A Reflection

…a former SI leader's thoughts on the value of PHYS230 and PHYS231 and words of advice to incoming students.

This account reflects the opinions and views of a former student. Professors do not endorse nor can they be held liable for the contents of this account.

While I was a student at Palomar College, it was rare I took a class with a professor who demanded high-quality work from a student. No one complained about this, though, as most students enjoyed getting high grades after professors provided thorough study guides which were near replicas of the exams, cramming for tests, and becoming very good at having their hands held as they through their education.

The educational system forgot that education's purpose is to improve a student's understanding, and now generations of students are entering schools placing priority on degrees and titles and subordinating their own personal development. The idea of entitlement to a passing grade or perhaps congratulations after exerting minimal effort—which is usually all that is required to meet the low standards set for community college students today—has reinforced the idea that a good student is one who gets high grades. Just as course difficulty is not necessarily an indication of course quality, high grades do not prove that a student is *capable*. A good student is one who *learns*, gains understanding, and develops his skill. As you may have already experienced at Palomar, one may not have to understand much to earn an A grade.

Nearly all students who enter the PHYS230 series have declared majors in the physics, engineering, mathematics, or science field. Participation in these fields requires diligence, precision, patience, adaptability, strong core skills (mathematics and physics, to name two of the many), and most importantly independence. Who will hire you and then hold your hand through your projects? School is the place to develop the wits and attention to detail characteristic of a competent scientist or engineer. Degrees and titles may win you jobs, but your skills will allow you to *keep* your job. Everyone you compete with in these fields will be degree-holders, but not everyone will be *competent* degree-holders.

Palomar's physics series is a change of pace for many students because suddenly students are treated as able-bodied individuals, capable of taking initiative, being responsible, and holding their learning in their own hands. The professors provide an opportunity for students to demonstrate their resolve and determination in solving challenging problems, much like what is expected of scientists and engineers. If a student does not enjoy the rigors of these fields and the high standard of excellence set for all scientists and engineers, what has the student lost after changing his major in community college? It is better to change majors in a community college than it is to pay tens of thousands of dollars in tuition at a four-year university and decide, “This is not the major for me…”

The professors understand that you are but students, and so they will be available to help you every step of the way, if you can demonstrate that you are an *active learner*. Asking questions when something is unclear, reviewing and repeating all in-class examples at home, mastering class notes and course subjects, and exhausting all ideas towards a solution before asking for help are qualities of an active learner. Professors will not spoon feed you solutions and approaches, not to be mean to you, but to prove to you that you *do not need* to be spoon-fed. They demand great academic achievements of you to prepare you for the expectations that will be placed on you in universities or colleges you may transfer to and to demonstrate that you are capable of these great achievements.

Many students who have dropped or failed a course in the physics series share that they learned more about themselves than they did about physics. This series highlights bad habits, habits that cannot continue in the life of a successful scientist or engineer, let alone a successful student. These bad habits include procrastination and a lack of diligence and initiative. I won’t elaborate here too much because you will discover your bad habits or rusty skills throughout your experience in the physics series.

The physics series is usually the first point in an undergraduate student’s academic experience where high quality is not just spoken of but is actually demanded. The courses are not designed as traps to punish students or reduce GPAs.

Why do so many students struggle with the course, then? Students struggle because for the first time many of them are coming to understand what it means to *learn*. To learn as a scientist or engineer is not to memorize keywords or know where to put numbers. You will find yourself using mathematical functions in these courses, and where we were so often taught what each part of the function did or represents and where we can insert numbers to receive some kind of output, we were hardly taught where the function came from! How well do we understand things we treat as black boxes? By the end of a collegiate education, who would you guess understands more: the student who can *use* tools or the student who can *make* them?

Newton had great ideas which he could not manifest mathematically because the mathematical tools of his time were inadequate. So, he developed more tools. Newton was not the end of mathematical learning. We may find ourselves in his shoes someday in whichever field we are working in. Will we be ready to develop the tools we need? We cannot build reliably from a foundation until we understand the way that foundation works. Perhaps we, like Einstein, will even come to challenge a foundation, recognizing that it is our own assumptions that limit our tools. How could you start thinking about such things if you are unsure of why we have the tools in the first place?

