

# Advice for Physics Majors (& potential majors)

updated 10/24/2018

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## ADVICE FOR FIRST YEAR STUDENTS CONSIDERING A MAJOR IN PHYSICS or ENGINEERING PHYSICS

1. The Department of Physics tries to keep the first year course requirements the same for all of our degree programs. With a couple of exceptions noted below, first year students don't have to worry about which of our degree programs they might eventually pursue.
2. To stay on track for a major in physics, students should take the courses described below during their first and/or second semesters at CWRU.
  - MATH 121 & 122. If you already have credit for one or both of these, you can either continue taking the other math courses (*MATH 223 & MATH 224*) needed for a major in physics or take another course you find interesting, perhaps in a subject you are considering for a second or alternate major or a minor. The same advice applies if you have credit for the courses described below.
  - PHYS 121 & PHYS 122.
  - CHEM 105 & 106 or CHEM 111 & ENGR 145. CHEM 105/106 is the 'normal' chemistry sequence for BA/BS physics majors but, if there is any possibility that you might pursue a major in engineering, including engineering physics, you should instead take CHEM 111 & ENGR 145 since this is required by the Case School of Engineering and accepted for all other physics degree programs.
  - ENGR 131 or EECS 132. Most physics majors take the ENGR 131 MATLAB-based computer programming course either their first or second semester at CWRU. However, if there is any chance that you will pursue a major or minor in computer science or computer engineering or an engineering physics major with a concentration in computer science or computer engineering, you should instead take the JAVA-based EECS 132 course, since this required for some of those programs and accepted for physics degrees.
  - All first year students at CWRU take a SAGES First Seminar in the fall. You might find it advantageous to choose a first seminar in the symbolic or social world categories so that you can later take a University Seminar in the Natural World category. This will give you a broader choice of Natural World University Seminars that include more depth than is typical in First Seminars.
  - PHYS 166, Physics Today and Tomorrow is a popular 1 credit course pass/no pass course designed to give first year students a sense of what physicists actually do with their physics training. It has a very different purpose from PHYS 121/122/123/124. A fall offering of PHYS 166 is limited to first year students; a spring offering is open to all CWRU students. PHYS 166 is not required for physics majors but it should be interesting to them!

3. Don't worry if you must delay taking some of the courses described above; for example, delaying the start of introductory physics until you have completed MATH 121. It is possible to catch up in your sophomore year. However, you might be better advised to catch up by taking summer courses rather than face a challenging sophomore year.
4. If you are invited to take the enhanced versions of the introductory mathematics and physics courses, you should seriously consider accepting the invitation - but note that these enhanced courses are NOT required.
  - Be particularly careful about taking MATH 227 in place of MATH 223 in the fall of your freshman year. It is fine to start out in MATH 227 but do not hesitate to switch to MATH 223 or some other course or simply withdraw from MATH 227 if you find yourself in over your head.
  - It is natural for potential physics majors to prefer the enhanced version of introductory physics, PHYS 123/124, over PHYS 121/122. However, potential physics majors do not need to take PHYS 123/124 and they are not necessarily a better choice. Historically, only about half of our majors have taken the enhanced version of introductory physics. The others either took PHYS 121/122 or used their AP credit to skip the first semester of physics altogether.
  - If your score on the MATH SAT is less than 700 or if you didn't have a good high school physics course, you will likely struggle in PHYS 123/124 and be better off in PHYS 121/122. PHYS 123/124 are designed to appeal to and challenge students who have a deep interest in physics, but PHYS 121/122 will cover everything you need to know in order to succeed as a physics major at CWRU.
5. First year student's official academic advisor is initially your SAGES First Seminar instructor but it is not reasonable to expect that person or your CWRU Navigator to be expert in every discipline. If you are considering a major in physics, you are strongly encouraged to contact someone in the Department of Physics with questions about the major, our degree programs, course offerings or anything else. Almost any physics instructor can offer good advice but the best people to contact are our official "*academic representatives*":
  - Prof. Chottiner [gary.chottiner@case.edu](mailto:gary.chottiner@case.edu) for general BS & BA degree programs.
  - Prof. Martens [michael.martens@case.edu](mailto:michael.martens@case.edu) for the Engineering Physics degree program.
  - Prof. Mathur [mxm7@case.edu](mailto:mxm7@case.edu) for the Mathematics & Physics degree program and the Mathematics Concentration in Physics
  - Prof. Michael Hinczewski [mxh605@case.edu](mailto:mxh605@case.edu) for the Biophysics Concentration. We don't have an official academic representative for this program but Prof. Hinczewski is the academic advisor for new students choosing this program.
6. Declare your major in physics as early as allowed, probably in November of your first year. You will then be assigned an expert academic advisor and you will be added to the department contact list for information about research opportunities, special talks, plans for course offerings, *etc.* It's very easy to drop a major if you later change your mind. If you are considering multiple majors and minors, declare them all!

