Physics 42 Syllabus and Course Description

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1 Contact Information

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Course Web page address: http://www.phy.duke.edu/ rgb/Class/phy42
Text: http://www.phy.duke.edu/∼rgb/Class/intro_physics_2.php
Aux Text: Tipler and Mosca, Physics for Scientists and Engineers, 6th ed.
Recitation TA: Chris Varghese Room 274-C
Email address: varghese at phy dot duke dot edu Phone: 60-2488
Lab TA: Chris Pollard Room 288
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2 Useful Links and Resources

The following links and resources may help you learn physics this semester by providing insight, the opportunity to discuss things with peers, the opportunity to ask questions, or nifty demos. It isn't complete, and may change as the semester proceeds. I'll try to alert you in class if you need to check back here to see a particularly nifty new link.

2.1 Class Mailing List

Everybody will be subscribed to the class mailing list; participation is mandatory. Everybody can *also* mail to the entire class via this link once subscribed. You are *encouraged* to use this mailing list to ask questions about the homework, hold discussions with your friends in the class about physics, announce events (within reason) and so on. Please keep the signal to noise ratio fairly high, though, because membership *is* mandatory. The class mailing address is:

phy42 at phy.duke.edu

In addition, you can alter some of the properties of the mail delivery to your subscribed address here:

http://lists.phy.duke.edu/mailman/phy42

Please do not unsubscribe, though, or you won't get important announcements from me when I send them out.

2.2 Web Links

The first is to the online textbook for the class. The second is to a crude collection of problems that have been used for quizzes and homework over the years.

http://www.phy.duke.edu/∼rgb/Class/intro_physics_2.php
http://www.phy.duke.edu/∼rgb/Class/review_42.php

2.3 Wikilinks

As you will see, in my opinion Wikipedia is well on its way to becoming the "Universal Textbook", with link chapters that span almost any subject especially in physics, mathematics, philosophy – things people care about.

I would suggest that at you own convenience you take "wikiromps" starting at any of the following links and following article links as it suits you until you have a pretty good understanding of the history and basic concept associated with the following ideas or laws. We'll then work extensively in class and recitation to turn that initial understanding into deep operational knowledge.

This list will expand as we encounter new concepts during the semester, although (as you'll note) you may well get to them quite early on your wikiromps as links will carry you quickly from "intro" level articles to graduate school level articles. Read and become familiar at your own pace, but don't hold back on following links to more difficult or advanced articles.

- Wikipedia: http://www.wikipedia.org/wiki/Electric Charge
- Wikipedia: http://www.wikipedia.org/wiki/Electricity

- Wikipedia: http://www.wikipedia.org/wiki/Coulomb's Law
- Wikipedia: http://www.wikipedia.org/wiki/Electric Field
- Wikipedia: http://www.wikipedia.org/wiki/Gauss's Law
- Wikipedia: http://www.wikipedia.org/wiki/Electric Potential

2.4 Course Description

In this course we will cover the following basic topics:

- Electrostatics. Charge, electric force, electric field and Coulomb's law, Gauss's law, electric potential. Capacitance and dielectrics.
- Magnetostatics. Current, magnetic force, magnetic field and the Biot-Savart law, Ampere's law. Magnetic moments, torque, magnetic precession. Magnetic materials (diamagnetism, paramagnetism, ferromagnetism).
- Electromagnetic Induction. Motional EMF, induced voltage, Faraday's law, Lenz's law. Mutual and self inductance. Generators.
- Elementary circuits (DC and AC). Kirchoff's rules. Ohm's law. Time-varying potentials, RC, LR, LRC circuits. High pass, low pass, band pass filters, and Q.
- The Maxwell displacement current and its connection to charge conservation. Maxwell's equations. The electromagnetic wave equation and light. Energy density, the Poynting vector, radiation pressure.
- Properties of light. Snell's law, simple polarization (absorption, scattering, reflection), Huygen's principle, dispersion, the spectrum. Geometric optics and ray diagrams: mirrors, lenses, the eye, optical instruments. Physical (wave) optics: thin film interference, 2,3,4...N slit interference, single slit diffraction, diffraction gratings.

There will be, as you may have guessed, lots of homework problems. Homework is an *essential* part of learning physics and must not be neglected. I expect all students to do the assigned problems and keep up with the reading. The structure and organization of the course will be (**approximately!**):

20% of grade Weekly Homework. This will include a Webassign component designed to stimulate reading of the chapter(s) *before* the associated lectures.

20% Weekly Quizzes

20-30% Hour Exams (3)

20-30% Final

10% Lab

1/3 letter grade Extra Credit Project

Grading Scheme: The final exam can replace any *one* hour exam grade, provided that it is higher. This allows students to make up for their worst single hour exam performance with their final, so one bad exam day won't hurt your grade. If you get below a 50 (and the curve is otherwise normal) and have not religiously handed in your homework, you fail (F). If you get less than a 60 and have not religiously handed in your homework, you get an D. If you get 60 or more you get a C- or better and "pass". If you have religiously done your homework, but have somehow managed to end up less than a 60 or (worse) 50, this will be taken into account and adjustments *may* be made at my discretion. If you have not consistently done and handed in your homework on time, *don't bother me about your grade.*

Note that the class performance will be plotted on a histogram and adjustments to the above scheme will be made as required by the distribution. In addition, I reserve the right to make modest changes in the exact percentages I assign to any particular component of the grade – there is some variation from year to year in the amount of homework, the number of quizzes, and the difficulty of the exams. Finally, I reserve the right to adjust your distribution-determined grade (up or down) in consultation with Dr. Mary Creason and the TAs if for any reason we feel that this grade does not correctly reflect your degree of learning.

