Chapter 10: Effective Memorization in Physics

You might be blessed with a good memory. For unlucky ones, lectures go in and out your ears. Reading comprehension is elusive to your mind. Life can be a frustrating ordeal and school can be a nightmare, unless …

…You can learn the memory techniques I am about to introduce (one of my favorite parts). They can be fun and creative.

Although physics require more utilization and less memorization, there still is some amount of raw information that must be memorized.

Eight Tricks for Physics Memorization

Organize It: Physics is a relatively structured subject. Organize the physics information in a logical way. Learn the details but keep the bigger picture in mind. Associate the related points and connect them together. Go from the general to the specific.

Understand It: The easiest way to memorize physics concepts and formulas, is to first understand them – what the concept means, how it is being derived and related to others, what are the quantities and units in the formulas, etc. Sometimes, even a little history behind them can help spark your memory when you need it the most. Ask yourself questions about the concept or formula and your answers can be used as a memory key.

Use It or Lose It: The best way to put what you learn into your long-term memory is to use it as much as possible. Solve as many problems as you can. Say the definitions and explanations out loud to yourself. Share with others what you know. Explain everyday observations with physics knowledge. Ask questions whenever, and of whoever you can. Participate actively in classroom discussions. All these activities will better enhance your understanding and boost your exam performance.

Use Both Sides of Your Brain: This is recommended only for the subject area that's hard to understand, and when you are at home. Read aloud. This will help your comprehension since you are using both the right (visual) and left (verbal) sides of your brain, with multiple channels of input to stimulate your thinking and understanding. It has been scientifically proven that a person will be more successful in any profession if they use both sides of their brain.

Incorporating physical movement can also improve your memory and comprehension. Some people pace back and forth while deciding upon the best way to solve a problem.

Practice Often: The best way to memorize a formula is to apply the formula to various problems and scenarios. The repeated practice leads to better understanding, and ultimately to you owning the knowledge. Even if you successfully complete a particular problem, you may want to do it again so that it becomes more integrated into your brain.

Use Super Memory Tricks: Sometimes just recalling the main concepts is not enough; you need details too. Mnemonics is a big help in recalling specifics. Many examples will be given.

Over Study: For hard to remember facts or very important concepts, you can use the technique of over-studying to fight mental fuzziness. Study the material 10-20 times using flashcards, a note sheet, etc. Look at it, write it, read it aloud and listen to it. The topic will become natural and a part of you. Your answers to questions will become practically automatic, just the way you remember the multiplication table.

Break It Up: People seem to remember best when they divide a long list into shorter ones. Segment the information into smaller chucks and work on them one group at a time.

> Consider how you memorize a phone number. People often chunk the information into area code, first 3 digits, and the last 4 digits. In this way, your brain remembers 3 blocks of information instead of a more numerous 10 blocks of information.

Scientific Memorization – The AIR Memory Method

Here is the formula for success in physics:

Successful Physicist = Critical Thinker + **Effective Memorizer**

Scientific facts are hard to remember. So what is a simple way to memorize them?

Let's get back to simplicity. We don't have time to sit under a tree and meditate for hours, or 'om' until the cows come home.

Introducing … the **AIR Memory Method**.

The **AIR Memory** Method is a simple, yet powerful three-step process I have distilled from all the core principles of scientific memorization. I have also used it for many years in my scientific career. While the **AIR Memory** Method is designed specifically for physics memorization, it can also be applied to other science courses like physics.

The **AIR Memory** Method consists of:

A – **A**ttention

I – **I**mpression

R – **R**elation

Once you master the **AIR Memory** method, scientific memorization will be like a breeze of fresh AIR, natural and easy for you.

Step #1: Attention

Attention: Giving close and thoughtful focus.

Paying attention is the first step of the memorization process. We often go through everyday life in a daze, doing many things as the world goes by and paying only a little attention to our surroundings. Most of the time, our mind is not focused. You need to create an environment and state of mind to be attentive.

How can one pay attention?

You can start paying attention and sharpen your memory by following a couple of tricks.

Create a State of Attentiveness – Tell yourself you are now going into the attentive state. Remove yourself from the distractions. Stop multitasking. You should focus on one thing and one thing only. During the lecture you can easily create this state of attentiveness by sitting in front, keeping your eyes on the instructor, sitting up straight, staying away from your buddies, taking notes, avoiding gazing out the window, etc. Refer to the Survival Lecture Guide for more tips.

Keep a Questioning Mind – Another trick of being attentive is to prepare a set of questions prior to the lecture. One of the purposes of preparing the preview notes with five burning questions is to keep you focused on the lecture by listening attentively and seeking out answers to those questions. With those burning questions lingering in your mind, like a hungry wolf waiting to be satisfied, you will surely be very focused. Activate your mind and keep asking yourself questions.

Step #2: Impression

Impression: Making a strong or vivid memory of a fact.

Knowing what to remember is one thing; learning how to remember is another. The memory keys are defined as the materials to be remembered.

How can you make a memorable impression?

In this second step, you will make these keys memorable via a number of memory techniques so that a vivid impression of them will leap into your long-term memory.

Repetition – This is the most common way to remember hard facts. Repeat facts through as many channels as possible – lecture, reading, homework, flash cards, audio, cheat sheets, rephrase, sounding out loud, etc.

Mnemonics – Using mnemonic devices is the most effective memory technique I‘ve encountered to use in science, physics in particular.

You may be familiar with the name **Roy G. Biv**. This name can be used to remember the colors of visible light.
Red, **O**range, **Y**ellow, **G**reen, **B**lue, **I**ndigo, **V**iolet.

From left to right, they are arranged from lowest to highest frequency. Instead of remembering 7 unrelated colors, you now only have to commit one name to memory.

Word Relations – Word relations are used to create a memory trigger using something you are familiar with. For example, you can easily recall the behavior of refracting light. This one was created by a student.

> If light goes into more **dense** optical medium, it bends **towards** the normal. If you have difficulty remembering this fact, remember that dense people need more assistance so they go to the normal people for help. While this may seem a bit harsh, it may help you recall the behavior of light.

Word Roots – Physics terms have very rich origins. Break the words into their prefixes, roots and suffixes. This will help you recall their definitions.

> For example, the prefix **ultra** means beyond the range of. This can help you recall the meaning of **ultraviolet** light. This is simply light that has a frequency higher than, or beyond, violet light. That's why it gives you a sunburn; a higher frequency correlates to more energy.

Use the above memory devices to jot down memory joggers on your cheat sheets of things to remember.

Step #3: Relation

Relation: The learner integrates the parts with each other, so that the whole has a coherent structure and meaning.

This step is the most important one in physics; the ability to relate pieces together into a whole. If you can integrate what you have just learned into what you have learned previously, learning physics will be an easy task. Memorization will become natural for you if you can see the big picture.

> For example, you can relate the idea of force to gravitational forces, centripetal forces, frictional forces, electrical forces, etc. Although they aren't identical, all of these forces will have some similarity.

How can I learn to relate?

The answer is simple – pause for a few minutes and ask yourself if what you have learned so far relates to the new concept just introduced. As I discussed previously, scanning a text is also a good way to relate what you learned previously.