7. Don't agonize too much about which type of physics major you should pursue. Although the various types of physics major are designed to facilitate certain career directions (e.g., *the biophysics concentration includes room for all the courses needed to apply to medical school*), it is possible, with careful choices of technical electives, to pursue any type of physics career with any of the different majors in physics.

### **GENERAL ADVICE for MAJORS**

1. Do not rely on your departmental academic advisor to know all the university's rules and to always provide flawless advice. It's your life and it's your responsibility to manage your academic responsibilities properly.
  - a. Feel free to ask for second opinions from other department faculty; the department's Academic Representatives are good starting points. (*Prof. Martens for Engineering Physics, Prof. Mathur for our two MATH/PHYS programs, and Prof. Chottiner for BA and general BS programs.*)
  - b. Be wary of acting on advice from other students. It's certainly useful to know what other physics majors have done but there have been several cases in the past in which the advice of other students was flawed and led to unfortunate consequences.
  - c. The experts on general university policies and special requests are the CWRU Navigators and deans in the Office of Undergraduate Studies. These people are normally better at this compared to most faculty advisors. You should make an appointment with your Navigator if you have doubts about any academic policy (*or concerns about personal issues*). See <https://case.edu/studentsuccess/navigators> .
  - d. Official university policies are detailed in the General Bulletin, which you can find online at <http://bulletin.case.edu/>. If someone tells you something that conflicts with what you read in the Bulletin, that person is probably wrong.
  - e. One of the benefits of studying at an institution like CWRU is that it's relatively simple to make *reasonable* exceptions to formal policies. Most special situations call for you to submit one of the forms posted at <http://www.case.edu/ugstudies/forms/> . The form most often needed by physics majors is the Academic Advisement Report Substitution Form [https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2018-08/Academic%20Advisement%20Report\\_0.pdf](https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2018-08/Academic%20Advisement%20Report_0.pdf). Your advisor's signature on this form lets you make sensible adjustments to the requirements specified by the Department of Physics in any of our degree programs. Adjustments to college, Case School of Engineering or university requirements require approval from curriculum committees or academic leadership in those areas.
2. This document has been revised to reflect changes instituted for the entering class of fall 2018. If you started at CWRU before fall 2018, you should refer to the General Bulletin in effect for your entering class to see the degree requirements that apply for you. See <http://bulletin.case.edu/bulletinarchives/>. Your SIS Academic Report should show the proper degree requirements. Students may switch to a more recent "General Bulletin year" but then must follow all the rules in place for that year. It's often more convenient

to seek approval for individual exceptions, using the Advisement Correction Form described above.

