# How To Learn From Homework

*Physics*

If you are ready and willing to use your homework as a learning experience, rather than to practice a skill you already know, read on! If you are frustrated by and/or resistant to this approach to learning, skip to the section "Why?" – it may help you understand why this technique is critical to learning how to solve physics problems.

***"How …"***

Typically, math homework is designed to help you practice a skill that you've learned but not yet mastered. That's why you have lots of problems that are very similar. The repetition allows you to move the process from your short-term to your long-term memory.

In physics, the overall process is generally relatively simple. There are only a few steps to remember and they are often the same (or very similar) from topic to topic. What's difficult about physics problems is that by convention, they are story problems that require you to make some sort of intuitive leap in order to finish the process. The intuitive leap – which I refer to as a "key" – is different for every problem. You and I may have our own opinions about what is important to learn in physics, but the rest of the world has decided that it is important for you to be able to puzzle your way through tricky story problems. So, that's what we'll focus on!

Determining the "key" to a physics problem requires intuition. Intuition can't be taught directly. It can, though, be developed. In order to develop your intuition, you need to train yourself to become highly conscious of which points in a problem require a key. That's where homework comes in – when you do homework in physics, you aren't repeating a process in order to move it to your long-term memory. Instead, you are deliberately trying to find problems that you CAN'T solve. Your goal is to identify as many places as possible where you get stuck in problems. By being aware of these places, you will "prime" your brain for learning (whether it's from me, the book, your friends, parents, tutors, or any other source). Here's how it works:

1. Make sure you try ALL the homework problems every night. Since the "keys" are all different, it isn't enough to just try a few and assume you've got it down.
2. If you get a problem right, in a reasonable amount of time, you don't need to spend very much additional time practicing problems that have the same key.
3. When you CAN'T get a problem right, that's where the real learning begins:
    a. Don't get frustrated. You aren't expected to be able to do all the problems correctly. If you find one that you can't do, it's not a bad thing – it's a learning opportunity that will help you develop your intuition.
    b. Make sure that you clearly indicate in your work where you got stuck. You may need to go back to that point several times.
    c. Try to verbally describe the barrier you've run into. Is it that you can't figure out which equation to use? You can't find any more numbers by using the equations? You feel like you're missing a number or piece of information? If you

can use words to describe why you're stuck, it will help you identify and/or learn a way around the barrier.

d. Use the resources you have available to try to figure out what to do next. When you're at home, that might just be the book. Or it might be the book, your notes, and information on-line. If you have a person you can talk to, that can be a huge help as well. You don't need to spend a ton of time on this – if you can figure out what to do in 5-10 minutes, great. Otherwise, set the problem aside until you have some additional resources.
e. Once you're back at school, you can definitely find the help you need by looking in the book of physics solutions or by asking me. (If you don't have time to come in outside of class, make sure to ask about the problem you're stuck on during homework review time.)
f. When you figure out how to get past the point where you got stuck, WRITE DOWN the solution (as well as you can articulate it). The solution that you found is one "key". For example, you might find that in a problem with two moving objects, the key is that at the end of the problem, they are in the same place. That means their final positions are the same. That means you can set their "x" variables equal to each other – which eliminates a variable, potentially allowing you to calculate a numerical answer.

As you accumulate information about the different keys you've discovered, resist the urge to try to memorize them. The reason that technique doesn't work is that no matter how many keys you've seen and memorized, there are always more that you've never come across. The way to get good at solving physics problems is by training your brain to recognize unfamiliar keys. That means you need to find and attempt as many problems as possible that you can't solve, and then follow the steps above. That will eventually allow you to recognize the *general* kinds of things that are clues to a key. Once you start to see that all the different keys are, in a broad sense, the same thing, that's when you will start being able to solve problems that rely on an unfamiliar key. Your brain will be able to deduce, from the information given in a problem, the additional connections you will need to make in order to come up with the correct solution.

***"Why?"***

Sometimes students don't understand the reason that they need to change the way they do homework for physics. It seems reasonable that something that's always worked in the past will continue to work well. And who knows your style of learning better than you do?