Seeking out for relationships among facts and concepts is not only a memory enhancer, but also a mind activator. This is another study technique most students have missed or skipped.

There you have it, as easy as breathing the **A-I-R** – **A**ttention, **I**mpression and **R**elation.

The **AIR Memory** method is the simplest way I know for physics memorization. Without an effective memory system, you will struggle with loads of facts, concepts, and rules coming your way at every lecture. Practice memorization using this method. Memory is like a muscle: The more you use it and develop it, the more powerful it gets.

How to Create Your Own Mnemonics

Typically in science, keyword mnemonics are a great way to memorize what is needed for class. Here is a simple 3-step process to do so:

Step 1: List the keywords in a logical order.

Step 2: Write down the first letter of each keyword.

Step 3: Create a word, phrase, or sentence from the first letters of these keywords.

That's it! If you get ever stuck in hard-to-remember terms, try to create a mnemonic.

How to Memorize SI Prefixes

In physics you will often be converting units. You'll use physics to describe the very large and very small scales. To help remember the relative order of some of the metric prefixes, use the following mnemonic:

Every	**P**layer	**T**hat	**G**ets	**M**angled	**M**ay	**N**ever	**P**lay	**F**ootball	**A**gain
Exa	**P**eta	**T**era	**G**iga	**M**ega	**M**icro	**N**ano	**P**ico	**F**emto	**A**tto
10^{18}	10^{15}	10^{12}	10^{9}	10^{6}	10^{-6}	10^{-9}	10^{-12}	10^{-15}	10^{-18}

The first letter of each word represents the first letter in a prefix. The large prefixes are in the beginning, the small prefixes are at the end. The very common prefixes of kilo, centi, mill, etc are omitted in the middle of the mnemonic. You may also notice that all of the exponents are spaced apart by values of 3.

How Phonics can Work for You

You can memorize some of your formulas and relations by grouping them phonetically into one work or sound. For example:

Voltage = Current x Reistance	**V = I R**	Remember as say it to your self as "vir". Rhymes with stir.
Power = Current x Voltage	**P = I V**	Remember, and say it to yourself as "piv".

Some formulas may even spell out things.

The formula for work can be written as W = F d or W = mad

Nobody want to do extra work, so you'd be crazy, or **mad** to do **work.**

A common memory device for the ideal gas law, **PV = nRT** is to sound it our phonetically to get something like piv-nert. You can even use corny jokes to remember that same formula.

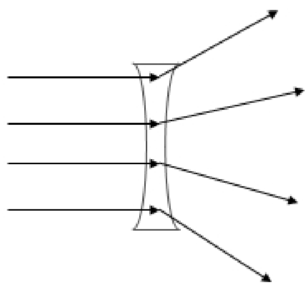
Q: Why are gas molecules always looking into your window at night?

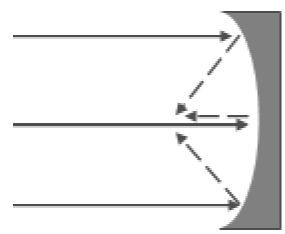
A: Because they are PVnRTed!

See the Lenses and Mirrors

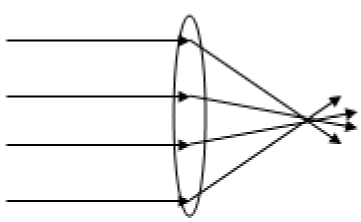
The shape of lenses and mirrors can be ascertained by examining the composition of their names.

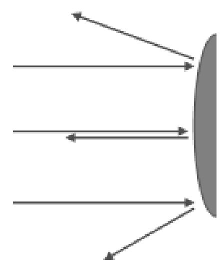
A concave lens or concave mirror obviously goes inward like a cave. Draw either so that there is an inward cave like space. This will describe both concave mirrors and lenses. Each is shown below.





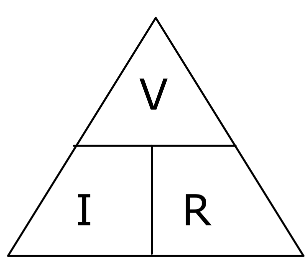
On the other hand, by process of elimination, the convex mirror or lenses wouldn't be like that, they would simply have the opposite shape.





Try the Triangles

A very simple way to algebraically rearrange some formulas is to use a triangle and your fingertip. Although this should be a mathematical piece of cake for most students, it can be used to quickly check for errors. Take a formula such as Ohm's law: V=IR and arrange it in the parts of a triangle as shown below:



For whatever quantity in that formula you want to find, cover that letter up with your fingertip. The remaining letters show you what to do to get that quantity you covered. For example, cover up V, and you must multiply I times R. Cover up R and you must take V divided by I. Try it! This same trick will work for similarly structure formulas like P=mv, F=ma, P=IV, etc.

Orbit Positions

The terms apogee and perigee describe certain points in an orbit around the earth. Since the terms are somewhat similar, they may be accidentally switched. When you see the "a" in apogee, think "a" for away. The other term, perigee, must therefore be the position closer to the earth.

Imagining Fields

Often, a certain notation is used to describe invisible force fields. These are usually electric and magnetic fields. It is difficult to illustrate 3 dimensional space on a 2 dimensional screen, paper, or chalkboard. It is a common convention to use a dot to mean a field pointing directly out of the plane of the page. An X means the field points directly into the page. To remember and visualize these fields, consider the structure of an arrow.

The tip of the arrow is like a dot. If you see that, it means the field is coming right at you, out of the page, like an arrow. . . .

. . .

The feather end of the arrow is like an X if viewed from directly behind. If you see that, it means the field is going directly away from you, into the page, like an arrow going away.

x x x

x x x

That certainly makes it much easier, doesn't it?

The list of memory tricks goes on… Start building your own!

Chapter 11: The Ten Core Survival Skills

Survival Skill #1: Study Effectively like Smart Students

I have talked to and observed hundreds of smart students over the years, and discovered that almost all of them have patterns of successful studying. They tend to follow consistent ways of learning.

Do you want to be just like them?

The easiest way is to find out what they do and clone their actions.

The Secrets of Smart Students

Here is the summary of the study patterns found in successful students:

Study Systematically

Follow a simple system day in and day out and keep it up. Physics is a subject with logic and reasoning. You can maximize your learning in a minimal time by following a system specifically designed for physics. Not all general study tips apply to science learning, and some may lead to failure. Adapt and adjust. Stick with it consistently.

Make it a Habit

Learn how to study effectively and make it your habit. Always prepare for class, show up in lectures, read the assigned text and complete the homework. Missing any of these parts would be like misusing your credit card, it will come back to haunt you. Keep up your good study habits. Once they become part of you, academic success will follow. This is often reflected by success later in life.

Impress Your Instructor

Try to make a good impression with positive study activities. Maintain perfect attendance in class and never be late. If you have valid questions or concerns, visit the professor's office during scheduled hours and be prepared.

Don't ask a question like "I don't get it". This conveys the idea that you're totally lost, and is more difficult for your professor to ascertain how to help you. Instead, ask a specific focused question like " What value should I use for the acceleration?" or " Which formula should I use?" or "What are we trying to solve for here?". This shows that you are at least on the right track, but just need specific guidance.