3. The descriptions of our various degree programs posted at <http://physics.case.edu/undergraduate-programs/undergrad-degree-programs/> include a typical schedule that shows in which semester each course is normally taken. There is some flexibility in this schedule but you should generally not take physics courses out of order without first carefully checking out whether this might lead to problems. Do not rely on course prerequisites as proof that you can take some arbitrary course, particularly 300-level and graduate courses; it is impractical to list all possible prerequisites and expectations for every course. For example, we expect that all junior physics majors will have completed MATH 224, differential equations, but we don't list MATH 224 as a prereq for 300-level physics courses. If you plan to do something out of the ordinary, consult with the instructor for the course you plan to take to make certain that you have the appropriate background.
4. Take PHYS 166. This 1 credit pass/no pass course provides an introduction to exciting new physics and an exposure to several fields of activity for professional physicists.
5. We don't offer all of our upper level physics courses every year, so try to plan at least two years ahead. For example, we generally haven't been able to offer both PHYS 350, Methods of Mathematical Physics II, and PHYS 365, General Relativity, in the same year recently. We often poll our majors to ask which is of greater interest. This is done even though PHYS 350 is required for some of our degree programs. The good news is that, if you are in one of these degree programs, your advisor is authorized to sign off on replacing PHYS 350 with PHYS 365. We WILL make certain that physics courses needed for our majors to graduate will be available.
6. If you want to check whether a course is likely to be offered at some point in the future, consult the Director of Undergraduate Studies, G. Chottiner, or, for graduate courses, the Director of Graduate Studies, Prof. Covault. Note, however, that it's actually the department chair who decides what will be taught and who will teach it. It is often difficult to settle teaching assignments more than a few months in advance, since we don't know who will be on sabbatical, a special assignment, or joining or leaving the department on a longer time scale. However, if there is enough demand for a certain course, we will go out of our way to accommodate our majors, so don't be shy about asking.
7. **DOUBLE MAJOR WARNING!** Students pursuing a single degree (in physics) should not run into time conflicts in scheduling required courses. However, it is quite common for CWRU students to pursue multiple degrees and it is impossible to avoid time conflicts between advanced courses in every department. Students pursuing or interested in more than one major should work out their anticipated schedules in advance for each semester until graduation, checking carefully for time conflicts so that you can take certain courses a year earlier or later than you otherwise might. You can request that a department shift the scheduled time of a course but they are not obligated to make a change and generally won't. Changing a class time might not be too difficult for courses that enroll 5 – 10 students if you make the request long before students start enrolling. Shifting the time of a larger course can be problematic, as is shifting the time once students have enrolled.

Departments are required to submit their course schedules 4 – 8 months before the start of each semester (*4 months for the spring semester and 8 months for the fall semester*).

8. The University gives students and faculty a great deal of freedom to make sensible changes to an individual student's degree requirements, at least for courses within the major. If you would like to make a course substitution in your degree, consult with your academic advisor. Note, however, that we only directly control the physics course requirements in your degree. Other types of requests might have to go to other departments or, for General Education Requirements, to the College's curriculum committee. This is a more complex process. You should expect that requests to be excused from SAGES and other GER requirements, or PHED, will be turned down unless you have a compelling reason. Wanting to graduate at the end of the semester isn't a compelling reason to the faculty committees that make these decisions. Every year there are several students taking PHED courses during the summer so that they can earn their degrees!
9. The department faculty listens carefully to the concerns of our students. Our majors have representatives on the department's Undergraduate Curriculum Committee and this provides students with a mechanism to raise general issues about our programs. You are also welcome as individuals to contact the department chair and/or academic representatives with constructive criticism and suggestions. Many improvements in our programs arose from student suggestions.
10. The wide world of physics is reflected in the many degree programs and tracks we offer. These are designed to satisfy the large variety of interests of undergraduate students, but any of these programs can prepare a student to pursue any career or physics graduate program. For example, someone pursuing a major in engineering physics could easily go on to study particle/astrophysics theory or biophysics. The key is to use your open electives wisely. Detailed advice about some of our degree programs is provided below.
11. Starting in the fall of 2011, the Case School of Engineering and the Department of Electrical Engineering and Computer Science modified their introductory computer programming offerings. Previously, CSE students and physics majors were required to take ENGR 131, Elementary Computer Programming, which was taught using Java. ENGR 131 is now taught using MatLab. CSE students interested in computer science are required to instead take EECS 132, Introduction to Programming in Java. The physics department accepts either course for our BA and BS majors but the paperwork to formalize this only applies to students who started at Case in or after fall 2015. This should not be a problem for more senior students who took ENGR 131 but students who took EECS 132 may have to file an Academic Advisement Report Substitution Form [https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2018-08/Academic%20Advisement%20Report\\_0.pdf](https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2018-08/Academic%20Advisement%20Report_0.pdf).
12. The department's Undergraduate Curriculum Committee has developed a one page 'Advising Checklist' for use by students and their academic advisors. This checklist, which can be found at the end of this document, briefly summarizes important advising/advisee tasks that should occur each semester during a student's time at CWRU.
13. Students sometimes ask their academic advisors for suggestions of courses to take as open electives. This is a difficult question since the open electives are meant as an

