UNIVERSITY OF MARYLAND 1856

DEPARTMENT OF PHYSICS

Teaching Assistant Manual

2016

Portions adapted from the Teaching Resources Guide, 2014-2015, Teaching & Learning Transformation Center, tltc.umd.edu.

Contents

Welcome

Dear Teaching Assistant,

On behalf of the Department of Physics, we welcome you to the University of Maryland. We have compiled this manual to help you get started as a Teaching Assistant. This manual contains general advice and overviews of policies that supplement the University of Maryland's official policies. Policies for Graduate Assistantships, including Teaching Assistantships, are given at http://apps.gradschool.umd.edu/catalog/assistantship_policies.htm.

In addition to this manual, much more information and support for TAs is available through the Graduate School, http://www.gradschool.umd.edu/, the Teaching and Learning Transformation Center (TLTC), http://tltc.umd.edu/, and the Physics Office of Student and Education Services.

The Physics Office of Student and Education Services (OSES) provides assistance to undergraduate and graduate students from pre-admission to graduation. The OSES staff is committed to supporting the growth and well-being of Teaching Assistants and we encourage you to contact OSES if any concerns arise.

We hope that you will use this manual as a resource throughout your time as a TA. Best of luck in your studies and your teaching.

The Office of Student and Education Services
Department of Physics
University of Maryland, College Park

Contacts

Contact	Position	Contact Info
Ms. Donna Hammer	Director of Student and Education Services	PHY 1120 301.405.5958 dhammer@umd.edu
Ms. Jessica Crosby	Graduate Coordinator (Graduate Admissions, Registration, Requirements, Forms, TA Office Assignments)	PHY 1120E 301.405.5982 jcrosby@umd.edu
Dr. Zackaria Chacko	Teaching Assistant Coordinator (TA Assignments)	PSC 3266 301.405.1774 ta_assign@umd.edu
Ms. Paulina Alejandro	Program Admin Specialist (Benefits, Tuition Remission)	PSC 0260F 301.405.5998 palejand@umd.edu
Ms. Pauline Rirksopa	Assistant Director (Payroll)	PSC 0260A 301.405.6183 pkomsat@umd.edu

Mutual Expectations Agreement

This guide was created to facilitate discussion around the expectations of TA responsibilities in order to help your TA experience run as smoothly as possible. Note that some items may not apply to your particular class. This document was developed by the graduate committee based on feedback from graduate students, staff, and faculty.

- ❏ **Logistics**
  - ❏ Exchange contact information and preferred means of communication with professor and fellow TAs
    - ❏ Professor phone number: ________________________________
    - ❏ TA phone number(s): ________________________________
      ____
      ____
    - ❏ Professor email: ________________________________
    - ❏ TA email(s): ________________________________
      ____
      ____
  - ❏ How often will we meet?
  - ❏ How much notice is necessary when I have schedule conflicts with TA duties?
    - ❏ Who can sub for a discussion session or lab section?
  - ❏ In case of emergency (sickness, family, flat tire, etc.), what is the protocol for finding a last minute replacement or cancelling a discussion session or lab section?
  - ❏ What online systems/resources will I need access to (e.g. Mastering Physics, Lecture Notes)?
- ❏ **TA Duties and Workload**
  - ❏ Describe what a TA led session will look like
  - ❏ Will we have quizzes during discussion sections/lab sections?

- ❑ When a student misses a quiz, can a student make up the quiz?
- ❑ How many quizzes are they allowed to make up?

❑ What is the attendance policy for students (in labs and/or discussions)?

- ❑ Is the legitimacy of an excuse at the TAs discretion or does the professor have a policy?

❑ What is the class policy on late work?

- ❑ Can a TA grant extensions?

❑ Who will grade the tests, homeworks, quizzes, and lab reports?

❑ What is the timescale for turnaround on grading:

- ❑ Homeworks
- ❑ Quizzes
- ❑ Lab reports
- ❑ Tests

❑ Who will write up solutions to homework, quizzes, and/or tests?

❑ How rigorously should I grade? What should the average score typically be?

❑ What should I do if I suspect copying/cheating?

❑ Who will handle student complaints about grading?

❑ Am I expected to hold office hours? Review sessions?

- ❑ If I hold review sessions, who will provide the material?

❑ What should TAs do in the event of University closures, especially when it only affects one or two of the sections that week?

❑ How much time should I expect to spend on a weekly basis:

    - ❑ Grading:
    - ❑ Discussion session prep:
    - ❑ Lab prep:
    - ❑ Class time (discussion, labs, attending lecture, proctoring exams):
    - ❑ Office hours (if any):
    - ❑ Total:
  - ❑ How much time can I be expected to spend grading tests during midterms and finals?
  - ❑ Although it will fluctuate throughout the semester, I will never expect to spend more than ____ hours in any given week, regardless of workload.
  - ❑ Which day(s) at the end of the semester will I need to be available to grade the final exam?
  - ❑ What is my absolute deadline at the end of the semester for having all homework/lab/quiz grades given to the instructor or recorded online?

- ❑ **Syllabus/Course Content**
  - ❑ Take a few minutes to review the course syllabus together. Does the TA understand what will be covered each week?
  - ❑ Are there chapters/sections/topics in the book which will not be covered (other than what is clear from the syllabus)?
  - ❑ Will any material be taught which is not in the book, or which will be taught in a significantly different way from what is in the book?
  - ❑ If changes to discussion session topics occur, how and when will they be communicated?
  - ❑ How will any changes to the syllabus/schedule be communicated?

Policies

Physics Department Expectations

Communication and Grades

Teaching Assistants (TAs) are expected to contact the instructor for the course at the beginning of the semester to establish course policies, procedures, and logistics. The Graduate Student Committee developed the Mutual Expectations Agreement to facilitate discussion between instructors and TAs.

TAs are expected to complete all duties assigned to them by the Physics Department. If any conflict should arise that prevents the TA from completing said duties, it is the TA's responsibility to speak to his or her instructor to make the necessary arrangements.

TAs are expected to provide feedback to students while in the classroom and on students' written work. This should be provided in a timely fashion, preferably for the following week of lab and no later than two weeks after the work has been turned in. TAs are expected to keep a grading record of their students' progress and be able to substantiate those grades.

TAs should respond promptly to instructor and student communications.

Substitutions and Emergencies

The TA is expected to be present, punctual, and available during the times to which he or she has been assigned. This includes discussion sessions, lab sessions, office hours, TA meetings, proctoring exams, etc.

It is the TA's responsibility to find a replacement for his or her session if he or she is not able to attend the scheduled times. The TA must notify the course instructor and/or the lead TA as well as the Graduate Studies Coordinator, Jessica Crosby (jcrosby@umd.edu) of any arrangements for substitution or switching of sessions. If the TA is not able to find a substitute, they must notify the Graduate Studies Coordinator at least 24 hours in advance of the scheduled time.