Participate in classroom discussions. Do your work neatly and show your effort. Never complain. You might get graded leniently if your instructor associates your name with a good impression.

Find Yourself a Mentor

Academically, an educator would be the best candidate to be your mentor. Find a professor you like and you can connect with. Go to the office hours often and establish a good relationship. If the professor seems receptive, ask for advice on other aspects of your education. You may even be assigned a mentor or advisor by the college or university. Use this resource!

Find Your Own Study Zone

Set up a place to study so you can focus and not be interrupted. Use it consistently. The moment you enter your study zone, your study mind is ready for action. Your own room may not be an ideal place since your neighbors and phone may be too enticing. A quiet cube at the library is a better zone if you really need to study.

Set your Routine Study Time

Schedule your prime time for physics. Try to study at the same time every day. As a student, studying is your job. Even if you don't have class for a particular hour of the day, that doesn't mean you are totally off. Your brain will follow this pattern and function at its best. If you are unsure when your peak efficiency hours occur, keep a record of your mental alertness for a week. You will learn your prime study time.

Keep your Concentration

Keep up the pace and study intensely to focus your full attention on the subject materials. Pull yourself back when your mind starts drifting away.

How do you do this when you are tired of studying? Sound familiar?

Here are a few ways to restore your mental acuity and regain alertness:

Physical exercises – a few minutes of jogging with music on or walking a dog will wake you up.

Household chores – brief housework such as doing the dishes or laundry will alter your mind and rest your brain.

Fun-Fun-Fun – a round of games or a chat with a friend will help relax you. Too much of this can be a bad thing. Maintain your discipline.

Short nap – If you still can't ward off your mental fatigue, take a nap – a short one.

My favorite is leisure reading or mingling with my iPod. Whatever it is, find a way to get your concentration back quickly so you can continue your core study.

Break Up Your Study – The 50-10 Method

Long hours of study without breaks is ineffective. The thought of sitting down to many hours of constant problem solving is enough to wear any mind to a complete halt.

I often use what it's called the **50-10 Method**. Partition your study into one-hour blocks – 50 minutes study and 10 minutes break. To top it off, reward yourself with a small treat after an hour of intensive study and indulge yourself even more after a long period of study.

As an analogy, a runner wouldn't train for a race by simply attempting for run for hours and hours at a time. That would be counterproductive. Even if they are a distance runner, they would have specific amounts of training to maximize their effort. You should do the same with your mental training.

Form a Study Group

Take advantage of the talents of your fellow students. Be selective with whom you study. Avoid the social club syndrome and only discuss physics. Have a plan for each group study session. Take turns chairing the sessions. In any group, the real learning occurs through participation. Try to form relationships with other in your particular courses. There is even a nation group called the Society of Physics Students, http://www.aip.org/education/sps/. There may be a chapter at your institution.

Study Alone

While you might want to engage productive group study once a week or so, you definitely want to stay alone when doing your core study. Otherwise, with the distraction of bonding activities, your three hours in the library might end up with only 30 minutes of study.

When you are alone, you can stick with your study plan better (1 hour per session) and don't have to accommodate your buddy's schedule. Besides, by spending your time effectively, you'll have more time to socialize later.

Sleep (not study) in Bed

We all like to do things in comfort. Reading in bed simply sends you to sleep quicker. You can do your non-essential reading there, but avoid doing your core study in bed. Besides, your mind and body normally associate sleeping with bed. Your brain is automatically in that mode while in bed, so study somewhere else.

Study Physics First

If physics is your most difficult subject, study it before all other subjects, when you are most alert and fresh. Make problem solving a part of every study session.

Keep Up Your Class Attendance

Make it a rule to attend all lectures and be an active listener. Don't fall behind by missing any class. With lecture materials such as PowerPoint or MP3 available online (such as on WebCT), it is very easy to talk yourself into skipping. Don't! Stick with the rule. Some schools even have businesses that will sell notes from a particular class. Don't fall into that trap. Missing class should be a rare event; only done for valid reasons.

Take Advantage of the Physics Lab

Make the lab a learning opportunity rather than a chore. In additional to having hands-on experience with physics equipment, you can reinforce the concepts learned from lectures and actually see the physics in action. The lab is not a separate part of your course. The lab exercises are probably very carefully selected to illustrate the very same concepts you are learning during the lecture.

Survival Skill #2: Top 10 Things You Should Know About Physics

Keep these concepts with you all the time. They are the must-know facts of physics.

Fact #1: Know g and G

The acceleration due to gravity, -9.8 m/s^2 is widely used in introductory physics courses. This value describes how fast the velocity of freely falling object changes with time. This is a result of gravity.

For example, initially, an object to be dropped would have a velocity of 0 m/s. After 1 second of falling, it would have a velocity of -9.8 m/s. After 2 seconds of falling it would have a velocity of -19.6 m/s, etc. If you're confused by the negative sign, it will be mentioned later.

Also associated with gravity is the universal gravitational constant, $G = 6.67 \times 10^{-11} Nm^2/kg^2$. This is a constant used in the universal gravitation formula. These two commonly used values are both associated with gravity, but they definitely aren't the same or interchangeable.

Fact #2: Always Find F_{net}

Often there will be multiple forces acting in a particular situation or problem. All of these forces must be accounted for. They must be combined to form the resultant, or net force. This is the force that you'll use to predict or describe the motion of the object it is acting upon.

For example, if you push on a stuck car with 300N for force, that doesn't necessarily mean that it is the only force acting on the car. Maybe there is also 300N of frictional force that is opposing your motion. If that's the case, then the net force on the car is 0N! The two 300 N forces cancel out to give a resultant of zero. This means your car is stuck in spite of your applied force.

Fact #3: Watch the Signs

A positive or a negative sign can make all the difference in a problem. Just as you made graphs or plot on axes in math class, you can use signs to establish direction in physics. In math, + on the y axis is arbitrarily assigned as up. – on the y axis is down. The same idea applies in physics.

The acceleration due to gravity is -9.8 m/s^2. Without saying anything else, this mean the acceleration is pointing downwards. This assumes we have setup the convention that up is positive. The negative sign doesn't mean its moving slower than zero, it simply refers to a direction.

If a ball is moving at +25 m/s, that means its traveling in whatever has been established as the positive direction. A velocity of -25 m/s means its traveling in the negative direction. They would both have the same speedometer reading, just different directions.

Fact #4: Use the Force

Forces are just in most areas of physics. Although Newton's laws are predominantly used to describe mechanics, forces are also used in electricity & magnetism, atomic & nuclear physics, and others.

You'll encounter many different manifestations of force. Among those are electric force, gravitational force, centripetal force, frictional force, strong and weak nuclear force, etc.

Typically all forces are measured in Newtons. They also obey Newton's 3 laws which form the basis of mechanics. These laws aren't complicated. They can describe as simple a concept as inertia. This means an object wants to continue doing whatever its doing until something acts upon it.

Fact #5: Conserve as Much as You Can

Many quantities are conserved in physics. Just as conservation applies to environmental resources like water, energy, and trees, you can also conserve in physics.

Many quantities can also be conserved in physics: momentum, energy, mass, electric charge.