opportunity for you to explore and discover interests that might not have any obvious connection to physics. You might find stimulating courses in the humanities, performing arts, social sciences and business school that you enjoy as much as any physics courses and you might discover connections to physics that you never expected. However, we have compiled a list of courses that do have some obvious connection to the study of physics and posted it at [ElectiveCourses.pdf](#). In several cases, instructors of these courses have contacted our department and specifically requested that we advertise their course to our majors.

14. Seniors often encounter problems with how SIS counts our two semester senior capstone and three semester departmental seminar courses. The SIS Academic Requirements page may not include that credit until the end of the final semester, suggesting that the student will fall short of graduation requirements. Don't worry if this happens to you.

### **BACHELOR OF ARTS**

15. Many CWRU students think of the B.A. as somehow less desirable than our other degree programs. The B.A. is NOT a lesser degree! Although the B.A. requires fewer physics courses, it doesn't prevent you from taking more - and you should take more if you are considering physics graduate school. The B.A. is designed to provide flexibility and you may use that flexibility in a variety of ways, such as taking a customized set of technical electives or pursuing other fields of study in preparation for a variety of careers - or just because you're interested in a variety of things. Many of our department faculty members have B.A. degrees and many of the country's best institutions only offer B.A. degrees in physics. A B.A. degree does NOT put you at a disadvantage when applying to graduate school or searching for jobs. People who understand physics will look at the courses you took and how well you did overall as an undergraduate. Most other people won't even know the difference between a B.A. and a B.S. in physics; they'll just be impressed that you have a physics degree - from CWRU!
16. The College of Arts & Sciences specifies that no more than 42 hours beyond the 100-level in any one department may be applied to the standard 120 credit total (*minimum*) for a B.A. degree. The B.A. in physics requires (*for students entering in the fall of 2015*) 27 credits of physics courses, 8 of which are at the 100-level. This leaves room for a student to count 23 more credits of physics courses towards the BA. Additional physics courses beyond those 23 credits may be taken but won't count towards the 120 credit total. You can read more about special requirements for the B.A. at <http://case.edu/ugstudies/programs-requirements/school-requirements/>.
17. It is particularly important for B.A. students to consult their academic advisor about physics course choices. A B.A. physics major who wishes to attend graduate school in physics should consider taking several physics courses that aren't specifically required for the major, including:
  - PHYS 310 - Classical Mechanics
  - PHYS 324 + PHYS 325 - Electricity and Magnetism
  - PHYS 332 - Quantum Mechanics II



Two of the above could count as the required physics electives in the B.A. program while the other two would be open electives (*there are ~ 43 open elective courses available in the B.A.*).

Students who might go on to work as experimental physicists should also consider taking one or both of the 4 credit sophomore labs. About 80% of all practicing physicists are experimentalists and these lab courses are also useful for other purposes, including high school teaching.

