show,” where second-year graduate students “roast” the faculty members, draws several hundred spectators each year. Harvard is one of the leading producers of physics graduates at the bachelors level in the nation, and our undergraduates take pride in belonging to a lively, close-knit community. All students interested in physics (official concentrators or otherwise) should sign on to the SPS mailing list at www.hcs.harvard.edu/physics/ mailing-lists to receive information on the many departmental events.

The Head Tutor (Howard Georgi) and Associate Head Tutor (David Morin) are always eager to talk to students about the Physics and Chem/Phys concentrations. Concentrators are also given an additional faculty advisor who acts as a mentor.

This packet contains:

- An explanation of the requirements for the Honors Physics, Basic Physics, and Chemistry & Physics concentrations.
- A set of sample programs for the various concentrations.
- A list of frequently asked questions.
- Information on the concentration meetings/signup procedure.

Please visit the undergraduate page on the Physics Department's website for more information: www.physics.harvard.edu/academics/undergrad.

REQUIREMENTS

Honors Physics Requirements (13-15 courses)	Comments
<p><i>Four intro physics</i> 15a or 16 (mechanics) 15b or 153 (E&M) 15c or sub (waves, optics) 143a (quantum)</p> <p><i>Four advanced physics</i> Three 100-level courses (any) 191r (lab)</p> <p><i>Four math</i> Two at 21, 23, 25, 55 level Two at 100 level</p> <p><i>One related</i> See Handbook for list.</p>	<p>15a/b/c and 143a taught both terms. Concentrators roughly split between 15a and 16.</p> <p>Common 100-level courses are 143b, 153, 181. 191r taught both terms. See Handbook for courses that count as “Physics.”</p> <p>If taken, 1a and 1b are additional (thus the “13-15”). Applied Math and some Stats courses count too.</p> <p>Generally, any math or science course counts. CS 50 is common.</p>

Basic Physics Requirements (12 courses)	Comments
<p><i>Four intro physics</i> 15a or 16 (mechanics) 15b or 153 (E&M) 15c or sub (waves, optics) 143a (quantum)</p> <p><i>Two advanced physics</i> Any 100 level</p> <p><i>Math through 21b</i> 21a 21b</p> <p><i>Related courses to total 12</i> See Handbook for list.</p>	<p>15a/b/c and 143a taught both terms. Concentrators roughly split between 15a and 16.</p> <p>Common 100-level courses are 143b, 153, 181. See Handbook for courses that count as “Physics.”</p> <p>If taken, 1b counts toward the 12 courses.</p> <p>Generally, any math or science course counts.</p>

Chem/Phys Requirements (13-16 courses)	Comments
<p><i>Three intro physics</i> 15a or 16 (mechanics) 15b or 153 (E&M) 15c or sub (waves, optics)</p>	<p>15a/b/c taught both terms. Concentrators roughly split between 15a and 16.</p>
<p><i>Quantum mechanics</i> Phys 143a or Chem 160</p>	<p>143a taught both terms.</p>
<p><i>Statistical mechanics</i> Chem 60, 161, Phys 181, or ES 181</p>	<p>161 or 181 or 181 recommended</p>
<p><i>General chemistry</i> LS 1a and PS 1.</p>	<p>Can be placed out of. If taken, see item 5b in the Handbook for details on the counting.</p>
<p><i>Organic chemistry</i> 17 and 27, or 20 and 30</p>	<p>20,30 recommended, except 17,27 for med school.</p>
<p><i>Inorganic chemistry</i> 40 or a 150's</p>	
<p><i>Math through 21b</i> 21a 21b</p>	<p>If taken, 1a and 1b are additional, but see item 5b in the Handbook for details.</p>
<p><i>Related courses to total 13-16</i></p>	<p>See item 5b in the Handbook for "13-16" details.</p>
<p><i>Four courses in each dept</i></p>	<p>At the end of the day, students must take at least four Physics courses and four Chemistry courses.</p>

SAMPLE PROGRAMS

The following is an example of an **Honors Physics** plan of study satisfying the minimum requirements (13 courses).