PHYS230 and PHYS231 require students to master foundations by not only being able to use them but also by stressing the ability to derive them. For many students this is not an easy task because this rigor requires overcoming bad habits and dedicating oneself to a much higher work ethic. For many of these same students, these bad habits and low work ethic persisted in education until now and appeared to be sufficient thanks to low academic standards. These foundations and the personal characteristics required to succeed in these physics courses are fundamental to a successful career as a scientist or engineer. PHYS230 and PHYS231 emphasize students' critical thinking abilities. These courses (currently) above all others provide future transfer students with the strengths and expectations they will need to be successful, survive, and thrive in other colleges or universities.

I'll end my reflection on the uniqueness I see in the physics series, and I will now share, in no particular order, advice for students of the courses. This is based off of the experiences and insight of several former students, several former SI leaders, and myself.

When the professors share an example on the board, ensure that you can perform that work on your own as well. To perform on your own is not to solve a problem using class notes as a guide. To perform on your own is to be able to do the problem the professor demonstrated without using any aids to solve the problem.

This is different than memorizing a problem. You should not memorize the question or the numbers involved. Instead, be able to work out problems without referencing notes for help. The professors follow fundamental steps, which they will share with you. These steps are applicable to all problems similar to the type you will be working on, and it is these steps that the professors expect you to apply in your solutions to problems. The idea is not to memorize a problem but to understand the fundamental steps taken in solving a problem of a particular type.

To properly rework a problem that was introduced or solved in class, be able to break the approach to the solution down into fundamental steps like you witnessed the professor do. *Do not simply copy your work*. Copying your own work is helpful for some students, but it does not guarantee that you can solve a problem by breaking it down into fundamental steps.

Quizzes often test your understanding of working with the fundamentals of physics. In a quiz, you cannot reference your notes, so prepare as if you were taking quizzes. Of course, you will need to look at your notes until you have mastered the fundamentals taught in that lecture, but once you are comfortable with them, start quizzing yourself on the fundamentals and what was taught that day.

Also, do not neglect what was taught last week, the week before, etc. Physics is cumulative, and as such, the course work is cumulative as well. Work later in the semester will involve the basics learned early in the semester. You cannot take an exam and then forget about the material it covered and still be successful.

The professors mention that students should do the homework four times to be fully prepared. They don't elaborate on the significance of "four" times, and this number may appear arbitrary. Doing the homework exactly four times will not necessarily prepare you for success. What the professors want to emphasize is that the homework must be done *as many times as necessary* in order for the student to master the fundamentals and concepts of that chapter. It is actually detrimental to do the homework too many times because you will start memorizing the problems and you will no longer think critically.

If you need more review and problems to practice with, do the homework problems from the relevant chapters in your course textbook. Doing the homework once may be sufficient for some students, but other students will need to do the homework a few times in order to grasp how to use the fundamentals of physics taught in that chapter. The point is that you must do the homework as many times as necessary to understand the concepts and fundamentals. Homework is not collected and graded because it is simply an opportunity for you to refine and develop your understanding.

AP students—I was also a physics AP student in high school. The warning letter mentions that AP students should take special care not to fall behind. I recognized many familiar fundamentals from my AP physics class, and I was comfortable with them, so I took the course lightly until the first foreign material was presented.

I did not have as good a grasp on the fundamentals as I should have, and when it came time for me to know those fundamentals inside-and-out to master the new material, I fell behind. It sneaked up on me quickly, and I was not able to catch up by the end of the semester. (I was always several days behind in my reviewing and about a chapter behind in the homework.) Do not make my mistake; do not underestimate the class.