- PHYS 203 - Analog and Digital Electronics
- PHYS 204 - Advanced Instrumentation Laboratory

### **ENGINEERING PHYSICS**

18. The Engineering Physics Degree is designed for students with an interest in both engineering and physics and provides a solid background for graduate school or a career in industry. More than half of the graduates of this program choose to pursue graduate studies in physics or engineering.
19. If you are unsure whether to major in Engineering Physics or some other physics degree program, start off in Engineering Physics. Policies for accepting substitute courses are far more rigid in the Case School of Engineering than they are in the College of Arts & Sciences. For example, either CHEM 105/106 or CHEM 111/ ENGR 145 will satisfy our B.A. and B.S. degrees but only the latter is accepted for the Engineering Physics B.S.E. ENGR 210 or PHYS 203 electronics labs are both accepted for any physics degree, except for Engineering Physics, which requires ENGR 210.
20. Note that engineering concentration courses, normally taken in the third and fourth years, may have time conflicts with physics laboratory and lecture courses. A study plan including scheduling information from the current schedule of classes should be generated well in advance to identify conflicts, and to adjust the plan accordingly.
21. Engineering concentration sequences posted on the program web page are suggested sequences. Changes can be approved based on scheduling considerations and student interests. Students are welcome to propose new concentrations for consideration.
22. When selecting an engineering concentration, it is recommended that you talk with a faculty advisor in one of the relevant engineering departments. They can provide valuable guidance and suggest specific courses.
23. Some engineering concentration courses have prerequisites that Engineering Physics majors might not have taken. When the list of concentration courses posted at <http://physics.case.edu/undergraduate-programs/undergrad-degree-programs/bsdegree-engrphys/> was generated, we received assurance that the course prereqs would not prevent Engineering Physics majors from enrolling. This is, however, subject to change; course instructors control override of course prereqs.

24. Students planning on co-op or study abroad should formulate a study plan well in advance to assure that the Engineering Physics program can be completed. Again, the study plan should be formulated with consideration of the schedule of classes.

### **MATHEMATICS & PHYSICS**

25. We offer two distinct degree programs for students who wish to study both mathematics and physics. This doesn't even include the option of pursuing separate degrees from each department or a B.A. with majors in both mathematics and physics or a major in one discipline and a secondary major in the other.
26. The Mathematics Concentration in Physics is designed for students who excel in their mathematics and physics courses and who are considering careers in theoretical physics. Students who aren't consistently earning A's in their first and second year undergraduate courses should be cautious about pursuing this degree, as they may encounter serious challenges later on when they take the graduate physics courses included in this program.
27. To make it easier to change from the Mathematics Concentration to the regular B.S. in physics, you should consider taking all of the advanced labs that most B.S. students take as sophomores and juniors, rather than just two of them as specified in the degree program. At the very least, you should consider taking both (*rather than one*) of the sophomore labs. Both of these labs include significant mathematics content in their associated lectures and taking them during your sophomore year will make it easier to switch to the B.S. if you decide to do this as a junior or senior.
28. There is no advantage gained in substituting math and graduate physics courses for the advanced labs, in terms of workload and course difficulty. Students who wish to replace lab courses with other courses should choose the B.A. instead. The B.A. gives you freedom to pick and choose more of your courses without forcing you to take some very challenging physics and mathematics courses. If your goal is to take fewer labs, keep in mind that physics is fundamentally an experimental science and you will have more opportunities for research (*even as an undergraduate*) and careers if you pick up additional laboratory skills.
29. The Mathematics and Physics degree can be guided by primary faculty advisors in either department. However, you should let both departments know when you declare this major, since SIS won't automatically notify the other department when you obtain a signature on your Major Declaration Form from one department.
30. Students in the Mathematics and Physics program need to decide before the fall of their junior year whether they will take their SAGES departmental seminar and capstone courses from one of these departments. This is because the physics departmental seminar, one credit of PHYS 303 + two credits of PHYS 352, with the latter spread across two semesters of the senior year, is integrated with our PHYS 351 Senior Project course and starts in the fall of the junior year with PHYS 303, which is not available in the spring. These courses are tied together with co-requisites and pre-requisites. If you are interested in taking the MATH departmental seminar and capstone, be certain to check their availability with the math department.



31. The Office of Undergraduate Studies only programmed SIS to include the Mathematics Concentration starting with the entering class of fall 2015. If you started at CWRU before fall 2015, SIS will not properly show your progress towards your degree. In order to graduate, you will need to file an Academic Advisement Report Substitution Form [https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2018-08/Academic%20Advisement%20Report\\_0.pdf](https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2018-08/Academic%20Advisement%20Report_0.pdf), signed by your academic advisor. Don't worry, this is just a formality and many majors have completed these degree programs. You should, however, work with your advisor and pay particularly close attention to your academic requirements since you can't trust SIS to do this for you.