Courses

Phys 15a
 Phys 15b
 Phys 15c
 Phys 143a

 Phys 143b
 Phys 125
 Phys 181
 Phys 191r

 Math 21a
 Math 21b
 AM 104
 AM 105

 CS 50

Schedule

Phys 15a Math 21a	Phys 15b Math 21b
Phys 15c AM 104	Phys 143a AM 105
Phys 143b CS 50	Phys 125
Phys 191r	Phys 181

The following is an example of an **Honors Physics** plan of study, starting with Math 1b, satisfying the minimum requirements (14 courses).

Courses

Phys 15a
 Phys 15b
 Phys 15c
 Phys 143a

 Phys 125
 Phys 181
 Phys 143b
 Phys 191r

 Math 1b
 Math 21a
 Math 21b
 Math 113
 Math 122

 Life Sciences 1a

Schedule

LS 1a Math 1b	Phys 15a Math 21a
Phys 15b Math 21b	Phys 15c Math 113
Phys 143a Math 122	Phys 125 Phys 181
Phys 143b	Phys 191r

The following is an example of an **Honors Physics** plan of study, starting with Math 1a, satisfying the minimum requirements (15 courses). Note that it is very much possible to satisfy the Honors Physics requirements by starting the 15 sequence in your sophomore year. If, however, your goal is to attend physics grad school, it is of course harder to squeeze in additional physics courses with this late start.

Courses

Schedule

Phys 15a
 Phys 15b
 Phys 15c
 Phys 143a

 Phys 143b
 Phys 151
 Phys 181
 Phys 191r

 Math 1a
 Math 1b
 Math 21a
 Math 21b
 AM 104
 AM 105

 Life Sciences 1a

LS 1a	
Math 1a	Math 1b
Phys 15a	Phys 15b
Math 21a	Math 21b
Phys 15c	Phys 143a
AM 104	AM 105
Phys 143b	Phys 181
Phys 151	Phys 191r

The following is an example of an actual **Honors Physics** plan of study that entailed 18 courses. The student went on to grad school in physics.

Courses

Schedule

Phys 16
 Phys 15b
 Phys 15c
 Phys 143a

 Phys 151
 Phys 143b
 Phys 125
 Phys 167
 Phys 181
 Phys 191r
 Phys 210
 Phys 145

 Math 23a
 Math 23b
 AM 104
 AM 105

 CS 50
 ES 109

Phys 16	Phys 15b
Math 23a	Math 23b
Phys 15c	Phys 143a
AM 104	AM 105
Phys 151	
Phys 143b	Phys 167
Phys 125	Phys 181
Phys 191r	ES 109
Phys 210	Phys 145
CS 50	

The following is an example of a **Basic Physics** plan of study, starting with Math 1b, satisfying the minimum requirements (12 courses).

Courses

Schedule

Phys 15a
 Phys 15b
 Phys 15c
 Phys 143a
 Phys 125
 Phys 181
 Math 1b
 Math 21a
 Math 21b
 Astro 16
 Chem 17
 CS 50

Math 1b	Phys 15a Math 21a
Phys 15b Math 21b	Phys 15c
Phys 143a	Phys 125 Astro 16
Chem 17 CS 50	Phys 181

The following is an example of a **Chem/Phys** plan of study, starting with Chem 20 and Math 21a, satisfying the minimum requirements (13 courses).

Courses

Schedule

Phys 15a
 Phys 15b
 Phys 15c
 Phys 143a
 Chem 161
 Chem 20
 Chem 30
 Chem 40
 Math 21a
 Math 21b
 Chem 135
 Stat 110
 CS 50

Phys 15a Math 21a	Chem 20 Math 21b
Phys 15b Chem 30	Phys 15c Chem 40
Phys 143a Stat 110	Chem 135
CS 50	Chem 161

The following is an example of a **Chem/Phys** plan of study, starting with Life Sciences 1a and Math 1a, satisfying the minimum requirements (16 courses).

Courses

Schedule

Phys 15a
 Phys 15b
 Phys 15c

 Phys 143a

 Chem 161

 LS 1a
 PS 1

 Chem 20
 Chem 30

 Chem 40

 Math 1a
 Math 1b
 Math 21a
 Math 21b

 CS 50
 Physics 125

LS 1a	PS 1
Math 1a	Math 1b
Phys 15a	Chem 20
Math 21a	Math 21b
Phys 15b	Phys 15c
Chem 30	Chem 40
Phys 143a	Chem 161
CS 50	Physics 125

The following is an example of an actual **Chem/Phys** plan of study that entailed 17 courses. The student went on to grad school in chemistry.

