Learning Tips for Introductory Physics

Physics is unlike any other subject you will encounter. It requires a unique approach: concepts and practice.

- **General rules**
  - **Don't memorize**
  - **Never miss class**
  - **Time**
- **Helpful approach to your intro physics class**
  - **Before class**
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    - **Information**
    - **Understanding the question**
    - **Use intuition**
    - **Apply physics concepts**
    - **Math**
    - **Does the answer make sense?**

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General Rules

Don't memorize:
Memorizing a solution to a problem will get you nowhere in physics. There more variations to problems than you can possibly memorize. Furthermore, looking at a solution helps only if you understand what it means. The goal is to solve problems on your own. Thus, focus on the main *definitions/concepts* and then apply them as necessary when solving a problem.

<u>Example:</u>
Example: What is Newton's second law? $\vec{F} = m\vec{a}$. What does this mean? It's easy to memorize "'F' equals 'm' 'a'," but that won't get you very far in physics. Look at each piece. "F": this stands for a "force" and it's a vector. Okay, what's a vector? A geometric entity that has magnitude and direction (this will suffice for intro physics). Now, lets look the right hand side. "m" is the mass of the object: a physical quantity that is characteristic of an object (note mass is a scalar: it only has magnitude). "a" is the acceleration. What is acceleration? The rate of change of the velocity of an object divided by the change in time. In calculus terms, $\vec{a} = \frac{d\vec{v}}{dt} = \frac{d}{dt}[\vec{v}] = \frac{d}{dt}\left[\frac{d\vec{x}}{dt}\right] = \frac{d^2\vec{x}}{dt^2}$. What does this mean? It describes how the velocity of the object changes. Now that we have a rough idea of the main components, lets put it all together. This equation can be read in either direction. From left to right: a force is something that gives a mass an acceleration (it makes the mass's velocity change). From right to left: when a mass is accelerating, a force must be acting on it. Try to make sense of each concept in this manner.

Never miss class:
Introductory physics is a rapidly paced class. Missing even one lecture will set you back. Playing catch-up in physics usually results in the student not fully understanding concepts. Get ahead and stay ahead.

Time:
Learning physics is comparable to learning a new language. If you don't put in the time, it's difficult to succeed. The goal is so solve the problems. Watching your professor's solutions will help. However, unless you can solve the problems yourself, you will have a difficult time with your class. Getting to the point of solving problems at will takes time. Expect to put in just as much time out of class (if not more) as you do attending class. You must put in the effort.

A Helpful Approach

Before class:
Read the material prior to class and focus on the chapter's basic definitions. When reading a physics text you should always have a pen and paper accessible; jot down the main concepts/definition/equations. Ask yourself: how does the textbook define

the concept? Don't aim for perfect understanding the first time though; the purpose it to expose yourself to new concepts. As a result, you will be able to more closely follow your professor's lecture; you won't get bogged down in the jargon since you already have already exposed yourself to the main concepts.

During class:
Don't worry about writing down definitions/equations (you already did that before class). Rather, listen to your professor and focus on how his/her presentation of the concept differs from you understanding after reading. Write down the differences. After class go back to each piece of the equation. What did you miss? Subtle differences have a huge impact in physics.

After class:
Go back to the main equations presented in class. By now you have already seen the equations twice. Compare your understanding to the way your professor presented the material. Think of each equation as a puzzle. Each component has a specific meaning and function; putting all the pieces together creates a picture. You won't have a complete picture unless you understand all the components. Be sure to finish each concept's picture before you start solving problems. Subsequently, practice, practice, and practice. The more physics problems you solve, the clearer the subject becomes. If you only solve the homework problems that are to be graded, you will struggle with exam problems. You must put in the effort to learn physics. But, you are not alone. UTP offers physics tutoring every week in Berliner 101: a great way to practice problems. Check the flier outside Berliner 101 for weekly tutoring times.

Most Common Problems

Separating math from physics:
One of the hardest skills to learn in an intro physics course is to understand where the physics comes into play. In general, physics makes several statements (equations) about a given problem. Once you write down those equations, all that's left is simple math. Essentially, you use physics to make statements about the problem and then use mathematic techniques to solve for various quantities. The more you practice solving problems, the easier it is to know what physics concepts to use. Once you become proficient in knowing the physics behind a problem, all that's left is math.

Math:
Math is the language used to communicate physics. A deficiency in the language will make the subject difficult to understand. Many students struggle with physics because they are rusty with their math skills. Taking time out to refine some math concepts will pay huge dividends in your progress. Focus on four main concepts: *vectors*, *trigonometry*, *algebraic equations*, and *systems of equations*.

<u>Vectors</u>

For *vectors*, understand the definition and the associated rules: addition, subtraction, multiplication (cross and dot products), resolving into components, finding the angle between two vectors, etc.