### **BIOPHYSICS CONCENTRATION**

32. The Office of Undergraduate Studies only programmed SIS to include the Biophysics Concentration starting with the entering class of fall 2015. If you started at CWRU before fall 2015, SIS will not properly show your progress towards your degree. In order to graduate, you will need to file an Academic Advisement Report Substitution Form [https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2018-08/Academic%20Advisement%20Report\\_0.pdf](https://case.edu/ugstudies/sites/case.edu.ugstudies/files/2018-08/Academic%20Advisement%20Report_0.pdf), signed by your academic advisor. Don't worry, this is just a formality and many majors have completed these degree programs. You should, however, work with your advisor and pay particularly close attention to your academic requirements since you can't trust SIS to do this for you.

### **ASTRONOMY & PHYSICS**

33. Students interested in taking advanced astronomy courses (*300 - level*) should factor into their plans that these courses are generally offered in alternate years on a rotating basis, and have ASTR 221 and 222 as prerequisites. Therefore students are advised to take ASTR 221/222 during their second year so that the full rotation of advanced astronomy courses is available to them in their junior and senior years.
34. You can obtain a minor in ASTR if you complete PHYS 115/121/123, PHYS 116,122,124, ASTR 221, ASTR 222 and one of ASTR 306,323,328.
35. If you are considering pursuing an astronomy major in addition to your physics major you should consult with Prof. Earle Luck in the Department of Astronomy about the requirements associated with various combinations of B.A. & B.S. physics and astronomy majors and degrees. You should count on taking about 20 credits of astronomy courses in addition to your physics courses. If one of the degrees is to be a B.S., you will need at least 150 total credits to satisfy a university requirement that a second degree must include at least 30 credits beyond the requirements of the first degree.

### **GRADUATE SCHOOL and/or JOBS**

36. Your physics GRE scores are critical for getting into the best graduate schools. Roughly speaking, you'll need a score in the top 10% to get into a top 10 program, top 20% for a top 20 program, *etc.* Your quantitative and verbal reasoning scores are also important; a

low score in these areas might disqualify you from consideration at a top institution. Remember, however, that there are a hundred or more excellent physics graduate schools (*an average of two per state!*) where you can succeed and be quite fulfilled.

37. You can and should study for the GRE in physics. If it's offered, take PHYS 339 Physics Review A-Z during the spring of your junior year. This course used to be known as a GRE prep course for physics majors but it's more accurately described as a course that covers all the physics a B.S. or B.A. student might be expected to know, even if this material isn't covered in an undergraduate course at CWRU. Students who take PHYS 339 generally take the physics GRE in April of their junior year; otherwise October of the senior year is more typical. The exam may be offered again in November, but you might not know your October scores yet.
38. Pick up a copy of the world famous CWRU Physics GRE Flashcards as described at <http://www.phys.cwru.edu/flashCards/>.
39. Five previous GRE physics tests & solutions available online: GR0877, GR0177, GR9677, GR9277 and GR8677 (*Search GRE physics + the number in google - the last two are not recommended because they are outdated.*)
40. Many CWRU students overestimate the odds that they will be admitted into a top 10 program. These departments can fill their class with students who aced the GRE and graduated with 4.0 GPA's. It is certainly okay to apply to a few top 10 programs as 'reach' schools even if your credentials aren't quite at this level, but be certain to apply to a few schools that give you 50-50 odds of admission, plus a few safety schools.
41. There are lots of ways to rank graduate programs and the list at <http://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-science-schools/physics-rankings> might not show the best school for you (*and is not to be trusted in any case, but it is a start*). Graduate school is about research and the breadth and quality of research at a university depends on what may be a small number of faculty members who may or may not be taking on new graduate students the next few years. For example, the University of Colorado-Boulder is only #19 on the general US News list but it is #2 and one of the best places in the world to study atomic/molecular/optical physics.
42. Try to identify graduate schools whose research programs match your interests, but be careful in your application not to describe your interests too narrowly, unless you don't want to go to a place unless you can join a specific research group. For example, a lot of applicants say they want to go into particle/astrophysics theory, but there are commonly a limited number of openings in this field compared to condensed matter experiment. Any limitations you place on your research interests can have a major effect on your chances of admission.
43. Do a careful job writing any required essays in the application. A poor essay can subvert your chances of admission. Ask an academic advisor or mentor to review your drafts.
44. Some departments will admit students to a master's degree program but will not admit them to a Ph.D. program. This might also mean that you'll pay full tuition and expenses rather than being supported on a teaching or research assistantship. If you do well in the MS program, you might be admitted to the Ph.D. program. While there may be no