Courses

Schedule

Phys 15a
 Phys 15b
 Phys 15c

 Phys 143a

 Chem 161

 Chem 20
 Chem 30

 Chem 15 (≈ 40)

 Math 21a
 Math 21b

 Chem 105
 Chem 135
 Chem 206
 Chem 27
 Chem 98r
 Chem 99r
 Chem 215

Chem 15	Phys 15a
Math 21a	Chem 20
Phys 15b	Phys 15c
Chem 30	Math 21b
	Chem 105
	Chem 135
Phys 143a	Chem 161
Chem 206	Chem 27
	Chem 98r
Chem 99r	
Chem 215	

FREQUENTLY ASKED QUESTIONS

1. How many concentrators are there per year?

There are roughly 35 Physics and 15 Chem/Phys concentrators per year. Of the 35 Physics concentrators, about 80% do the honors track.

2. What does the requirement of “13–15” courses listed in the Handbook for the Honors Physics concentration mean?

It means 13 if you don't take Math 1a or 1b; 14 if you take 1b; and 15 if you take both 1a and 1b. Similarly the “13–16” courses for Chem/Phys is explained in item 5b in the Handbook.

3. Are there different “options” within the Physics concentration?

Yes. In addition to the standard Honors Physics route, there are three other honors options: “Biophysics,” “Applied Physics,” and “Physics and Teaching.” The Registrar doesn't distinguish among these; it recognizes all of them simply as Honors Physics concentrations. The distinction is only an internal one in the Physics Dept, where we verify that you have satisfied the requirements of the relevant option, as listed in the Handbook.

4. Is there a required tutorial?

No. But an optional tutorial-style class is Physics 95, which involves weekly (Wed night) seminars by all of the physics professors.

5. Is there a common set of courses every Physics concentrator takes?

The courses taken during freshman and sophomore years look roughly the same for most students (15a or 16, 15b, 15c, 143a). In contrast, however, probably no two students take the same set of courses in their junior and senior years.

6. Can I take Physical Sciences 12a/b instead of Physics 15a/b?

Yes, but meet with Howard Georgi or David Morin to develop a coherent plan of study.

7. Can I substitute higher-level courses for 15b and 15c?

Yes, with the permission of Howard Georgi or David Morin. However, the 15b and 15c labs must still be completed (on a pass/fail basis). See David Morin if you are planning on skipping 15b and/or 15c.

8. Which courses count as “Physics” and “related”?

These are listed in the Handbook in the Physics section. The “cross listing” of courses in the course catalog is for the most part meaningless.

9. Which 100-level math courses should I take?

If you are a Physics concentrator who likes math for math's sake (that is, you're not worried about acquiring the math tools to do physics), then you will probably want to take courses in the Math Department. Common courses are 113, 115, 122, and 131. If, on the other hand, your goal is to pick up the necessary math tools for physics, then Applied Math 104/105 are probably the right courses for you. Stat 110 is also commonly taken.

If you fall into the first of the above categories, it is very easy to do a joint concentration with math, with no extra courses needed (as long as math is listed second). Just distribute three math courses in the 110's, 120's, and 130's. The third of these counts as the last "related" course for the Honors Physics requirements.

10. Can I take graduate courses as an undergraduate?

Yes, but some are much better for undergrads to take than others. Make sure you talk to us before you spend too much time planning.

11. How many concentration courses should I take if I plan on going to physics grad school?

You should take more than the minimum requirement of 13-15 courses. It is impossible to say exactly how many, but try to aim for somewhere around 17 or 18. It is also helpful to throw in a grad course or two, but not necessary. And although they aren't required for the concentration, Physics 181 and 143b are essential for grad school, and 153 is highly recommended.

12. How do I get involved in lab research?

This is very easy to do. Just look through the faculty webpage and see whose work interests you, and then send out emails and/or knock on doors. You can do research for pay in the summer, and/or for pay *or* credit (via a Physics 90r course) in the academic year. It is generally very difficult to find a theoretical project, but the opportunities for experimental projects are essentially endless. If you are planning on going to grad school, lab experience is a must.