This idea is more important than just remembering the fact that momentum is conserved. Instead, this is a concept that can lead you to solve a wide variety of problems.

- Conservation of energy, typically kinetic and potential energy, can solve many kinematic problems.
- Conservation of momentum can solve many types of collision or impact situation problems.
- Conservation of mass and charge can be used to predict the outcome of radioactive decay processes.

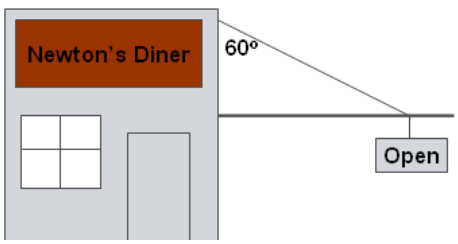
Fact #6: Mass is Conserved (sometimes)

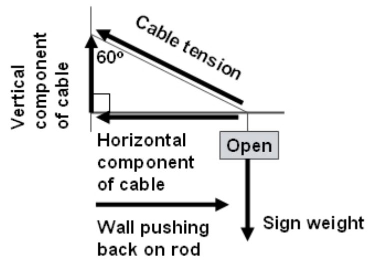
As mentioned earlier, mass is conserved, sort of. This isn't meant to point out an error in physics. Instead, it points out its adaptive nature. You may have learned how mass is conserved. This isn't entirely true. In some cases mass can actually be created or destroyed. The same is true of energy. It would be more accurate to say that the sum of mass and energy is conserved. You undoubtedly heard of the famous equation $E=mc^2$. This describes the equivalence between mass and energy.

In physics, one theory may not completely and accurately describe all situations. It may be accurate enough in some, but not all. Even though physics does rely on several main concepts to derive many results, there still isn't one grand theory to unify all of physics.

Fact #7: A Picture is Worth a Thousand Words

Diagrams are exceedingly important in physics. They help you to visualize the forces, measurements, or other quantities in a problem. Below is a situation where a sign hangs from a building. The diagram shown helps visualize the forces acting on it.





Similar diagrams can be used for a variety of problems. Graphs can do the same too.

Fact #8: Obey the Cosmic Speed Limit

The speed of light is a very universal fact. Although very precise values can be referenced, it's approximately $3.0x10^8$ m/s. This is more than just an impressively large number.

- In your study of waves, you use it extensively to study light.
- Regarding special relativity, you'll see how it represents an absolute speed limit for movement.
- It's also used to relate mass and energy as mentioned earlier.
- You'll even see how it relates to electricity and magnetism.

Fact #9: Acceleration Isn't Velocity

For some reason, one of the most widely misinterpreted physics terms is acceleration. This term is used all the time in introductory physics classes. It refers to the rate of change of velocity of an object. People often mistake acceleration as the same thing as velocity. Velocity is your change in position per time, how fast you are going. Acceleration relates to how fast you gain that speed. They even have similar units, m/s for velocity, and m/s/s for acceleration. If these quantities are switched, that will obviously lead to errors in a problem. Even if there is some sort of essay or short answer question, such a mistake will also lead to incorrect results.

Fact #10: Physics is an Experimental Science

At times, it may seem like physics has nothing to do with the real world. It may seem like its all about abstract, unrealistic, unimportant book problems. Nothing could be further from the truth. Physics describes the workings of everything around you. This extends from the thermodynamic workings of your car engine, to the fluid dynamics of the blood moving through your body.

Often, your physics labs will attempt to verify, quantify, or predict examples from your lecture. You will need to keep up on your class work to help your lab work. Additionally, lab work may require careful or even tedious skill to obtain the necessary results.

As an example, you will often use the acceleration due to gravity, -9.8 m/s^2 in your class work. It's quite possible that you may measure this value in a laboratory activity. With modern equipment, there are a variety of ways to directly or indirectly make such a measurement.

Survival Skill #3: Basic Math for Physics

Physics is a quantitative science. Your quantitative skills may be a life support system for your physics survival. It is essential that you have the basic math needed for physics. It could be said that the language of physics is mathematics.

About the Calculator

In science, numbers matter. Hand held calculators are widely used in physics. An expensive graphing calculator isn't needed unless your instructor specifically requires it. Usually, any calculator that is described as scientific will do. Most of you know how to key in numbers and get results. There are a few things to keep in mind while using a calculator:

Common Mistakes: By far, the No. 1 mistake students make in using the calculator is punching in a bunch of numbers and operations, only to have the calculator not "understand" what the student wanted. Use parenthesis if necessary to specify what order the calculator should do things.

If you want to do the following, $(3+2)^2$ be sure to use parenthesis on your calculator. If you mistakenly type in $3+2^2$, you obviously won't get the same answer.

Also, students often don't take full advantage of the scientific notation capabilities of a calculator. There is often and EE or EXP key that is used to input numbers that are in scientific notation.

If you want to input the number 6.67×10^{-11}, type in 6.67, then EE, then -11. Sometimes students incorrectly input 6.67, x 10, EE, -11. This introduces an extra power of then that will make all of your following calculations off by one power of ten.

Don't Play Games: On modern graphing calculators, there is a staggering array of program available. There are even many arcade style video games that can be played on your calculator. Absolutely avoid these. It is a distraction and waste of your time. Don't even think about playing such games on your calculator in view of your professor. That's a sure ticket to a bad impression.

Calculator for Exams: Typically, you are not permitted to bring in just any calculator, since some can store text, which might provide a way to cheat on exams. Check with the professor ahead of time as to whether you are allowed to bring a calculator to the exams and which model calculator is acceptable. Also, be sure to use a brand new battery for your exam calculator.

Computer Calculator: Your computer (windows) has a built-in scientific calculator. Just go to Start > All Programs > Accessories > Calculator to open it and click View > Scientific to switch from standard to scientific mode. Mac OS has a scientific calculator, too. Most PDAs have built-in calculators too, but usually not for scientific calculations.

How to Work with Physical Units

A unit is an essential part of a numeric answer for any physics problem and any physical property of matter. Whenever you see a number, always ask yourself about the unit associated with it.

Standard SI Units (Physics related)

SI is a worldwide measurement system based on the older metric system. There are minor differences between the SI and metric system, but a few conversions will make them interchangeable.

There are a wide variety of units used in physics. Some are very basic, others are derived from those basic units. A small sample is listed in the table below. Try your best to always keep units through the calculations of a problem.

Occasionally the units may become so numerous and complicated that you may not be able to exactly keep track of everything. Do your best and don't give up on using units.

Table 11-1. The SI and SI-Derived Units

SI Units commonly used in physics		
Measurement	**Unit**	**Symbol**
Mass	Kilogram	kg
Volume	Liter	L
Temperature	Kelvin	K
Length	Meters	m
Time	Seconds	s
Amount of substance	Mole	Mol
Energy	Joule	J
Charge	Coulomb	C

There are also a few non-SI units being used in physics. The conversion factors are something you should be able to utilize.