guarantee of this, your additional experience might help you gain admission to a Ph.D. program elsewhere.

45. If you plan to go to a physics graduate program, you should seriously consider taking PHYS 349, Methods of Mathematical Physics I. Our graduates who have not taken PHYS 349 report being at a disadvantage compared to students from other institutions, many of which require a course such as PHYS 349.
46. Graduate programs generally request 3 letters of reference from people who know you well. A research advisor (*departmental, summer job, senior project, etc.*) is generally the best source for such a letter. Another excellent reference is any instructor you have had in a course in which you have done especially well. Advanced lab instructors are likely to know you better than a lecture course instructor will.
47. One class meeting of PHYS 352, Senior Physics Project Seminar, is normally devoted to a discussion of graduate school, including application considerations. The faculty members in charge of this course plus the department's cadre of academic advisors have access to a file that shows recent historical patterns of where our graduates were admitted - or not - and how that may have correlated with their GRE scores and GPA. We do not post this file or provide it to individual students out of respect for students who provided data for this file, since it is possible in certain cases to identify their GRE scores and GPA. Examples of the information in this file are posted below, to help you understand some of the uncertainties in admissions decisions and the challenges in gaining admission to some top programs.

School	NRC S-Rank high	RANK-USnews	GPA admit	GRE admit	GPA deny	GRE deny
Princeton	1	2	4	850	3.66, 3.7, 3.75, 3.777, 3.84, 3.867, 3.87, 3.912, 4.0, 4.0	31%, 600, 730, 760, 780, 800, 840, 850, 900, 900
University of Chicago	4	7	3.85, 3.89, 3.97	730, 850, 990	3.33, 3.65, 3.66, 3.67, 3.84, 3.777, 3.88, 3.89, 3.912, 3.918, 3.94, 4.00	540, 600, 710, 710, 720, 730, 750, 750, 760, 800, 840, 850, 900, 900, 960, 990
Cornell	8	7	3.63, 3.75, 3.895, 3.95, 4.0	610, 850, 900, 920	3.33, 3.498, 3.87, 3.88, 3.89, 3.918, 3.94	520, 540, 710, 730, 750, 900, 990
UC Irvine	8	29	3.59, 3.75, 3.88, 3.97, 3.97	830, 840, 900	3.2, 3.31, 3.74, 3.867, 3.89	