Keep in mind that labs are meant to teach you something. Perhaps you may have been conditioned already to envision lab time as time where you set up some kind of apparatus and then perform the steps you are told to perform in order to obtain fill-in-the-blank information. The physics labs in the 230 series are the middle ground between fill-in-the-blanks labs and designing your own experiment from scratch. They will help you transition from guided lab experiments to upper-division design-your-own-experiment labs. Because of this, the 230 series labs are generally more challenging than labs in other classes.

"Lab reports" are very real things; they are present in any field of science or engineering. In the professional realm, they are called "papers". A paper is the ultimate lab report where researchers detail how they set up their own unique experiment (their procedure), the results their experiment produced (their data), how they may have worked with their results (their calculations) to confirm or deny a theory or question (their conclusion). Unlike introductory labs, at the professional level researchers are not told which procedure to follow. They need to create, on their own, a lab to test or demonstrate something in question.

Remember that the entire lab is concerned with the idea that you will *confirm or deny* a theory or a fundamental of physics. In these classes, you will be attempting to experimentally confirm nearly everything you learn.

Do not mentally separate lab from lecture. Sometimes quizzes or exam problems are based on what you performed in a lab. Theoretically, these are “easy points” to earn, but many students are incapable of correctly solving the quizzes or exam problems based on labs because they have not reviewed what they learned in lab.

You may have heard the rumor that final scores on a lab report can be negative (as in, below zero). This is true. If you find yourself ever getting negative points on your lab, you are either fabricating data or are repeating a mistake that the professors have warned you about. You *must* review the professors’ notes on your old labs so that you do not make the same mistakes twice. If you continue making mistakes professors have warned you about, your grade will be affected severely.

Are the professors out to punish you? No, you are punishing yourself. You are making mistakes you have been warned about. Employers and team members will not tolerate this for long in a work environment. You must learn now, in school, to recognize those mistakes and bad habits and be diligent to correct them. You are never (rightfully) given a negative score out of spite. Every negative score I have seen students receive is rightfully awarded due to the particular lab team’s carelessness. Pay special attention to the professors’ recommendations and any list they may share that details mistakes to avoid.

Regarding papers, the most reputable papers today are peer-reviewed. That is, they are read and critiqued by scientific peers before they are published. In a similar fashion, you *must* have your entire lab team read *every* part of the lab before submission. Professors do not necessarily check that everyone has read through the lab before you submit it, so you can still submit a lab without your team’s full peer review; however, you can catch many small mistakes before you submit your report if everyone scrutinizes the report. Otherwise, the professors will catch all of your mistakes and that will be reflected in your lab score.

The professors constantly emphasize several rules to follow to create a well-organized lab, yet students often break these rules at the expense of lab points. One such rule is that the “data” portion of your lab should be just that—data. *Never* include in your data tables a number that you have manipulated.

For example, if you need the radius of a disc for your calculations, in your procedure you will state that you must measure the *diameter* of the disc and record the diameter in the data table. Then, in the calculations (where you are allowed to start manipulating data—doing conversions and corrections for instrument offsets, etc.) you can obtain the radius from the diameter.

How can one accurately measure the radius of an object? With the tools in this class, we cannot accurately measure a radius. It is more reliable to measure the diameter. In the data section, you record *everything you measure, exactly as you measure it*. To get the radius from the diameter, it is a simple matter of dividing the diameter in half, but we didn't measure the *radius*, so we cannot write the radius in the *data table*. The point I am making will be much clearer if you ask a professor or a Supplemental Instruction leader for a former student's high-quality lab report.

Another quick example of record-what-you-measure: pretend you are to work with measurement values in kilograms, but your instruments only report mass in pounds. You read values in pounds from your instruments, so you must record the values *in pounds*. You can take care of the conversion to kilograms in the calculations section.

Another rule stressed by the professors is that of *parallelism*. The procedure must parallel the data table. That is, in the procedure, if you say that you are measuring the hypothetical values *length1*, *length2*, and *length3* (and you list them in that order), then your data table must present those measurements *in the order listed*.