Trigonometry

***Trigonometry* is constantly used in introductory physics. Review the unit circle, sine, cosine, and tangent. Working with components, angles and trigonometric relations should be second nature for you.**

Algebraic Expressions

Recall *algebraic expressions* from your high school math class. If asked to solve for x when $2x + 6 = 12$, you could easily say $x = 3$. Solving for a variable in your physics class involves the same method. However, students struggle with distinguishing between variables and known quantities. Helpful tips are to circle what you don't know in the equations (the variables) and underline the known quantities (given information and fundamental constants).

Example

For example, solve for the coefficient of friction when N, m, g, a, and θ are known in the following expression:

$$ma = mg\cos\theta - \mu N$$
$$ma - mg\cos\theta = -\mu N$$
$$-ma + mg\cos\theta = \mu N$$
$$\frac{1}{N}(-ma + mg\cos\theta) = \mu$$
$$\mu = \frac{m}{N}(g\cos\theta - a)$$

Once you distinguish between variables and known quantities, solving the expressions becomes quite simple. Then all that's left is to plug in the known values.

Systems of Equations

The most common math problems arise with solving *systems of equations*. You must become very familiar with the methods of substitution and elimination; many of the physics problems you will see require these tools. Go back to your algebra text and refresh solving problems.

Example

if $2x + 3y = 6$ and $x - 3y = 9$, find x and y.

Using substitution:

Since $x - 3y = 9$, $x = 9 + 3y$

Now substitute this expression into $2x + 3y = 6$

$$2(9 + 3y) + 3y = 6$$
$$18 + 6y + 3y = 6$$
$$9y = -12$$
$$y = -\frac{4}{3}$$

Now substitute the value for y back into the expression for x:

$$x = 9 + 3y$$

$$x = 9 + 3\left(-\frac{4}{3}\right)$$
$$x = 9 - 4$$
$$x = 5$$

Using elimination:

$$2x + 3y = 6$$
$$x - 3y = 9$$

This case is easy since if we add the two equations, we get

$$(2x + 3y) + (x - 3y) = 6 + 9$$
$$3x = 15$$
$$x = 5$$

Substituting x back into one of the equations, we get

$$x - 3y = 9$$
$$5 - 3y = 9$$
$$-3y = 4$$
$$y = -\frac{4}{3}$$

Notice both methods give the same answer.

Once again, students tend to struggle with distinguishing between variables and known quantities. Use the same method as before (circle variables and underline known quantities). Subsequently, you can set up your system of equations and solve for the unknowns. Remember that you must have as many equations as unknowns to solve the system.

Example

For example, consider solving for the acceleration and coefficient of friction when you have the following expressions (m, g, f, N, θ are known):

$$ma = mg\cos\theta - \mu N$$

and $f = \mu N$

Now we can solve for μ using the second equation

$$\mu = \frac{f}{N}$$

Now substitute μ back into the first equation to find a

$$ma = mg\cos\theta - \mu N$$
$$ma = mg\cos\theta - \frac{f}{N}(N)$$
$$a = g\cos\theta - \frac{f}{m}$$

Notice that both of the expressions for μ and a are in terms of known quantities. Now, just plug in the various values to obtain the answers.

Problem Solving:

Now that you have the necessary foundation, you are ready to solve physics problems. When given a problem, always draw a *picture* first. Visualizing the problem will give you insight into the physics concepts you will need to apply.

Next, write down all the given *information* next to the picture. Many times students get stuck on a problem because they think they have more variables then there are actually present. Writing down the given information will ensure that you don't forget you know certain quantities.

Now, try to *understand the question*. What are you asked to find? Many students write down the quantity that the question is asking to find and place a question mark next to it; this reminds them what they are trying to find.

Next, use your *intuition*. In general, introductory physics is very relatable to everyday experiences. Try to imagine the given problem happening in front of you. Can you predict what should happen? What direction will the object(s) move? What trajectory should an object take? Making informed predictions about the problem will give you insight into the physics concepts you must apply.

Now you can *apply the physics concepts*. Since you understand the question and have an intuitive idea of what should happen, you can write down statements (equations) using physics concepts. This is the hardest part of doing physics: knowing when and how to use a concept. This comes with practice. If you solve enough problems, eventually it will become very obvious which concepts should be used. Then it's just a matter of applying that concept to the given problem (this is quite easy if you really work on understanding the definitions). Once again, physics tutors are here to help you increase your "physics intuition." Stop by Berliner 101 for weekly tutoring.

The rest of the problem comes down to *math*. Separate the variables from the known quantities and use the necessary algebraic techniques to obtain the answer. Even calculus-based physics largely involves algebraic tools. Once again, continual practice will solidify the mathematic tools you need to easily solve problems on your exams.

Finally, always *ensure sure your answer makes sense*. Is the answer close to what you predicted it would be? Are your units correct? If you practice enough problems, you will know what the answers should relatively look like. Some cases are obvious when checking your answer: if you get a speed higher than $3 \times 10^8 m/s$ or a weight of $9000N$ for a little girl, then your answers are wrong. Always go back and check your work. You will be surprised with the amount of careless mistakes you will find.