Ohio State	21	23	3.31, 3.498, 3.867, 3.9, 3.912, 3.918, 4.00	520, 600, 640, 740, 800, 900, 900		
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48. It can be useful to talk to people who went to the graduate schools you are considering. You can see where some of the department faculty went to graduate school at <http://physics.case.edu/directory/faculty/> . Prof. Chottiner keeps records of where each of our undergrads went to pursue a graduate degree but you can see the overall list of schools directly at <http://physics.case.edu/hsstudent-info/physics-majors-where-did-they-go-from-here/> .
49. There are lots of resources on the web that might help you understand graduate school and the admissions process.
- If you would like more information about the physics GRE exams, check out the postings at <http://www.physicsgre.com/viewforum.php?f=1> .
  - A faculty member at RPI has posted a presentation on GRE exams and graduate student admissions data at [http://homepages.rpi.edu/~persap/GRE\\_primer\\_2011\\_public.pdf](http://homepages.rpi.edu/~persap/GRE_primer_2011_public.pdf). This posting is similar to information presented in our PHYS 352 SAGES Department Seminar.
  - AIP's Physics Resources Center called GradschoolShopper.com. This site features a directory of graduate programs in physics and related fields plus useful resources for students and faculty. Visit <http://www.GradschoolShopper.com> . Graduate School acceptance rates for almost 200 physics departments, as well as the size of the most recent admitted class, are posted at <http://www.gradschoolshopper.com/gradschool/rankby.jsp?q=2&cid=3>
50. Graduate programs often send us messages and/or fliers to distribute to our majors. These are sent out *via* our Google group [cwru-physics-majors@case.edu](mailto:cwru-physics-majors@case.edu). Majors and minors are registered in this group when they declare the major or minor but students can individually turn off or on the flow of messages.
51. Our online undergraduate newsletter <http://www.phys.cwru.edu/undergrad/Newsletter/> includes advice on finding jobs during the academic school year, summers, and after graduating from CWRU.
52. If you have a GPA > 3.8, consider applying for one of the prestigious graduate fellowships listed below. The NSF and NDSEF fellowships will pay tuition and a stipend for the first few years of graduate school and the stipend will generally be higher than you might receive as a teaching or research assistant. These fellowships may also help you get accepted to a graduate school of your choice and free you to pursue your own interests when you start graduate school, since you won't be dependent on the department or a faculty member's research grants for support. The CWRU School of Graduate Studies sponsors information and training sessions to help CWRU students, including undergraduates, win these awards. The sessions for undergraduates are usually by

invitation only, with invitations sent to students who likely meet the award requirements for GPA *et al.*

- d. National Science Foundation Graduate Research Fellowships  
[http://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=6201](http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=6201) &  
<http://www.nsf.gov/pubs/2014/nsf14590/nsf14590.htm> : 3 years of support starting at \$34,000 per year.
- e. National Defense Science & Engineering Fellowship <https://ndseg.asee.org/> : 3 year award with stipend starting at > \$30,000 per year.
- f. DOE Computational Science Graduate Fellowship  
<https://www.krellinst.org/csgf/about-doe-csgf/eligibility-program-requirements>
- g. DOE Nuclear Physics Graduate Fellowships <https://www.krellinst.org/ssgf/about-doe-nnsa-ssgf>
- h. NASA and DOE have other programs open to graduate students. See <http://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId=%7BB6CDCEA6-8EDD-A48A-FAF8-E588F66661C3%7D&path=open> and <http://science.energy.gov/wdts/scgf/>

*See the next page for the Advising Checklist.*

## Advising Checklist for Physics Undergraduate Advisors

*version 01/07/2013, approved by the department's Undergraduate Curriculum Committee*

<b>FRESHMAN</b>	
Post-graduation/career plans	
Various physics degree programs – clarify goals & requirements of each	
Opportunities for academic year work in research or teaching	
Summer Plans	
<b>SOPHOMORE FALL</b>	
Review course choices and grades	
Summer Plans ( <i>REU and other deadlines arrive as early as December</i> )	
Post-graduation/career plans	
Start a resume	
Visit Career Center & investigate resources there	
Review co-op and study abroad opportunities	
<b>SOPHOMORE SPRING</b>	
Review course choices and grades	
Check that choice of degree program is still appropriate	
Discuss potential PHYS 300 electives	
Opportunities for academic year work in research or teaching next year	
Summer Plans	
<b>JUNIOR FALL</b>	
Review course choices and grades	
Post-grad/career plans	
Grad School & GRE preparation	
Summer Plans	
<b>JUNIOR SPRING</b>	
Review course choices and grades	
Grad School & GRE preparation	
Review resume	
Identify potential senior projects/advisors	
Summer Plans	
<b>SENIOR FALL</b>	
Review course choices and grades	
Post-graduation/career plans	
Grad School or job applications	
<b>SENIOR SPRING</b>	
Post-grad/career plans	
Outcome assessment & exit form	