13. Is a thesis required?

No. Although we strongly encourage you to do research in a lab, we don't require you to write up your results in a thesis. But if you are eager to collect all of your results and put them in a nice polished form and practice your scientific writing, then by all means write a thesis. Roughly five concentrators each year write one.

14. How can I get a Physics Master's through the AB/AM program?

If you have Advanced Standing, you have the option of earning a Physics Master's degree in your fourth year. However, the requirements for this are *very* demanding, and only a couple students do it each year. But a few Physics concentrators get a Master's in another field. Also, a few Chem/Phys concentrators get a Chemistry Masters. If you are thinking about pursuing a Physics Master's, you should talk this over very carefully with Howard Georgi or David Morin sometime during your sophomore year.

Note that if you plan on going to grad school and eventually getting a Physics PhD, there isn't much to be gained by getting a Physics Master's now. Instead, you will probably find it far more pleasant to take a few grad courses, but not the extra couple that are needed for the Master's and which might make you miserable with an oppressively heavy course load.

15. How do I sign up to be a Physics or Chem/Phys concentrator?

See the last page of this packet for the signup procedure.

16. How does the Physics and Chem/Phys advising system work?

All Physics and Chem/Phys concentrators have Howard Georgi (Head Tutor) and David Morin (Associate Head Tutor) as advisors. Additionally, you pick one more faculty advisor to serve as your mentor. Carol Davis is the Student Coordinator who handles many administrative items and social events, etc. Chem/Phys concentrators should also make a point of getting to know Gregg Tucci (Head Tutor in Chemistry).

17. How are announcements/information sent to Physics and Chem/Phys concentrators?

Although we have a concentrator email list, virtually all of our announcements are sent via the Society of Physics Students email lists. All Physics and Chem/Phys concentrators (and also any interested freshmen) should therefore sign up for *both* the SPS list and the SPS-open list at:

<https://lists.hcs.harvard.edu/mailman/listinfo/sps-list>
<https://lists.hcs.harvard.edu/mailman/listinfo/sps-open>

18. What do Physics and Chem/Phys students do after they graduate?

About 40% go to graduate school. Of the rest, a handful enter into each of: med school, law school, technology, software, teaching, finance, and consulting. The remainder do a very wide variety of things (start a business, play in a rock band, etc). Many employers like to hire physicists because they think we're smart. It's a good bet to hire someone with strong quantitative skills who can then learn the specifics of the job as they go along.

19. Are there any regular weekly events that physics undergraduates can participate in?

Indeed there are:

- Monday lunches with the colloquium speaker.
- Monday colloquium, with tea and cookies beforehand.
- Wednesday evening seminars.
- Wednesday night homework session in the Leverett dining hall.
- Various other events (monkeybread, cookouts, etc.). And new ideas from students are always welcome. For example, the Monday lunches with the colloquium speaker came into existence simply because a student wanted them to happen.

CONCENTRATION SIGNUP

Students are not required to sign up for a concentration until the fall semester of their sophomore year. However, this certainly doesn't preclude you from signing up for a concentration during the spring of your freshman year, if you are reasonably sure about what you want to do. You simply have the choice between signing up freshman spring or sophomore fall.

For students who sign up as sophomores, David Morin will send an email in mid October to the SPS list with information on the signup procedure. In short, the procedure involves a 20-minute meeting to go over your plan of study, talk about the concentration, and take care of a few other logistics. It's a fairly harmless procedure. But a few things you will need to do beforehand are:

- Fill out the Registrar's online Plan of Study tool on my.harvard, and then print it out and bring it to the meeting with David Morin. Take a look at the concentration requirements listed in the online Handbook, and think about what courses you want to take to satisfy the requirements. This is your "Plan of Study," but note that it is by no means written in stone.
- Think about whom you want as your faculty advisor. Everyone has Howard Georgi and David Morin automatically, but we also give you another faculty member. Make a list of a few possibilities, in case your first choice is overbooked. You can peruse the list of Physics faculty on the Physics Department webpage. You should have **three names in mind** when you meet with David Morin.

For more information, see the "FAQs for Concentrators" link in the left sidebar on the Physics webpage: www.physics.harvard.edu/academics/undergrad.