If there is an emergency that prevents the TA from attending a scheduled shift, the TA must notify the instructor and the Graduate Studies Coordinator as soon as possible. Emergencies are events related to illness, death in the family, ER trips, or family emergencies. Please note that last-minute panic for a test or other TA duties are not considered acceptable emergencies.

TAs should contact the Office of Student and Education Services (OSES) in PHY 1120 if they encounter any problems during class. This includes disruptive students, broken/malfunctioning equipment, or locked classrooms.

Copy Center

The Physics Copy Center will make copies of quizzes and exams at the request of faculty instructors. The Copy Center requires a minimum of 48 hours' notice in advance of the desired pick-up time. Requests can be submitted here. Copies can be picked up in the Office of Student and Education Services, PHY 1120.

Accommodating Students with Disabilities

The University of Maryland Disability & Accessibility Policy states that the University is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The University of Maryland provides reasonable accommodations to qualified individuals. Reasonable accommodations shall be made in a timely manner and on an individualized and flexible basis. Discrimination against individuals on the grounds of disability is prohibited. The University also strictly prohibits retaliation against persons arising in connection with the assertion of rights under this Policy.

Disability Support Service coordinates services that ensure equal access to University of Maryland College Park programs for individuals with disabilities. The DSS is located in 0106 Shoemaker Building and can be reached at 301-314-7682 or www.counseling.umd.edu/DSS.

Classroom Accommodations

- Students with disabilities are found eligible for classroom accommodations by meeting with a DSS counselor to share their disability documentation and to discuss their specific classroom accommodation needs.
- They receive a formal accommodations letter at this meeting which lists each specific accommodation that has been approved by the DSS.
- The students are guided by their DSS counselor through an interactive process in which they share and discuss their classroom accommodations with their instructors at the beginning of each semester.
- During these discussions, students give their instructors a copy of their approved accommodations, which should be kept in the instructors' files.
- Classroom instructors are responsible for working with the student and the DSS in the implementation of each student's approved classroom accommodations.
- Students and instructors are encouraged to contact the DSS at 301-314-7682 or via dissup@umd.edu if they encounter any problems, concerns, issues, or need further clarification regarding the implementation of approved accommodations.

Accommodations for Classroom Exams

When students have approved testing accommodations (extended time; use of adaptive technology; distraction-reduced environment, etc.) and plan to take their exams in the DSS testing office, additional paperwork and preparation is required.

- Early discussion between the student and the instructor about the testing accommodations is important. Students could face scheduling conflicts with regard to extended time testing. If, for example, a student might have back to back classes on the scheduled exam date and need to reschedule the exam for another time.
- When scheduling to take exams at the DSS testing office, the student is responsible for providing the instructor with a Test Authorization Form approximately five (5) days before the exam date. The Test Authorization Form is designed to be completed by the instructor with specific testing instructions and to be delivered to the DSS Testing office along with the exam. Forms are available at http://www.counseling.umd.edu/DSS/.
- Students can take accommodated classroom exams in the classroom building as long as the instructor is able to provide the approved accommodations listed on the student's letter.

Attendance and Religious Observance

The University expects each student to take full responsibility for his or her academic work and academic progress.

Excused Absences

1. It is the policy of the University to excuse the absences of students that result from the following causes: illness of the student or dependent (see medically-related absences); participation in University activities at the request of University authorities; compelling circumstance beyond the student's control, and religious observances. Students claiming excused absence must apply in writing and furnish documentary support.
2. Students must notify their instructor of the reason for absence as soon as possible. In the case of religious observance, requests should be made within the first two weeks of the semester.
3. Prior notification is especially important in connection with final exams since failure to reschedule a final examination before conclusion of the final examination period may result in loss of credits during the semester.

Religious Observance

Examinations or other significant assessments may not be scheduled on Rosh Hashanah, Yom Kippur, Good Friday, or the first two days of Passover. The website interfaithcalendar.org maintains a reliable calendar of widely recognized religions and their respective holy days.

Code of Academic Integrity

The student-administered Honor Code and Honor Pledge prohibits students from cheating on exams, plagiarizing papers, submitting the same paper for credit in two courses without authorization, buying papers, submitting fraudulent documents, and forging signatures. On every examination, paper, or other academic exercise not specifically exempted by the instructor, students must write by hand and sign the following pledge:

I pledge on my honor that I have not given or received any unauthorized assistance on this examination (or assignment).

Compliance with the code is administered by the Student Honor Council, which strives to promote a community of trust on the College Park campus. Allegations of academic dishonesty should be reported directly to the Honor Council (HonorCouncil@umd.edu, 301.314.8450) by any member of the campus community. For additional information, consult the Office of Student Conduct.

For a description of the University's definition of academic dishonesty, suggestions on how to prevent cheating, and practical answers to frequently asked questions about the Code of Academic Integrity, consult the Student Honor Council's webpage.

Code of Conduct and Professional Conduct

University codes establish expectations for faculty and graduate students regarding conduct and professionalism. For graduate students, the Graduate Catalog explains that "In their interactions with students, faculty, and all other members of the University community, teaching assistants are expected to conduct themselves with the same sensitivity and thoughtfulness that they expect to receive from others."

The University of Maryland Non-Discrimination Policy states that the University affirms its commitment to a policy of eliminating discrimination on the basis of race, color, sex, gender identity or expression, sexual orientation, marital status, age, national origin, political affiliation, physical or mental disability, religion, protected veteran status, genetic information, personal appearance, or any other legally protected class.

Family Educational Rights & Privacy Act (FERPA)

The University complies with the regulations set forth in the Buckley Amendment, which is a part of the Family Educational Rights and Privacy Act (FERPA). This amendment protects a student from the disclosure of personal and academic information to anyone other than the student, including parents, except under special circumstances. Posting student grades with either student names or social security numbers, in whole or in part, is strictly prohibited and exposes the University and the responsible faculty member to civil litigation. Graded exams and papers should be returned to students individually, rather than left for retrieval outside of office doors. Other "protected" information includes, but is not limited to, special requests, current and past course registrations, enrollment status, financial aid disbursements, billing history, and any disciplinary actions.

The University conforms to the Family Educational Rights and Privacy Act in order to maintain compliance with federal law and the Board of Regents policy. The Board of Regents requires that all colleges and universities in the University System of Maryland protect student confidential education records and comply with federal and state laws, including definitions of "students" and "educational records."

In general, under FERPA guidelines you are not allowed to give out grades to students via email or phone except in cases 1) where you can clearly identify that the request is directly from a student; 2) where there is a signed and dated written consent from the student and his/her parent; 3) the student's parents provide proof that the student is a dependent for federal tax purposes. It is recommended that grades be transmitted through the UMEG system and ELMS, which protects student confidentiality. Contact your department chair or faculty advisor if you have a parent who continues to ask for information regarding student performance. See the University policy.

Maintaining the confidentiality of student records is everyone's responsibility, whether you are faculty, staff, or student. Complete the FERPA tutorial here.