Table 11-2. Non-SI Units in Physics

Non-SI Units commonly used in physics	
Measurement	**Conversion**
Length	1m = 39.4inches = 3.28feet
Speed	1m/s = 2.24 miles/hour
Force	1N = 0.225 lb
Pressure	1Pascal = 1.45×10^{-4} lb/in^2
	1 atm = 14.7 lb/in^2
Energy	1J = .2388 cal

Power	1 horsepower = 746 Watts

Common Physical Constants

Most instructors do not require you to memorize the physical constants, but you might want to know some basic conversions. They are usually printed on the inside covers of a physics textbook. Don't worry if you aren't familiar with these initially. They will come up one at a time when that particular topic is studied.

Table 11-3. Common Physical Constants in Physics

Constant	Description of constant
$g=9.8m/s^2$	On earth, this is the typically used acceleration due to gravity.
$G=6.67x10^{-11}Nm^2/kg^2$	This is the universal gravitation constant that is used to calculate the attraction between massive bodies.
$\varepsilon_o=8.85x10^{-12}C^2/Nm^2$	This is the permittivity constant used with Coulomb's law.
$\mu_o= 4\Pi\ x10^{-7}Tm/A$	This is the permeability constant used with magnetic fields.
$k=9x10^9Nm^2/C^2$	This is a combination of ε_o that is often used with Coulomb's law.
$c=2.998x10^8m/s$	This is the speed of light in a vacuum. It is usually rounded to $3.0x10^8m/s$
$e=1.6x19^{-19}C$	This is the intrinsic charge on one electron.
1Coulomb= $6.25x10^{18}$ electrons	This is the number of electrons in 1 Coulomb of charge.
$h=6.63x10^{-34}$ Js	This is Planck's constant

Scientific Notation

Physicists use scientific notation for a couple of reasons:

It is very cumbersome and difficult to work with commonly encountered, very small and very large numbers. Physics describes both the expansive galaxies, and the tiny atom. Expressing them in exponents makes it much easier to write and read.

Physicists must deal with significant figures. Express 3400000 as 3.40×10^6 and you can tell right away there are 3 significant digits.

Exponential Notation expresses any number as a product of two numbers, a decimal and a power of 10, e.g. 11×10^3. This notation is often used to express very large or small numbers.

Scientific Notation is a more systematic form of exponential notation that is used widely by chemists. The number is expressed with one (and only one) non-zero digit to the left of the decimal point and an integer exponent or power of ten, e.g. 6.023×10^{23}. The same number above (11×10^3) in exponential notation would have to be rewritten 1.1×10^4 for scientific notation.

Algebra, Trigonometry, and Calculus

Since physics is so mathematically based, your knowledge of algebra, trigonometry and calculus will be important. Here is a paraphrase of an insightful statement made by one of my favorite students:

> I've finally figured out why I've been taking all these math classes that don't seem to have a purpose. It's so I can use them in physics class! Physics class should be called applied math!

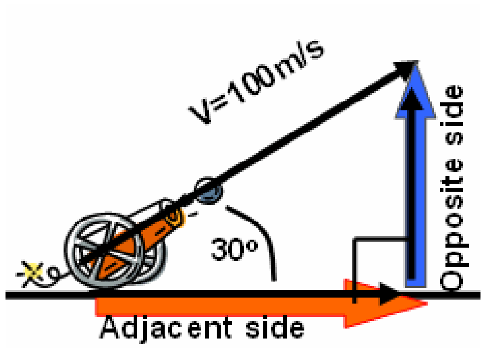
For algebra one of the most important skills you'll need is to easily manipulate formulas to rearrange or solve for certain variable. A simple example is shown below.

$$G\frac{mM}{r^2} = \frac{mv^2}{r}$$

$$G\frac{M}{r} = v^2$$

$$v = \sqrt{\frac{GM}{r}}$$

In trigonometry, you'll often work with various triangles found in nature. This means familiarizing yourself with trig functions like sine, cosine, and tangent. You won't often need in depth trigonometry work, but you will often use the basic function mentioned. A simple example is shown below. Here you may need to find the side of a right triangle where the hypotenuse is the movement of a cannon ball.



Vertical component:

$$\sin\theta = \frac{opp}{hyp}$$

$$\sin 30^\circ = \frac{opp}{100m/s}$$

$$opp = .5(100m/s)$$

$$opp = 50m/s$$

The degree of importance will depend upon the exact type of physics class you are taking. In high school and college there may be algebra and trigonometry based physics classes that require no calculus at all. Other courses will emphasize the calculus connections to physics.

Significant Figures

Observations and measurements are the key to physical data. Measurements are never exact, but physicists try to record a result with the least amount of uncertainty. Significant figures are the number of digits written after the decimal point to measure a quantity. Almost all measured numbers in physics are used to calculate other quantities. You need to report the proper number of significant figures in the computed results. It is essential to know the rules about significant figures – a very common mistake students make.

The following rules are used to determine the significant figures in any quantity:

Rule #1: All nonzero digits are significant.

2.15 m ➔ 3 (significant figures)

Rule #2: Zeros between nonzero digits are significant.

3.05 m ➔ 3 (significant figures)

Rule #3: All zeros written to the left of all the nonzero digits are not significant.

0.05 m ➔ 1 (significant figure)

Rule #4: Zeros to the right of all nonzero digits are only significant if a decimal is actually shown.

3.20 m ➔ 3 (significant figures)

Rule #5: With logarithms, the result is reported with the same number of digits to the right of the decimal as the number of significant figures in the original number.

$-\log[3.5 \times 10^{-3}] = 2.46$ ➔ 3 (significant figures)

Rule #6: When multiplying or dividing numbers, the result should be written with the least significant figures.

3.62 x 2.2 = 8.0 ➔ 2 (significant figures)

Rule #7: When adding or subtracting numbers, the result should have the least decimal places.

32.61 - 6.2=28.4 ➔ 3 (significant figures)

Survival Skill #4: Problem Solving Made Easy

Physics is all about problem solving, learning the knowns, and applying to the unknowns. If you are pre-med you should know that medical schools are moving an information-heavy curriculum to a concept-centric curriculum – shifting focus toward problem solving and holistic thinking. It's not as important what you can memorize, as what you can figure out.

If you survive physics, you will learn the techniques of problem solving, which is far more important than your ability to recite all the random facts of the universe. Your survival in physics will make your life much easier in future courses and in the real world. After all, regardless of your course of study or profession, don't we all solve problems everyday?

Five Step General Problem Solving Process

I earlier introduced my **KUDOS** method specifically for physics word problems. Similarly, the same process below can be applied to generic physics problems – calculations, concepts, mechanism, etc.

Step 1: Identify What is Given

Separate the problem into the facts, conditions and assumptions. List them symbolically as familiar chemical terms and formulas.

Step 2: Clarify What is Being Asked

Understand what is asked and if unclear, try to rephrase the question in terms that you know.

Step 3: Select a Strategy

Choose an appropriate method to solve the problem. These strategies include trial-and-error search, deduction, working backward and the knowledge-based method. The goal is to establish a path to get to what is being asked from what is given.

Step 4: Solve

Apply the skills and mathematical expressions needed to carry out the strategy chosen.

Step 5: Review

Examine the reasonableness of the solution, and correctness of the units, significant figures and order of magnitude. Fix the possible errors and re-evaluate the approach.