The truth is that some students (many, in fact) CAN continue to use homework as (optional) practice, just as they've always done. These students typically either have lots of experience with problem-solving or they are "the lucky ones" – the students who seem to simply have a gift for an intuitive sense of how to go about solving the types of problems encountered in physics.

The rest of us, though, have at least a slight disadvantage. Most science and math problems – up until physics – rely on a set of learned processes; steps that when followed will reliably lead to the solution to a problem. Typical physics problems, though, **require** us to identify a "key" – a trick that is necessary to hurdle in order to follow the process steps. Without the key, we get stuck. Even if we have a step-by-step process right in front of us, we can't figure out how to complete one (or more) steps in order to move to the next one.

It is not impossible to learn how to determine which keys to use when solving problems. However, it requires a different kind of learning than is usually necessary in other math and science classes.

Sometimes students ask (or wonder): "Why doesn't Mr. Bregar just teach us how to do these problems? Then we could practice them on the homework, get good at them, and do well on tests." The answer to that question is "because it **won't work**." I, and hundreds of other physics teachers, have tried. Some students are able to successfully pull it off, but far too many experience something like this:

1. The teacher shows the students how to solve a few different types of problems. (For example – a Big 4 problem that has an initial velocity opposite from the acceleration, a Big 4 problem that requires variable expressions as intermediates, and a Big 4 problem that has two steps necessary to solve it.)
2. The students go home and look at their homework. The problems have been selected to allow students to practice what they've learned (instead of learning new skills), so they are highly similar to the ones taught in class. The students do their homework, or at least a few problems, and feel very confident in their abilities to do the work.
3. Prior to a test, the teacher distributes a study guide. Some of the problems are a little different from the homework problems in that they require a different set of "keys", or the initial conditions are tricky. However, the students ask questions, look up information, and/or work together in groups and eventually successfully solve the problems.
4. The teacher gives a test. Many students do just fine. A sizeable group, though, is shocked at how poorly they do, despite how hard they've worked on homework, the study guide, and studying in general. They feel like the problems on the tests look completely different from the problems they've solved before*. They followed the given steps to the best of their ability, but on many of the problems they got stuck and just couldn't get any further. The students, their parents, and the teacher are all frustrated because they all want the students' strong efforts to pay off with corresponding scores on the test.

(* The problems aren't as different as they look, by the way. The students just haven't learned how to pick out the keys necessary to solve them. For example, if the students have seen problems with an initial velocity that is opposite from the acceleration, they may not know how to solve a problem where the initial velocity is in the same direction as the acceleration. Or if it is a two-step problem, they may need to solve it in reverse chronological order. In the world of physics problems, these variations don't equate to completely different problems. But to a

student who has learned the steps of solving problems without developing the **skills** of problem solving, the similarities just aren't apparent.)

If that's the issue, some students wonder, then why don't teachers just make sure to either a) make the test questions match the homework more closely, or b) show the students how to solve **all** the different types of problems so they're not taken by surprise?

The reason teachers can't choose option (a) is because there is an expectation (on a number of levels, from parents, teachers, administrators, politicians, and the community in general) that students who do well in a high school physics class can solve a wide variety of problems. The reason teachers can't choose option (b) is because there are an **infinite** number of types of problems that can be examined.

The solution, then, is for students to learn how to identify and use the "keys" to the problems *without ever having seen those particular keys before*. This can't be done in the classroom – that time is used to teach general concepts and the step-by-step processes that are necessary. (Classroom time is also used to look at homework problems as part of the learning process, as described in the "How…" section above.) That means we have to be creative about when and how students learn to identify and use unfamiliar "keys". By far the most practical way to do that is by using homework as a learning tool, rather than a practice tool. This is why in countless physics classrooms around the country (and around the world), teachers use this approach to help their students learn how to solve physics problems. It's a little uncomfortable for some students at first, but it is highly effective and is a tremendous learning and growth experience.