Sexual Harassment Awareness and Prevention

The University is committed to maintaining a working and learning environment in which students, faculty, and staff can develop intellectually, professionally, personally, and socially. Such an environment must be free of intimidation, fear, coercion, and reprisal. Accordingly, the campus prohibits sexual harassment. See the University's policies here.

Definition

Sexual harassment is defined as unwelcome sexual advances, requests for sexual favors or other verbal or physical conduct of a sexual nature when:

- Compliance to such conduct is made either explicitly or implicitly a term or condition of employment or of educational progress
- Compliance to or rejection of such conduct is used as the basis for employment or academic decisions affecting that employee or student
- Such conduct has the effect or purpose of unreasonably interfering with an employee's work performance or a student's academic performance or creating an intimidating, hostile, or offensive working or educational environment

Guidelines

Consensual sexual relationships are prohibited between a student and any TA or instructor who teaches that student. Since a TA is in a position of power over a student, any relationship would either be a conflict of interest or give the impression of a conflict of interest.

If you are interested in a student, remember that professional ethics restrict teachers, including teaching assistants, from becoming personally involved with their students. For this reason, and to protect yourself from charges of sexual harassment, you should keep any interest in a student to yourself until after the student-teacher relationship is completely finished, including the submission of all grades.

If you find that any person with whom you have a special relationship: romantic, family, or otherwise, ends up in your class, see the Director of Education, Donna Hammer, or Zackaria

Chacko about transferring that person to another TA. You have an overriding responsibility to treat all students equitably and fairly and it is important to not only fulfill this obligation but to be seen by others to be fulfilling it.

For instructors, this includes but is not limited to the following:

- Informing the Office of Student and Education Services of the conflict of interest
- Resigning from any supervising committees (dissertation, advisory) affecting the student
- Refraining from writing letters of recommendation for the student (for grants, fellowships, jobs, graduate or professional school, etc.)
- Giving up any position of authority over or responsibility for that student's career, inside or outside the University, at any time in the present or future.

Just as importantly, students and instructors have the responsibility to treat TAs equally. If you feel that you have experienced sexual harassment from a student or instructor, please see the Director of Education, Donna Hammer, or the Associate Chair of Graduate Studies, Peter Shawhan.

How to Avoid

Some suggestions to help you avoid putting yourself in a situation where you may be the victim, falsely accused of, or misinterpreted as the perpetrator of sexual harassment:

- Schedule meetings with students/advisors during regular 'business' hours, not on weekends or at night.
- Leave the office door ajar if you are alone with a student/advisor.
- Avoid sexist language, terms of endearment and sexual innuendo in dealings with students and faculty.
- Do not ask students to do favors for you. This will help avoid misunderstanding.
- Document and report inappropriate actions by students to your supervisor.
- Maintain a professional demeanor with your students.
- Avoid dating students over whom you have a position of power, or perceived power.

Required Training

As one step toward creating an environment free from sexual misconduct and other forms of discrimination, all UMD students, faculty, and staff are required to complete online training entitled Responding Effectively to Discrimination and Sexual Misconduct.

Guidelines

Tips for Your First Class

The first class is an opportunity to set the tone for the semester, introduce the idea of the class as a learning community, and establish the ground rules under which you operate.

Get to the room early and write the course number, section number, and your contact information (name, email, office number, office hours) on the board, even if the instructor already put it on the syllabus. Continue to post this information for the first two or three weeks of school, as many students are still adjusting their schedules.

Introduce yourself and the way you want to be addressed. Should students use your first name or your title? Explain who you are and what your function within the course will be. You can also tell the students a bit more about yourself (where you are from, what your research is) so they get to know you better. Discuss your office hours and consider dedicating time to discussing appropriate email communication and how long students should expect to wait for an email reply.

Ask the students about themselves. You might ask them why they are taking your course, whether they have any prior knowledge or experiences that relate to the topics you will explore, what they would like to do when they graduate, and perhaps what their expectations of an undergraduate education are. If your class is small, consider getting this information by going around the room and asking students to share these details aloud. If your class is large, consider an exercise in which you present questions to the entire class and ask students to respond by raising their hands. Of course, be mindful of student privacy. The object of this exchange is to learn about the class and to stimulate self-reflection, not to interrogate or violate privacy.

Do your best to get to know everyone's name. It gets students' attention better and increases their participation when you call them by name. Students are more impressed by an instructor who gets to know them quickly. Consider having students make name cards to be used during the first few sessions until both you and your students learn everyone's names.

Review the syllabus, but avoid simply reading it. You should describe the course's goals, explain expectations and requirements for successful completion of the course, review the course format, and briefly describe any major projects. Explain your and your instructor's expectations for participation, assignments, and grading. Also invite students' questions regarding the syllabus or the course. In addition to reviewing course details, try to give students a sense of what the course is about by introducing the subject and offering them an idea of what the class will be like.

Review the objectives for the semester and how each assignment and assessment will contribute to achieving those objectives and to measuring their learning. The first class is an excellent opportunity to clarify long and short-term goals for the course, as well as providing context for how this course is important for their academic development at the University of Maryland.

For lab courses, make a sample lab report for the first lab exercise. This helps students know the quality of work you expect them to turn in and to what depth you expect their answers to be.

Slow down and be confident. New teachers, especially on the first day, have a tendency to rush through the material. Remember that even if the course is not in your area of expertise, you still know more than the students. Even if you are learning the material, you have the skills necessary to assist and direct the students. Remember that you are in a position of authority. While a dictatorial pedagogy will very likely not serve you or your students well, students should neither be encouraged to treat you as a peer, nor should they regard you as an obstacle to the professor.

Office Hours

There is too little time in discussion sessions to go over a question or problem of interest to only one or two students. Provide detailed and individualized coaching during office hours for those students who seek it out. Schedule office hours at staggered times to provide convenient times for as many students as possible. Stress that you are available by appointment if your office hours are inadequate. Remind students often of your availability. Even if they do not take advantage of it, your reminders will reassure students of your interest in helping them.

During office hours, you should be prepared to field questions related to the lab, lecture, and homework. Students will most likely come with questions about specific homework problems or lab questions. You should not just do the problems on the board for the students, though it is ok to help the students set up the problems. Guide the student by asking questions about their understanding and perceptions. You do not have to answer questions like, “Check my work and tell me if I did this correctly.” If you get a request like this, ask the student to explain the concepts in their own words and try to offer feedback on their explanation.

Though you may not be expected to work through the lecture’s homework, it is useful to read and understand the chapter being covered in lecture to remind yourself of the concepts before your office hours.

Be as equitable as possible in distributing your time among individual students. If your office becomes a little crowded, get students to help each other and work with several students at the same time if they share common difficulties.

Grading

When assessments are graded, the instructor must be consistent with University grading standards. Note that students occasionally believe that merely satisfactory work deserves an A, and so instructors should consider discussing the University's official grading definitions on a syllabus or in the classroom. TAs should seek to ensure that students have a clear understanding of what grades mean and how they are awarded.