Include Formulas

Many students like to jump right into the problem by plugging numbers into their calculator and arriving at an answer quickly. While this may be possible for some short problems that are completely understood, generally this is not a good idea.

A good problem is like the culmination of an athletic performance. An athlete spends a great deal of time training and preparing so that they can finally have a good performance or play. You will need to prepare and build towards the successful solution to a problem.

Do the Math

Again, students often have a tendency to put a few numbers into the calculator and arrive at the final answer quickly. Resist this temptation and supply as much work as possible.

You should write down and formulas you'll use. In addition, you may need to rearrange those formulas to solve for a particular variable. Don't try to do all of this in one step either. Show all of the algebra required to arrive at the variation of the formula you need. An example is shown below. Here a formula is solved for an angle, θ.

$$\overline{S} = \overline{S}_o \cos^2\theta$$

$$\frac{\overline{S}}{\overline{S}_o} = \cos^2\theta$$

$$\sqrt{\frac{\overline{S}}{\overline{S}_o}} = \cos\theta$$

$$\cos^{-1}\sqrt{\frac{\overline{S}}{\overline{S}_o}} = \theta$$

$$\theta = \cos^{-1}\sqrt{\frac{\overline{S}}{\overline{S}_o}}$$

Resist the temptation to plug values in first. This will result in much more math work on your calculator which will lead to a greater chance of error. Instead, do algebra work first, then substitute near the end of the process. This will also cut down on recopying very length numbers and their attached units.

Although it was stated earlier, it is important enough to mention again. Use units throughout your problem. They will help you arrive at the correct unit for your answer, plus, they will help you solve the problem correctly by showing when unit conversions are needed.

Be Neat

Your instructor can't give you credit if they can't read your work. Many students are so hurried to get the right answer, their work is either missing or illegible. Making your work neat will not only help your instructor find your answers, it will also probably leave them in a better mood if they don't have to sift through piles of chicken scratch. Never use pen in physics class. Even the best students makes mistakes and a pencil erases much better than any pen.

Arrange Your Work

With all of the parts that go into some complicated problems, its not surprising that it can get garbled and mixed up. You must take steps to avoid this so that your logical and reasoning can be understood by your teacher. If you are having difficulty with a complicated problem, you may need a working or scratch version before you recopy for a final, readable, complete solution.

Even if you don’t get the right final answer, partial credit is usually available for free response type questions. Use the PhysMastery problem solving template. If that isn’t possible because you need more space for one of the particular sections, be sure to still include all of those parts. Physics is an orderly, logical science. Your problem solutions should be that way too. If they are, even if you have a mistake, it will be much easier to find and fix.

Try to make your problem solutions as neat and organized as the example solutions you find in your textbook. When in doubt, show all work!

Survival Skill #5: Top 10 Answer Checkers in Physics

1. Estimating a Numerical Answer

Learn to estimate a reasonable answer. For many quantities to be solved, you can approximate the answer by using your basic knowledge and visual inspection. Check if your answer is the correct order of magnitude, decimal point, or the power of 10. If the quantity is familiar to you, judge if the result makes sense or not.

For example, if you do a problem involving the speed of a running man, you can see if your answer is in the right ballpark. Consider a 100m sprint. A world class athlete can run that distance in under 10.0 seconds. For this person, their speed would be 10.0m/s. If you obtain an answer for a running person to be 50 m/s, you obviously have made a mistake somewhere.

In addition, a calculator provides an exact answer almost as quickly as you can arrive at an estimate. Cross-checking these two often can avoid gross errors. Calculator error is one of the most common mistakes, yet the easiest one to avoid. Run through the numbers a second time to double-check the answers.

2. A Number and Its Unit Go Hand-in-Hand

In math, you use numbers, but in physics you use quantity. Every physical quantity is described by the number AND its unit. Units are essential in physics problems. Plug in units and their values into the formula or equation being used. Try to form the proper-labeled ratios (equalities). The resulting unit must match the unknown to be solved. Mastering this technique will give you incredible leverage in every chemical calculation.

The two basic, simple rules:

Rule 1: Always write the unit and the number associated with the unit.

Rule 2: Always plug the number and its unit into any mathematical operation. Cancel units until you end up with the unit you want in the final answer. In addition, if this involves multiple steps, be sure that in every step you have the correct interim units.

As a rule of thumb, always set up a problem as follows, in its extremely simple form:

$$\text{Starting Units x } \frac{\text{Desired Units}}{\text{Starting Units}} = \text{ Desired Units}$$

Here is a very simple example. In your physics lab you may make a measurement of 50.0 cm. You might want to convert this into meters so that your answer also has units of meters.

$$50.0cm \times \frac{1m}{100cm} = .500m$$

You might remember this conversion by recalling that there are 100 years in a century.

3. Efficiency 100%

The efficiency of a system is often calculated. This could be a thermal efficiency, an energy efficiency, a mechanical efficiency, or others. In any case, efficiency refers to the ration of output divided by input. If virtually all circumstances, your efficiency will NOT by 100%. One exception may be if the problem is some idealized situation with no friction, heat loss, air resistance, etc. Generally, these factors will exist, so your efficiencies will be somewhat less than 100%. On the other hand, if you calculate an efficiency over 100% you have made an error somewhere. When students get an answer over 100%, this usually means two numbers were inverted.

4. Count Those Amperes and Volts

In circuit problems, two of the most important quantities are current and electric potential. These two items have units of Amperes and Volts.

The Junction Rule describes how current, or charge, must be conserved. In a way, this is like a restatement of conservation of mass. This rule is often used to arrive at, and check final answers for complicated circuits.

The Loop Rule describes how electric potential, or volts, must be conserved. In a way, this is like a restatement of conservation of energy. Electric potential is not exactly a measurement of energy, but it is similar. Again, this rule is often used to arrive at, and check final answers for circuits.

5. Momentum is Conserved

The law of momentum says that the total amount of momentum in any system will be constant as long as there are no external forces applied. This simply states that the momentum before some collision or interaction will be equal to the momentum after the interaction.

Sometimes conservation of energy can be tricky since energy can be changed from one form to another. However, with momentum, its a bit easier. Even in inelastic collisions where kinetic energy is changed into other forms, momentum is still conserved.

6. Follow the Trends

This answer checker isn't referring to the latest fashion craze. Instead, you can often follow trends in data or equations to arrive at, or check your answers. If you have data or a graph, extrapolate to predict outcomes. This may be the method you use to find an answer, or it may just be a convenient way to check an answer.

You can also find follow the trend as one variable gets very large or very small. This is basically the limit concept from calculus.

If you look at a typical physics equation, you can see how this can help.

Newton's universal law of gravitation:

$$F_g = G\frac{m_1 m_2}{d^2}$$

If the two masses are brought closer and closer together, you can see how the denominator would get smaller and smaller. Thus, the value for the entire fraction would get larger and larger. As the distance between two masses decreases, the gravitational force between them increases.

On the other hand, if the distance increases, even to infinity, you can see how the value of the fraction would get smaller and smaller. It would even approach, but never get exactly to, zero.

7. Work the Problem Backward

To verify your answer to a problem is correct, work out the same problem in reverse to prove you can match the known information. You'll simply be using your answer as a known, and try to find an unknown which you already have given. Hopefully, your answer will match what you are already given in the problem.