Do not pain the reader by listing the measured lengths in your procedure as *length1*, *length2*, and then *length3*, and then recording these in the data table in the order *length2*, *length3*, *length1*. This sounds trivial, but this is the attention to detail that the professors expect. You can choose not to fulfill their expectations, but your lab score will suffer. If errors like these persist in your career, then a review committee who is tasked with attempting to make sense of your poorly-organized presentation will probably reject your papers.

Again, for the clearest examples, request an old high-quality lab from your professor or SI leaders, and look for how the authors organized their report and preserved parallelism between the procedure and data tables.

Your lab team members have a huge influence on whether or not your lab group will be successful as a whole. The professors (and I) encourage you to work with the best lab members possible. These individuals will, more likely than not, be active learners. On your first day of lab, you will probably not know anyone in your lab period, so you will be stuck with strangers. In about a week or two, you will discover which lab members are high quality.

Do not feel obligated to remain with your lab group for as long as possible. If you feel that you would be more successful in another group, get the other group's permission to join their lab team and announce to your team that you are leaving their group. This is in your best interest. It is your lab score at hand.

Conversely, if you feel that a particular lab member does not perform in a manner satisfying to the rest of the lab group, you are free to remove that member from the team with the group's consent. For any complications, visit the professors about these issues. Changing group members is highly encouraged in order to be in the group that is best for you. If you leave a group, do not feel like you have insulted your team members.

Consider what happens when your team must meet for a lab but one member does not show up. You've waited for her for nearly twenty minutes because you don't want to start the lab without her. It turns out that she has either dropped the course or has joined a different lab group. Because she didn't tell your lab group, your team has just lost twenty valuable minutes of lab time. This time is non-recoverable.

There are two good measures that you should put into place for a well-organized lab group. The first is to set a deadline. That is, agree that if your lab team has not assembled by fifteen (or whatever deadline you choose) minutes after the lab period starts, whoever is missing from the group at that time cannot participate in the lab. A lab member cannot walk in on an ongoing lab and join the group. If a person wants to join a lab that is *in-progress*, that lab group must start the entire lab over in order to add the new-coming lab member to their team for that lab. This is why you should enforce a deadline: to prevent lab members from holding your team back any longer than is reasonable.

The second measure you should undertake is to stay in contact with your lab group. *Do not wait for your lab members to contact you.* You must contact *them*. Otherwise you may be stuck waiting for a member who will never show up, like in the case mentioned above.

It should not need to be mentioned, but for reiteration's sake, do not fabricate numbers (cheat and lie) in your lab reports. The professors have been working for many years with the labs you will be assigned, so they are familiar with which results and measurements are reasonable. Some professors may give you a score of zero points for that lab. Others may report your cheating to the school board, and you will be expelled.

Finally, it is important for as many lab members as possible to attend lab prep sessions. After reading the lab manual and pre-lab documents, you will likely be uncertain about the look and feel of the equipment you'll be using, or maybe you can't visualize how the procedure should be performed. Lab prep serves to demonstrate every lab that you will participate in. Lab prep shows which equipment to use, how to use the equipment, possible pitfalls and tips, and even the calculations for that lab. If you miss lab prep, do not expect the professors to explain the lab to you later in as much detail as was in lab prep, unless you have previously arranged your absence with them.

You must prepare yourself for lab prep. The professors expect you to know the general procedure, equipment you will use, what you will measure, and what you will calculate and demonstrate (theory or fundamental confirmed or denied), among other things. If the professors ask for participation (ask questions) in lab prep and no student participates (no one responds because they have not read the lab material before lab prep), the professors are likely to walk out of the lab prep session and you will be left to fend for yourself. If this happens, the professors will still grade the lab just as critically as if they had given a complete lab prep.

Prepare yourself for a difficult undergraduate course. The series is challenging, but the reward is great. You will be hard-pressed to find another institution that produces students, at the same academic level (lower division), as capable as those that complete this physics series. Be a diligent, active learner, and the hardships of this class will pay off greatly throughout the rest of your academic career.

Best wishes,
Former physics and engineering SI leader
Computer Engineering, Cal Poly SLO
8/21/2012

[Revised 14/12/2012]