Grades must be consistent for all assignments. It is not acceptable for one TA to give mostly A's while another gives mostly C's. To avoid this situation, discuss grading practices and ask the instructor for examples.

Read through several students' assignments before creating your grading scale and establish a "standard deduction" with other graders for math errors, significant figure lapses and the like. Be consistent across problems, assignments, and discussion sections. It helps to determine the major components of each question and decide how much each component should be worth. Attempt to grade the partial credit that is deserved by crediting that which is right at least as much as penalizing that which is wrong.

Give feedback as much as possible and be specific. Tell the student what you thought was good and what needed more effort or further thought. You might consider making a couple of strong points at the end of the assignment rather than many little marks throughout the entire assignment. Make a swipe mark on every totally blank page and any large empty areas to alleviate suspicion that a student may add new work before asking that the problem be re-graded.

Techniques for Effective Recitation Sessions

Before Class

Prepare by reviewing lesson-related material including the lecture and reading materials, even if you have already mastered content. Attend the professor's lectures. Many faculty members require TAs to attend the lectures, but even if attendance is optional you are well-served by reviewing the same material to which your students are exposed. Extemporaneous recall can breed trouble.

Write out more discussion questions and practice problems than you think you will need, but do not treat these as a to-do list. Your questions and problems should be a resource for you; they should not inhibit your students from taking the discussion in a productive direction. Do not excuse students early if they do not have questions. Be prepared with problems and exercises to make the best use of the time.

If students were assigned reading prior to a class meeting, **plan to use the text**.

During Class

Be respectful of the students and their time.

- Stay on topic. Have a plan, but be flexible and prepared to deviate from it.
- Admit when you make a mistake in class.

- Avoid questions that are designed to punish inattentive or lazy students.
- Refer to your students by name. This models the intellectual community.

Create a balance of questions and lecturing. It is not the job of the TA to lecture in this situation, but students will not always ask questions right away. Use the questions you prepared to engage the students in reflecting and thinking critically about the problems.

Use a variety of activities to achieve instructional goals. You may consider dividing the class into small groups to tackle problem sets, while making each group responsible for presenting one problem. While the groups work, circulate and act as a consultant, asking questions that highlight important ideas and concepts.

Ask good questions and avoid bad ones. Don't phrase questions in a way that the students can answer in one word. Open-ended questions elicit student thought. Ask a mix of questions, including questions that ask students to:

- Recall specific information
- Describe topics and phenomena
- Apply abstract concepts to concrete situations
- Connect the general with the specific
- Combine topics or concepts to form new topics or concepts
- Evaluate information

Making Your Lab Run Smoothly

Know the experiment and check that the equipment is working before starting the experiment. If necessary, lab should begin with a short lecture (no more than 10 minutes) to introduce the basic physics concepts involved, briefly describe the laboratory equipment and possible difficulties (with equipment or procedure), and give any feedback about the general performance of the class (i.e., "I noticed that in last week's lab, most people did not understand…" or "In the lab notebooks, many students did not accurately describe…"). Answer as many questions as possible with the whole class, as it will save you repeating yourself.

Keep the pace of the lab by establishing timelines and circulating to keep groups on track. While circulating, lead the students to deduce ideas on their own rather than answering their questions outright. Use real examples of what they are seeing in the lab. For example, "Think about these collisions next time you play pool" or "This is why hurricanes spin clockwise in the northern hemisphere."

Make sure the equipment is working and organized before leaving the lab.

Creating a Productive Classroom Environment

Classes are structured communities. While there are certainly many ways to **promote an equitable and successful learning environment in your classroom**, any approach should be founded on a sense of participation in an intellectual community founded on the importance of free exchange and respect for ideas. Consider including a statement encouraging students to understand the classroom in this way in your course policies. For instance:

This course requires university-level work and, as such, requires university-level participation. Every student will be expected to treat his or her peers are members of a scholarly community, to provide useful critique, and to refrain from destructive or harassing commentary. Do not talk while your peers are talking. Turn off phones when you arrive. Do not disrupt the class by packing up your materials before our meeting time has ended.

Do	Do Not
Integrate student comments into discussion to model good discourse.	Make students spokespeople for ethnic, gender, socioeconomic, or other groups.
Circulate through the room, attentive to group behavior, in order to reinforce positive student-to-student interaction.	Ignore observed antagonism between groups of students.
Show students how to diplomatically critique each other's work and rely on peer critique as a feature of your course.	Disrespect or humiliate any student, particularly in the presence of his or her peers.
Learn and use student names and encourage students to use each other's names in class discussion.	Create an ongoing sense of difference between a student whose exceptional work you share with the larger group and the rest of the class (i.e., be sure that emphasis is on the work and not on the individual student, if you single him or her out for praise).
Provide opportunities for students and groups of students to present their work to the class.	Let students regularly form the same small groups (if possible, put students together whom you think could learn from each other, given expressed interests and previously submitted work).
Be attentive to the varied experiences students bring to your course.	Make assumptions about students' experiences and identities.

Students who do not contribute: Be attentive to the sensibilities of shy and quiet students; integrate them into the discussion with support. Nervous or inarticulate students may be greatly aided by writing down some thoughts before contributing (even before the class meeting). Encourage them to try that approach.

Students who contribute more than appropriate: Approach students who dominate the discussion before or after class. You might suggest they develop some of their discussion points with you via ELMS or email and let them know that their contributions are limiting the ability of others to contribute to class discussion. Alternatively, you might resort to restructuring the discussion a little. Make other students responsible for presenting small group discussions, require students to raise their hands, or begin calling on individual students.

Students who fail to respect the discussion and their peers: Make the group responsible for controlling unproductive antagonists by structuring a group response, i.e., articulate the student's position (on the chalkboard, perhaps) and ask for a response. Of course, students who violate University codes of conduct should be referred to the Office of Student Conduct.

Students who are unprepared: Quizzes or reflections to stimulate out-of-class reading may be effective.

Supporting Students with Disabilities

Disability Support Service (DSS) coordinates services that ensure equitable access to University of Maryland College Park programs for individuals with disabilities. The DSS is located in 0106 Shoemaker Bldg. and can be reached at (301) 314.7682 or via www.counseling.umd.edu/dss.

Managing Disruptive Student Behavior

Successful class climates contribute to student learning and limit the sort of distractions that stifle learning. The following guidance from the Office of Student Conduct should help to create a class community in which student learning is not impeded by disruption.

The Office of Student Conduct offers the following advice.

Both students and faculty members have some measure of academic freedom. University policies on classroom disruption cannot be used to punish lawful classroom dissent. The lawful expression of a disagreement with the teacher or other students is not in itself "disruptive" behavior.

Rudeness, incivility, and disruption are often distinguishable, but may intersect. In most instances, it is better to respond to rudeness by example and suasion (e.g., advising a student in private that he or she appears to have a habit of interrupting others). Rudeness can become disruption when it is repetitive, especially after a warning has been given.