For example, if you calculate that it takes an object 5 seconds to fall from the top of a building, reinsert that answer into the formula $d = v_i t + at^2/2$ and see if you get that same distance for the building. If not, go back and check all your steps from the beginning.

8. Find Alternative Solutions

Play with the possibilities. Many times there is more than one correct way to solve a problem. A good example is a kinematics problem solved with conservation of energy. You'll probably learn kinematics formulas early on in your physics schooling. They are the formulas that involve distance, time, velocity and acceleration. These can solve a wide array of problems. Later on, you'll learn how conservation of energy can solve the same problems easier.

If a skydiver jumps from an airplane and freely falls 100m, how fast will they be moving at that position?

From kinematics equations:

$d = v_i t + at^2/2$

Here our $v_i = 0$ m/s

Solving for t gives $t=\sqrt{(2d/a)}$

Substituting the given values $t = \sqrt{2(-100m)/-9.8m/s/s}= 4.5s$

Then use the acceleration formula $a = \Delta v/\Delta t$

Solving for the change in velocity gives $\Delta v=a\Delta t$

Substituting values gives $\Delta v=(-9.8m/s/s)(4.5s)=-44m/s$

From conservation of energy:

The potential energy of the skydiver turns into kinetic

PE=KE

$mgh=mv^2/2$

Solving for v gives $v=\sqrt{(2gh)}$

Substituting values gives $v = \sqrt{2(-9.8m/s/s)(-100m)}=-44m/s$

Notice how the two different methods give the same answer!

9. Know the Range of Commonly Tested Quantities

Building a quantitative sense of a physics term is part of learning physics. Take notes on commonly used properties from lectures, textbook, homework assignments, and end-of-chapter problem sets. List their normal value ranges and orders of magnitude as you learn them. Even if the quantity doesn't have an absolute range of values, know the general vicinity of those values.

For example:

E) coefficient of friction values, μ, range from 0 to 1.

F) visible light wavelength ranges from 400 to 700 nm

G) common amount of charges are usually less than 1 Coulomb

H) most magnetic fields are usually less than 1 Tesla

I) index of refraction values range from 1 to ~2

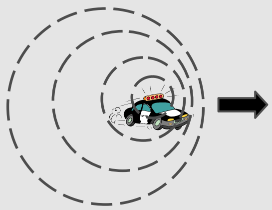
10. Solve Problems Qualitatively

The last answer checker is the most important one. You should attempt to solve the problem qualitatively before you write down all the quantitative data. You should have some idea of what your quantitative answer should be before you even get it.

For example, you may use a fairly complex Doppler effect formula to determine the shift in frequency of some wave.

$$f' = f_o\left(\frac{V \pm V_0}{V \mp V_S}\right)$$

However, even before you begin doing any math, you should be able to state if the answer will be an increase or decrease in the frequency. If the source and observer of the waves are approaching one another, the frequency will be higher. This is the section to the right of the police car siren. It would be lower if they were going away from each other. This would be the section to the left of the police car siren. This can easily be seen in the diagram below.



Survival Skill #6: The Four Step Panic Plan – How to Cram Systematically

"Help! I am half way into the course and still have no clue." Rest assured that we've got you covered in this situation. It is never too late to start a simple and effective way to study, even if you are closing in on the final. We do not encourage cramming at the last minute. The easier formula to success is to keep up - not catch up.

Granted, this happens! What do you do if you are down to the wire and have no choice but to try to stuff a lot of material into your head in a very short time? You have to cram, of course. Cramming is not a study strategy but rather a Band-Aid to save you from disaster. After it is all over, you will have to relearn the same material.

If you do fall behind but are willing to put in extra effort to make it up, just follow the simple steps below and you will do fine for the rest of the course. The goal of cramming is to create a set of super concentrated study sheets and focus most of your time reciting them.

How to Cram Step-by-Step:

For those crammers, you may want to put out extra effort in the last 2-3 days prior to the exam, but avoid at all cost cramming the final night. All your efforts may be wasted if you feel tired or mentally exhausted during the exam, which will block off your knowledge retrieval process. This is particularly true for crammers since cramming only puts information into your short-term memory.

Here are the steps:

Step 1: Get the Lecture Notes: If you have not attended all the lectures, get a decent set of lecture notes from your pal, or buy them from the note-taker if you have to.

Step 2: Rewrite the Lecture Notes: If you still have time, rewrite the notes into yours using the PhysMastery Lecture Notes. If you are cramming for the midterms or finals and running out of time, skip this step.

Step 3: Create the Cheat Sheets: Print a few blank copies of the PhysMastery Cheat Sheets (one copy per chapter). Go to your study zone and lay out the notes and the text side-by-side. One chapter at a time, write down all the key concepts, facts, formulas and equations onto a single cheat sheet. Be selective in what you record and limit your coverage. As needed, use your text to further your understanding by quickly reading the explanation and walking through the examples.

Step 4: Over Study the Cheat Sheets: After going through all the testing chapters, you should have a set of cheat sheets created from step 3. Study-study-study these cheat sheets. Say them out loud if you have to. Carry them with you so you can make the most of every spare minute you have.

If you have completed these four steps in the limited time you have, you should still be able to walk in and take the exam with confidence.

Rules of Cramming

I hope that you won't get yourself into the position that you must cram to survive. However, if you are running out of time to prepare for the upcoming exam, follow these simple rules:

Be Realistic and Practical: Cramming is not the best way to study so you need to set your expectations on how much you can accomplish. The key is to study enough to survive the exam and store what you know long enough to retrieve during the exam.

Study in Depth not Breadth: The most effective way to cram is to find out what topics are important and put all your efforts into them. Producing a concise study sheet will serve this purpose well.

Maximize Your Short-Term Memory: Deploy every memory method to cram the key terms into your short-term memory. Be sure to understand their concepts and applications.

Cramming is to make use of the short-term memory (STM), also known as working memory. It has a capacity limited to 5-9 items in a set, lasting 1-2 days. To be effective in storing information short-term, one method is called "chunking", where you arrange pieces of information into sets of meaningful clusters, which increases your capacity to remember.

To cram, focus on the essential – your cheat sheet.

Survival Skill #7: Fighting the Computer Distraction

Most traditional study guides and test-prep books ignore this issue. With increasing use of software applications and web resources for study purposes, this turns out to be one of the biggest time management issues for today's students – spending too much time on the computer, specifically on the web.

Activities such as reading e-mail, checking the news, surfing endlessly over the web, or simply fiddling with mp3 music files, can prove to be significant impediments to productivity for many students. It always interrupts your "cognitive flow" – a state of strong focus on a particular task. Your core study hours should be computer-less.

Don't Sit in Front of Your Computer to Study!

If your do, you are going to waste your valuable study hours for sure.

Your teachers will recommend you use the web at the fullest to maximize your learning – Google this and ASK that. Web search is a great tool for research and learning. However, there is just way too much physics information scattered over the web in an unstructured manner. You would need to sort it out before you could find something useful. It is often a time consuming process. The information over the web is not always accurate and objective. Many physics sites were created as class projects by high school students. Verify with your textbook and instructor if in doubt.