Strategies to prevent and respond to disruptive behavior include:

- Clarify standards for the conduct of your class. For example, if you want students to raise their hands for permission to speak, say so, using reminders as needed.
- Serve as a role model for the conduct you expect from your students.
- If you believe inappropriate behavior is occurring, consider a general word of caution, rather than warning a particular student. (E.g., "We have too many contemporaneous conversations at the moment; let's all focus on the same topic.")
- If the behavior is irritating, but not disruptive, try speaking with the student after class. Most students are unaware of distracting habits or mannerisms and have no intent to be offensive or disruptive.

- There may be rare circumstances when it is necessary to speak to a student during class about his or her behavior. Try to do so in a firm and friendly manner, indicating that further discussion can occur after class. Public arguments and harsh language must be avoided.
- A student who persists in disrupting a class may be directed to leave the classroom for the remainder of the class period. Whenever possible, prior consultation should be undertaken with the Director of Student Conduct (301) 314.8204.
- If a disruption is serious and other reasonable measures have failed, the class may be adjourned and the campus police summoned, 911 or (301) 405.3333. Teachers must not use force or threats of force, except in immediate self-defense. Prepare a written account of the incident. Identify witnesses for the Campus Police, as needed.

Readings

The Making of a Teaching Evangelist

Why Every College Student Needs To Take Science Courses

Knowing Student Misconceptions Key to Science Teaching, Study Finds

The Making of a Teaching Evangelist

By Dan Berrett | June 05, 2016

Eliza Grinnell, Harvard John A. Paulson School of Engineering and Applied Sciences

Eric Mazur photographs a car that students created in an active-learning lab. Designing and carrying out experiments, not sitting through lectures, was how Mr. Mazur came to understand and appreciate science. "I learned physics through apprenticeship rather than through courses," he says. "That's when I discovered the joy of science."

Eric Mazur could barely contain his excitement. His teaching evaluations had just come in, and they were glowing.

He was still untenured, an associate professor of physics and applied physics at Harvard University. Eager to share his good news, he phoned his friend and mentor, Albert Altman, then a professor of physics at the University of Massachusetts at Lowell.

His students, Mr. Mazur crowed, had rated him about as highly as they could.
An uncomfortable silence hung between them.
"Eric," Mr. Altman finally said. "This is the kiss of death."

That conversation, some 25 years ago, was a clarifying moment for the Harvard professor. Conventional wisdom for a young, early-career faculty member is that good teaching won't get you very far. The incentives, particularly at research-oriented institutions, favor scholarship, and tooting your horn about how good you are in the classroom won't exactly burnish your tenure bid.

Mr. Mazur's career since then has defied those truisms. He's become an academic celebrity, crisscrossing the world as an evangelist for improving teaching, mostly by lecturing about the need to end the lecture.

His most popular speech is a story of personal awakening: how he once thought he was an excellent teacher, became aware of his failures in the classroom and, by researching how his students learned, reinvented his courses. By framing his story as a confession, he gives voice to the anxieties that many of his fellow professors feel about their own teaching. He has been a key player in the effort to transform how science is taught, which is part of a broader debate about the flaws and virtues of the lecture, one of higher education's most beloved, reviled, and enduring institutions. That argument, in turn, elicits deeper questions about professorial expertise, academic rigor, and who, in the end, is responsible for student learning.

Mr. Altman, as it turns out, didn't have to worry about how his friend's devotion to teaching would hurt his career. But his advice carried a second warning that Mr. Mazur didn't grasp at the time. Teachers who think they've figured everything out risk becoming intellectually complacent. And that surely is the kiss of death.

The signals Mr. Mazur received as a young professor pointed to one conclusion: He rocked. His lectures were clear and well received. His students could solve complex problems about rotational dynamics by calculating triple integrals.

"I'd been fooling myself for many years thinking I was an effective professor. But it was a house of cards."

His serene confidence was shaken by an unusual source: the Force Concept Inventory, a test of basic understanding of Newtonian physics, which was then making the rounds among physicists.

Mr. Mazur had heard about the test's results at other colleges. Students generally showed a poor grasp of underlying scientific principles, whether they took seminars or large lectures, were taught by award-winning instructors or by graduate students, or attended elite institutions or less-selective ones.

Mr. Mazur was sure his students were different. This was Harvard. And he was a terrific teacher, after all.

Then he tested them.

What he found out unsettled him. The results showed that the majority didn't understand the fundamentals of Newtonian physics, a subject they'd covered in the second week of the semester.
He retested them at the end of the course and they didn't fare much better. The class average went up eight points, from 70 to 78, on a 100-point scale.

Struggling to understand the results, Mr. Mazur devised an experiment. On a midterm, he included two questions about circuitry. One was traditional and came from a textbook; it tested students' ability to identify and carry out the appropriate calculation. The other was word-based and conceptual.

He thought the conceptual one would be simple, taking about 30 seconds to answer. Instead, he says, his students panicked. One of them filled six pages with everything he knew about circuits and currents in the hopes of stumbling across the right answer.

The students fared better on the calculation-based question. Mr. Mazur realized what he had really been teaching them: to memorize formulas.

Suddenly, other warning signs came into focus. He thought back to the people who told him they'd aced physics in school but never really understood it. He remembered the despairing comments scribbled on his otherwise stellar teaching evaluations. The subject is boring, some students wrote. Physics sucks.

Mr. Mazur reflected on how he had come to learn physics. It wasn't during lectures, when his professors would turn their backs to the students and solve problems on the board. That was how he taught, too.

No, it was in his third year, when he worked in a lab, designing and carrying out experiments, that he came to understand and appreciate the subject. "I learned physics through apprenticeship rather than through courses," he says. "That's when I discovered the joy of science."

Joy is not a word that often describes the lecture. But this method of teaching has come to arouse passions in an increasingly pitched and moralistic debate.

Critics, like Mr. Mazur, favor approaches that demand more classroom participation from students. In their view, students need to do more than listen during class; they must actively grapple with the subject matter, whether in small groups, by responding to questions using clickers, or through other exercises.

One scholar likened lectures to bloodletting, antiquated and not terribly effective. Another described lectures as "toxic" to student learning. When he was asked once about a large-scale analysis that showed greater gains in student learning from participatory strategies compared with lectures, Mr. Mazur wondered whether lecturing was an ethical teaching choice.

Defenders of the lecture counter that it has endured for hundreds of years for good reason: It works. To discard it, they say, is to acquiesce to the erosion of educational standards and let students off the hook for their own learning.

One humanities professor wrote last year that lectures work because they demand that students pay close attention, connect ideas, and understand how to build an argument.
For Alex Small, an associate professor of physics at California State Polytechnic University at Pomona, a lecture is only as passive as the listener. Students learn when they think about what they're hearing and organize it into salient points. "This places the responsibility for learning on the student," he wrote on his blog, "whereas the modern zeitgeist places the responsibility on the instructor."