Don't Always Rely on Google for the Answers to Your Problems

Google is one of the best research tools available and I use this friendly search engine everyday – it's the best research tool I know. However, there are downsides if you are using it for homework.

First, this tool is so readily available it might deprive you from thinking of problems actively. This is much like checking your answer key before attempting to solve the problem yourself.

Secondly, it often takes too much time to sort out what you are actually looking for from the irrelevant content, or the answer that might not be there in the first place. Meanwhile, you spend your core study hours surfing the net, which is not a productive study activity.

Your goal for survival in the class is to become intimately familiar with your textbook and lecture notes. Always begin your learning or searching for answers with these first because they are the most relevant content, and this process will further your understanding of the core content.

Don't Be a "Computer Potato"

Do not spend too much time on the computer for non-course related activities.

Computers can be addictive and too much of them can be destructive to your academic success. We are at an age where students seemingly can't survive without a computer. Use it as a tool. Remember, your success depends on what you do in the core hours (Stage 1-5). Anything else is icing on the cake.

Don't Turn On Your Computer First Thing

Many of us, myself included, spend too much time emailing which takes away from our daily productivity. My suggestion: Don't check your email first thing when you wake up in the morning. Do your preview and get ready for your lecture first. Be sure to keep up your lecture notes, reading and homework. Try to finish these core study activities before diving into the web for your email, surfing, blogging, IM, or chatrooms. Keep these a low priority and do them only after you have completed the day of study. Resist the temptation when near the computer.

Survival Skill #8: Focus On What You Need To Learn

> *"To go beyond is as wrong as to fall short."*
>
> *-- Confucius*

"Don't give all of your attention to the trees or you may get lost in the forest." Many students like to spend more time on the subject areas that really interest them. It is natural and captivating. However, it is the wrong way! You should balance your effort on all required areas, and focus more on materials that you are uncomfortable with, yet are important. This is one survival skill you must master in order to survive physics. The materials are important because the teachers happen to think that way, not because you happen to like it. The core study materials should be guided by the lecture notes you take.

Your required textbook is also your core study material. Many students like to check out a stack of physics books, guides, and problem solvers at the beginning of the class, as evidenced by the empty shelves in the library. Having so many books, you end up shuffling page after page among these books. This can be counterproductive. Using the wrong textbook is like getting on a wrong train – it might move forward but it will never get you to the destination.

One more tip on the textbook; consider your text as the "Bible". That's not to say there are no errors in it (there are plenty). As long as you use the information in the text faithfully, (even if there is an error in the information you use) you can argue with your instructor to the end of the world to get credit for your work. Guess what? Your instructor will honor your work and make corrections if you were graded unfairly.

The Order of Your Core Study

Here is the priority of your study for the exam, in order. Nail the first one before spending any time on the second one.

1. PhysMastery™ Cheat Sheets and Mock Exam Sheets
2. PhysMastery™ Reading and Lecture Notes
3. Your Required Textbook (mostly Problem Practice)
4. Additional Books or Resources (optional)

Anything else is optional. Do what you need in order to master the core terms and problem solving skills. Spend your core hours on 1-3, in that order, with all your focus.

Survival Skill #9: Learn to Predict Exam Questions

This is an interesting topic. There are patterns to how professors write their exams. Learning a few of them can help boost your grade by guiding you to a more targeted study.

Integrated Problems - One likely area includes the questions that require integration of more than one concept, idea, or equation. Learning how to relate is a skill that physicists like to test on. It's particularly prevalent on tests like the AP and MCAT.

Multi-Chapter Concepts – Main concepts that are being discussed across several chapters are also exam favorites. Anything in the lecture or text that has been repeated often is worth paying attention to.

Fundamental Principles – There are a few physics principles being used widely in many areas of physics. These are important ones tested. One simple idea may be expanded to describe and include a large variety of questions and problems.

Reviewed – Another likely target is the material that is being discussed in the review session for the upcoming exam.

Homework – Instructors often make up exams from assigned homework problems by modifying them slightly, to reward students who work hard and understand the homework problems.

He Says So – Many instructors are not shy about telling you directly that a term being discussed will be on the exam. No brainer! Mark those down. Also, watch indirect indications on potential test targets. Read more about this in the section *How to Read Your Professor's Mind* (Chapter 12).

Lecture Only – If information is presented in a lecture but not covered in your text, your instructor obviously feels that such material is of special significance for whatever reason. Mark it down. However, consult with your instructor if material is not being discussed in the lecture but assigned as reading assignment.

Handouts – If your instructor has invested the time to provide you a handout about a special topic, he or she must feel strongly the information is important and relevant. Most instructors also like to reward students who pay attention and appreciate the value of the extra materials provided.

Lengthy Lecture – If your instructor allocates an unusually long time to discuss just one concept, you should mark it with triple stars (***).

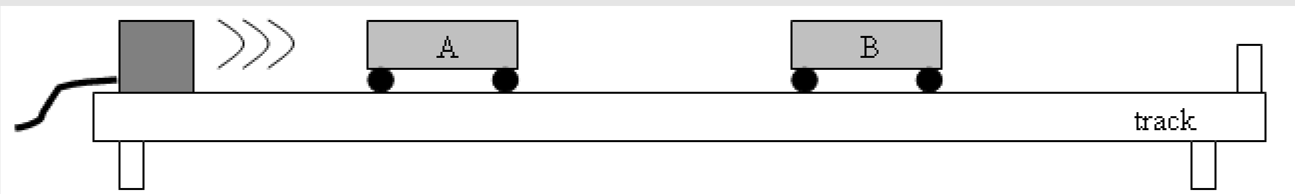
Pay attention to these hints; you will become skillful in predicting exams in no time.

Survival Skill #10: How to Survive the Physics Lab

Notice the Common Thread

Your laboratory course, or lab component of your physics course, will undoubtedly have common themes to what you are learning about during lecture. The laboratories aren't randomly assigned to give you grief and heartache. Instead, they are intentionally picked to compliment the concepts being taught. They may give you an opportunity to hear, see, and feel things that were described during the lecture. They may also give a chance to experimentally verify what was assumed to be true from the lecture. So don't look upon your physics lab as an unusual burden. Instead, recognize it as an opportunity to expand your learning. You may find it very interesting.

For example, a common investigation shows how momentum is conserved. Small carts roll along air tracks or other low friction surfaces. Various sensors may be used to measure the velocities of the carts. From this data, the conservation of momentum can be verified. A rough diagram of this type of apparatus is shown below. This is the type of event that may be discussed in lecture, but in the physics lab you will really get to make it happen.



Observe and Measure Carefully

Any science, including physics, includes taking data. For physics, you will often be measuring positions, velocities, wavelengths, charges, currents, voltages, etc. Each of these situations has its own special set of circumstances. However, in each, you must measure as carefully, accurately, and precisely as possible. These measurements will often determine the conclusions you draw. Your conclusions will them at least partially determine your grade!

Analyze Your Data

The information you collect from your measurements is only useful if you can draw some conclusions from it. The type of physics investigations you may experience can vary widely. So will the type of data analysis. From the previous cart collision investigation, you may need to determine velocities from some instruments.