Lecturing, he says, serves another important purpose. It reaffirms the importance of expertise and allows students to see how an expert role-models the process of working through a problem.
In truth, though, the distinctions between lecturing and active learning aren't always clear cut. Mr. Small, who has defended the lecture in *The Chronicle*, says that in his own courses he frequently stops to ask and answer questions.

Eliza Grinnell, Harvard John A. Paulson School of Engineering and Applied Sciences

Eric Mazur listens in as his students discuss the concept of momentum. "If you're only delivering information, you're doing it wrong," he says.

"Should students do problem solving? Well, of course," he said in an interview. "If you're only delivering information, you're doing it wrong."

For his part, Mr. Mazur appreciates the lecture's value. Some can be inspiring, and many are effective at dispensing information. But if students are supposed to learn, he says, they need to do more than simply listen. "Learning is not a spectator sport," he says.
After all, it's not like you'd expect to pick up a dance step by watching a trained dancer, or learn to drive by observing someone else do it. You have to do something.

Why, then, does the lecture endure? Money is one reason. Lectures are inexpensive for institutions, allowing hundreds of students to be assigned to one faculty member.

Custom is another. Professors and students can each walk away from a lecture convinced they've gotten something out of the exchange, even if they haven't. Mr. Mazur often likes to cite education research suggesting that students overestimate how much they learn from a smoothly delivered lecture.

"The lecture creates the perfect illusion," he says. "As the primary vehicle for teaching, it's completely outmoded."

Confronted with his classroom failures, Mr. Mazur needed an alternative way to teach. It came to him by accident.

He was explaining a question on the Force Concept Inventory that about half of his students had gotten right. It asked them to compare forces that a car and truck exert on each other when they collide. He scribbled equations on the board but could tell from their faces that his students were lost. To him, the answer was simple. According to Newton's third law, the forces were equal. He tried to explain again. No luck.

His despair mounting, Mr. Mazur told them to discuss their answer with a neighbor.

"I'd taken something broken, the lecture, and tried to make it better."

The tenor of the room changed. The students grew animated and the staid lecture hall began buzzing.

Mr. Mazur has developed an entire method around that experience. At its core, peer instruction requires students to learn, typically from a brief lecture, about core concepts, which they apply to problems and explain to their fellow students. It's a simple way to get them to participate actively within the construct of a large lecture.

He has studied the effect on his students. Three years after switching to peer instruction, their learning gains on the Force Concept Inventory over the semester had doubled, from eight points, when he lectured, to 16. Four years after that, his students' increase in conceptual understanding had tripled over the original group's gain.

"I'd been fooling myself for many years thinking I was an effective professor," he said in a lecture at the University of Maryland at Baltimore County that he gave in 2009 and that has been viewed online more than 145,000 times. "But it was a house of cards."

His narrative of discovery has struck a nerve.

It is a staple of his lecture, "Confessions of a Converted Lecturer," that has helped turn him into an academic celebrity. His message, that professors must move away from the lecture, is one that some faculty members are reluctant to embrace. But he's been asked to deliver more than 1,100 talks about teaching since 1990.

Mr. Mazur tailors his pitch carefully. People don't like to feel pushed or told that what they're doing is wrong, so he grounds his talk in his own experience. "I essentially make a fool of myself," he says.

The demand for his speeches also reflects a hunger for advice about teaching. "Deep down," he says, "everybody realizes that there are huge failures in the system."

Harvard, too, enhances his influence. It is supportive of teaching in general and of his work in particular, he says. The institution also provides him with a perch to spread his message and bypass his audiences' resistance. If students as well prepared as Harvard's aren't learning through traditional methods like the lecture, his story suggests, then the same thing must be happening elsewhere.

A key moment in his talks is a demonstration of an exercise he does with his students. One of his standbys involves a basic concept about how molecules behave when they are heated. He explains it, then asks those in his audience to apply the idea to a new context, make a prediction, and persuade someone nearby that their answer is right.

How to Remake a Course From the Ground Up
Eric Mazur has crusaded for decades against the lecture, favoring an alternative method called peer instruction. Three years ago, he went back to basics and designed a new physics course for nonmajors. It emphasizes team-based projects, uses positive peer pressure to motivate students, encourages cognitive growth and risk taking, and harnesses the social aspects of learning. Here are how three familiar features of a typical course get a makeover:

Readings
Students read material before class on an online platform called Perusall, which Mr. Mazur and his colleagues developed. Students post comments on the reading and respond to one another's annotations, and these comments drive the next class.

Homework
To answer each problem, students do four things: articulate the problem in their own words, devise a plan to answer it, execute it, and evaluate how well it worked. They complete the problem sets alone before class and work in teams during it to correct errors. They are not graded on how correct their answers are but on their effort and their accuracy in judging how well they understood the problem.

Exams
There are none, but students do complete five hour long "Readiness Assurance Activities" during the semester. In the first half-hour they solve the problems alone; they can consult the internet but not one another. In the second, they go over the problems again, this time with their teams. Their scores reflect individual mastery and collective contribution.

The effect can be galvanizing. Lynda A. Murphy, director of the Office of Teaching and Learning with Technology at Texas Woman's University, recently brought Mr. Mazur to her campus in Denton after a year and a half of effort. She had been encouraging her colleagues to use techniques that prompt students to apply what they learn. Mr. Mazur, she says, had the scholarly gravitas to get instructors to see these methods' value and try them.

"Everyone in the room was buzzing," she recalls. People were pounding on desks, trying to persuade one another that their answer to the thermodynamics question was correct, she says. "It was hysterical."

Mr. Mazur has visited more than 40 countries delivering presentations like this, and awareness of the kinds of strategies he advocates is growing in his field.

Close to 90 percent of physics faculty members said they had heard of research-based teaching strategies like Mr. Mazur's, according to a 2012 study. A similar percentage had used these practices, and, among those, nearly two-thirds stuck with them.

Peer instruction is regularly cited in grant proposals and papers, both in physics and beyond. Over a recent lunch, Mr. Mazur unholstered his iPhone to run a search of scholarly citations of the term. The last time he checked, there were about 1,000 references to peer instruction, he said. His expressive eyebrows rose. "Wow," he said. Today there are more than 9,000.

Even now, Mr. Mazur remains keenly aware of the academic hierarchy that separates researchers and educators. He is adamant about maintaining his productivity as a researcher. Next year, he will serve as president of the Optical Society, a disciplinary group. His lab employs some two dozen researchers, most of whom work on projects involving short laser pulses and black silicon (he maintains a separate, and smaller, project on education research).

Still, being a teaching evangelist has proved lucrative. He and two partners developed software called Learning Catalytics, a cloud-based assessment system, which they sold to Pearson in 2013 for a reported $10 million. And in 2014, Mr. Mazur won the inaugural $500,000 Minerva Prize, a no-strings-attached grant recognizing his work in the classroom.

But every evangelist needs an audience of doubters to convert. Mr. Mazur estimates that the vast majority of faculty members are still content to lecture, and he likens changing the habit to moving a mountain. His gut feeling, he says, is that the share of professors who still lecture is somewhere around 95 percent. "Maybe I'm underestimating," he says.

Mr. Small, of Cal Poly, disagrees. It has become almost obligatory, he says, for physics professors to talk up the importance of active learning instead of lecturing. Even though a method like Mr. Mazur's has become widely accepted, says Mr. Small, "people will often respond as though it's revolutionary."

Even as peer instruction became widely adopted, Mr. Mazur was restless for change.

In studying data on his students, one point bothered him. Although peer instruction produced gains in conceptual understanding, his students' sense of competence, or self-efficacy, dipped. It wasn't as bad as in traditional courses, he says, but it was still a decrease.

"I felt crushed," says Mr. Mazur. He thought back to how he once felt as a 5-year-old in the Netherlands, where he grew up. His grandfather gave him a book about astronomy that captivated his imagination. When he entered Leiden University, he declared his major in that subject but dropped it six weeks later. The big questions that once animated him had been replaced by the drudgery of equations about star positions.

Eliza Grinnell

The Harvard physicist and education innovator Eric Mazur discusses momentum and potential energy with students as they demonstrate their Rube Goldberg machine. "Learning," he says, "is not a spectator sport."

He wanted to help his students regain that sense of wonder. Peer instruction did little more than make the best of an inherently flawed model, he realized. "I'd taken something broken, the lecture," he says, "and tried to make it better."

He decided to build a course from scratch. After persuading his dean to let him take time off to rethink his teaching, he dug into education research and took a tour of other campuses to study what they were doing. He concluded that two things needed emphasis: students' motivation and the social dimensions of education.

The result is Applied Physics 50, a yearlong course designed to fulfill physics requirements for majors in other science disciplines. A few universities are adopting the model on their own campuses.

Project-based learning is the center of the new course. Students work in teams. Many projects have low-stakes competitions attached to them, like constructing the most secure safe by using magnets as locks. Other projects have an explicit social benefit, like building musical instruments for an orchestra for poor children in Venezuela.

If peer instruction forced students to participate in class, the new course makes them take it over. Professors are often urged to place more onus for learning on students; the advice is that they should be a guide on the side instead of a sage on stage. In his new course, Mr. Mazur has moved himself far offstage; he missed about 40 percent of the meetings this past semester. Class just rolls on without him.

During a recent visit, students huddled around tables near whiteboards. They designed spectrometers, figuring out which lenses had the right focal length. They chose materials and argued over dimensions. Teaching assistants walked through the room, dispensing advice here and there. "Don’t just go off and build," one said. "Draw up a plan."

Mr. Mazur reconceived homework for the course, too. Students aren’t scored strictly on the accuracy of their answers but on their effort and how well they evaluate their work. If one of them skips a problem set, the score for the entire group suffers. Peers, Mr. Mazur says, are a far greater source of motivation than a professor.

His syllabus dedicates two paragraphs to the virtues of failure. Students are warned that some of their scores may be lower than what they’re used to. They should see failures, he writes, as "learning opportunities, not negatives, as steppingstones to success."
Repeated failure, as he has learned, is necessary for success.

Dan Berrett writes about teaching, learning, the curriculum, and educational quality. Follow him on Twitter@danberrett, or write to him at dan.berrett@chronicle.com.

Why Every College Student Needs To Take Science Courses

Chad Orzel , CONTRIBUTOR

I write about physics, science, academia, and pop culture.

My "day job" is as a physics professor, and one of the things those of us in the business agonize about is the steep drop-off in students taking physics at various levels. Using statistics from the AIP, nearly 40% of high-school students take physics, while putting together enrollment numbers and the total college population suggests that the fraction of college students taking physics is a factor of ten smaller (this is a crude estimate, and seems low but not wildly implausible). Very few of those take anything beyond an introductory course required for some other major– years ago, I went to a conference on introductory physics teaching, and the factoid I remember is that only around 3% of students who take the intro course go on to take another class.

The problem is particularly acute for physics, because we have a (not undeserved) reputation as the hardest and most mathematical of the sciences, but it's part of a more general phenomenon. Lots of students take science in high school because it's required (either formally as a graduation requirement, or informally as a "you need to take this set of elective courses if you want to get into a good college" kind of thing), then run away as fast as they can when they get to college, and have (nearly) full control of their course selections.

Students who aren't already planning to major in science often regard it as a waste of their time, a message unfortunately echoed by powerful politicians. Most colleges and universities have some sort of "general education" requirement forcing students to take at least a couple of math and science courses, but many non-science majors will take the barest minimum, and work very hard to put those off as long as possible. Disgruntled spring-term seniors who don't want to be in the course but can't graduate without it are a regular and unpleasant feature of our "Gen Ed" courses in physics and astronomy.

This approach is a major mistake, and having offered some advice to future science majors, let me offer some encouragement for non-scientists facing the prospect of having to take science in college. There are lots of reasons why you *should* take science, or at least shouldn't avoid it; here are a few.

The passage tomb at Newgrange, outside Dublin (photo by Chad Orzel).

Science Is What Makes Us Human Academics studying art and literature aren't shy about claiming fundamental status for their subjects, regularly declaring that art and literature capture something essential about the nature of being human. They've even successfully branded themselves as "the humanities," as if all other areas of study are inhuman and alien.

In fact, though, science is every bit as fundamental to the human experience as art. Art scholars will point to ancient paintings and sculptures as evidence of the fundamental human drive to make art, but science is a necessary precursor to those. Before some proto-human could paint hand prints on a cave wall, they needed to figure out what rocks to grind up to make the pigment, and how to mix them with ash and animal fat to make paint. That process demands reasoning that is fundamentally scientific.

Branding aside, the scientific mode of thinking is not alien and difficult– scientists are smart, but not *that* smart. When you actively avoid engaging with science, you're cutting yourself off from a deep and fundamental part of the human experience.

Science Is More Familiar Than You Think Following closely on the previous point, I would argue that scientific thinking, broadly defined, is an essential part of all manner of everyday activities. Things that non-scientists do for fun and relaxation are, in fact, making use of the same reasoning process as scientists making discoveries. Hobbies like stamp collecting, hidden-object games, or playing sports draw on the same process that scientists have used in the past to make great discoveries.

Yes, science requires a good deal of specialized background knowledge; so does anything worth doing. The core process is fundamental and universal, though, and if you focus on that, you'll find that science is not so different from ordinary hobbies. If you understand how to play cards, you can understand the path to dark matter, and pretty much any of the other great discoveries that have reshaped our understanding of the universe.

(As you can tell from those links, this is a Thing for me– I have a whole book about the ways scientific thinking shows up in everyday activities.)

Leah Roth (2R), a junior biology and pre-medical major, attends physiology class before soccer practice April 15, 2015 at the University of Mary Washington, a coed school and Division III member of the National Collegiate Athletic Association, in Fredericksburg, Virginia. The 2015 FIFA Women's World Cup, hosted by Canada, will be held from June 6th to July 5th. AFP PHOTO/BRENDAN SMIALOWSKI (Photo credit should read BRENDAN SMIALOWSKI/AFP/Getty Images)

Turnabout Is Fair Play At this point you might be thinking "You may be right that I *can* use scientific thinking, but I'm not comfortable doing that." And, sure, personal inclination plays a big role.

But then, the same thing is happening to many of your classmates who plan to major in science. Those same general education requirements that make English majors take science classes force science majors to take English classes. And in the very same way that many future literary scholars find it uncomfortable to work in an explicitly scientific mode, many future scientists find it uncomfortable to grapple with the fuzzy ambiguity of literature. If anything, the non-scientists often have it easier, because science departments generally offer special courses tailored for the interests of non-majors. Pretty much any college or university will have some variant of "Physics for Poets," but it's exceedingly rare to find anyone offering "Poetry for Physicists."

So, yeah, you may not necessarily find the scientific mode of operation congenial. But some of your classmates feel the same way about whatever you're majoring in, and they have to take those classes, too. It's all part of the essential process of " making yourself into the person you want to spend the rest of your life with."

In this April 3, 2009 photo, Vassar College biology and cognitive science professor John Long, second from right, and his students look on as swimming robots navigate in a science lab pool in Poughkeepsie, N.Y. Long is among a small group of researchers worldwide building robots that can do things like shimmy through water or slither up shores to aid the study of biology and evolution. They believe the practice is likely to grow as technological advances allow robots to mimic biological actions far better than before. (AP Photo/Mike Groll)

College Science Is Not High School Science A lot of the apprehension new college students bring to math and science classes stems from bad past experiences. These often result from teachers with limited resources, sometimes working well outside their own areas of expertise, forced to teach a prescribed curriculum aimed toward a particular test.

Many of these constraints will be different at the college or university level. If you take physics in college, you'll be taking it from a physicist, not a biology education major who needed to pick up the physics class because the district can't afford a separate physics teacher. The people teaching your classes will be genuine experts in the subject matter in ways that high school teachers often are not. And the available resources for labs and hands-on investigation are often far better than you'll find at the high school level.

More than that, if you're taking one of the targeted "gen ed" courses for non-majors, you'll be getting the "Good Parts Version" of the subject in question, a selection of the most interesting topics presented in an accessible way. Last fall I taught a non-majors course on relativity, where in a single course we got to topics that only show up in senior-level electives in the major sequence. You don't need to go through two courses' worth of blocks sliding on inclined planes before getting to talk about black holes and wormholes.

You may think you don't like science based on bad experiences in high school, but it may just be that you don't like *high school science. What you see in college is a very different thing, and you may well find it more appealing, even inspiring.*

The road ahead will be rough, and science will help you navigate it. (Photo by Chad Orzel)

Even If You Don't Care About Science, Science Cares About You There's really no way to avoid an "eat your vegetables" item on a list like this, so, well, you need to eat your vegetables. By which I mean that even if you don't personally find science congenial, your future life will be affected by scientific issues in a deep and profound way, and you need to understand at least a little bit about it to make informed decisions.

The biggest challenge facing future generations will be dealing with climate change and its consequences, which is fundamentally a scientific issue. In coming decades, critical policy decisions will need to be made– about energy sources, mitigation strategies, etc.– and getting those questions right demands some scientific information. Public health is another huge issue, requiring informed decisions about how to fight pandemic disease, an aging population, etc. There are even strong scientific components to economic and ethical issues like the societal displacement caused by increasing automation and computerization of, well, everything.

Scientific knowledge even comes in to more personal decisions. Scientific thinking will help you avoid all manner of medical quackery and other scams, which can have disastrous consequences.

Successfully navigating the road ahead will require making informed decisions. This will demand not just trivial knowledge of facts, but some understanding of scientific standards and methods for evaluating information. This is acquired in, yes, science classes.

So, for these reasons (and many more), I would urge all students to take science classes in college, and take them seriously. They'll connect you with an essential part of the human experience, they'll probably be better than you fear, and they'll help you gain essential skills for navigating the future. Science courses aren't an arbitrary bullshit requirement imposed to protect faculty jobs, they're a necessary step in helping you become a better citizen and a better human being.

Knowing Student Misconceptions Key to Science Teaching, Study Finds

By **Erik Robelen** on May 3, 2013 10:02 AM

It seems obvious that teachers need to understand the content they're trying to convey to students. But a new study finds that what's especially critical to improved science learning is that teachers also know the common misconceptions students have. And in science, there are plenty of things that young people—and a lot of adults—don't correctly understand, such as what causes the change of seasons.

The study, conducted by researchers at the **Harvard-Smithsonian Center for Astrophysics**, targeted middle school physical science. The researchers enlisted 181 teachers to administer a multiple-choice test of student knowledge of science concepts. Twelve of the 20 items were designed to have a "particularly wrong answer corresponding to a commonly held misconception," explained Philip Sadler, the lead author and a senior lecturer at the Harvard-Smithsonian center.

The "unusual" part of the study, he said, was that teachers also took the test, and were asked to identify both the correct answer and the one students were most often likely to incorrectly select. Although the teachers overall did "quite well" at selecting the correct answer, the results were more mixed in predicting students' incorrect response.

"Teacher knowledge was predictive of higher student gains. No surprise there," Sadler explained in an email. "However, for more difficult concepts where many students had a misconception, only teachers who knew the science and the common misconceptions have large student gains." What's key, he said, is knowing "what was going on in their students' heads."

The study, supported by funding from the National Science Foundation, was recently **published online in the *American Educational Research Journal***. The study also is the focus of an article**published yesterday in *Science Daily***.

The researchers acknowledge that many educators question the value of tests composed of multiple-choice items, but said in the study that when items are written to include popular misconceptions as "distractors, they function well in diagnosing misconceptions that impede the learning of science." The test questions were based on concepts covered in a set of **science content standards published by the National Research Council** in 1996. Topics addressed included properties of matter, motions and forces, and transfer of energy.

In his email, Sadler said the study was sparked by the reaction many educators have had to a video he helped to develop, called **"A Private Universe,"** in which graduating Harvard University seniors reveal "the same wrong ideas" about science as middle-school students.

"So many teachers have sought me out at conferences after viewing [the video] to tell me that it was a turning point in their teaching of science," he said. "They report that although they knew that some students had unusual ideas, they were unaware of the extent and near universality of misconceptions concerning concepts that they teach."

By the way, while I had Sadler's attention, I asked him for a few quick thoughts about **the Next Generation Science Standards** just finalized. He was upbeat about the standards, but cautioned that effective implementation will be a heavy lift.

"I think they represent a terrific ideal for what students should be learning," he said. "However, their implementation really depends on investing in teacher professional development, more lab equipment, and far better assessments than we now have."