If you are concerned about your grade, you should come see me early and often; extra credit can be obtained a variety of ways to help avoid a bad grade or to augment a good one. However, it is **too late** to do much about this in mid-April!

2.5 The Rules

- You **may** collaborate with your classmates in any permutation on the **homework**. In fact, I *encourage* you to work in groups, as you will probably all learn more that way. However, you must **each** write up *all* the solutions even if they are all the same within a group. Writing them up provides learning reinforcement.

- You may **not** get worked out solutions from more advanced students, former students, a Tipler solution manual (if you can find it), from the web(!) or anyplace else. It obviously removes the whole point of the homework in the first place.

- You **may** ask more advanced students, former students, other faculty, personal friends, or your household pets for help or tutoring on particular problems, as long as no worked–out solutions to the assigned problems are present when you work with them. Again, if you work in groups I *encourage* you to take turns teaching each other how to work through to the solutions to the problems you encounter, as teaching is an excellent way (perhaps the best way) to learn.

- You may use the library and all available non–human resources to help solve the homework problems. I don't even care if you find the solution somewhere (other than on the web, which is strictly prohibited) and **copy it verbatim** provided that you **understand it afterwards** (which is the primary goal), **cite your source**, and provided that you do **not** use any resource labelled as a solution for Tipler problems, including the solution manual for **Tipler** problems (which exists, floating around somewhere), see second item above. I would prefer that you do not routinely look for solutions rather than work them out yourself; save this approach for the toughest problems. Remember, you can't take these resources into an exam with you; you will need to learn to solve the problems on your own. On the other hand, real problem solving often involves a certain amount of library research.

- Quizzes and Exams: All quiz and exam problems are to be worked out alone. Calculators may be used on physics exams but the storing of physics formulae or other crutches in calculator memory or firmware is strictly prohibited. Looking at or copying other students' work is obviously not permitted, and *will be severely penalized if discovered*. I *assume* that all my students are honorable persons and will play the game honestly – do not damage your own honor and spirit by behaving dishonorably in my class.

  Remember, I don't like grading you any more than you like being graded, and ultimately your *grade in this class does not matter*, at least no where nearly as much as you might think it does. What *does* matter is how much you *learn* – if you are getting a poor grade, it most likely reflects a failure to give the course the attention and effort it deserves and requires in order to properly facilitate that learning. Don't try to cheat your way to an empty and meaningless grade – come talk to me and we'll see if we can't repair your learning methodology to *earn* you a better one!

3 Structure and Expectations

The primary expectation I have of you is that you will all work *hard* to learn physics. You are all presumed or probable physics majors *or* have opted to take this course instead of the far easier physics 5x "equivalents" as a free choice. I therefore expect that this "hard work" will, for you, be a form of "hard play" – you will be doing what you might well end up doing professionally for the rest of your life and if it isn't fun and exciting for you, you're probably making the wrong choice of major. Hard work leads to great rewards in *anything* you put your hand and mind to, and I don't just mean in physics.

Note that I *do not* mean that you should necessarily do well on everything you try – physics is difficult and may take you years to conceptually absorb. I've had students get C-'s in this sequence from me who went on to be happy and fulfilled physics majors. I just mean that even when you can't or don't get a problem, *trying* to solve it and puzzling over the answer should be a satisfying activity for you rather than an annoying and distracting chore.

This course is extremely problem-oriented. One truly *learns* physics by learning how to think of and solve physics problems. The problems assigned are carefully selected to both illustrate important principles and to make you analyze and develop complex, multistep solutions that require conceptual insight and guidance. You will *not* be expected to do this often difficult work in a vaccuum – the course is carefully designed so that *every* student should be able to get 100% of their homework (at least) perfectly correct.

The following describes the structure of the class and what you should do to take maximum advantage of it.

- Read and study chapter **before** relevant lecture. A webassignment will be due before each chapter is begun in lecture, for credit, to help you prepare mentally for lecture.

- Lecture is intended to present a general, conceptual, derivational overview of the principles and laws of the physics being covered. It will be rich with examples, but real problem solving methology will primarily be self-taught with close support during recitation.

  Lecture will have three main aspects (in no particular order):

  - Concept/philosophy introduction and discussion
  - Review and presentation of detail
  - Questions

- Recitation will be used to go over the most difficult homework problems in small groups. This is intended to be a time when you teach each other, and learn thereby. The TA and I will move from group to group and provide tutorial support. Students may be asked to present problems at the board for the entire class at any time. Computers may be used to simulate some of the mechanical systems that we study. A graded short quiz will generally terminate recitation.

  Recitation will have three phases:

  - Question time.
  - Break into structured groups and work on homework problems.
  - Quiz.

- 3 Hour exams in class.

- Lab/tutorial: as much to focus on intuition and verbal understanding of concepts as to "do a dumb lab". This year's lab requires an advanced independent project.

- Although Duke Physics doesn't formally recognize "honors" work, I do. Any student may elect to extend their project into an "honors" dissertation or may select an honors project from a number of topics and formats in consultation with me during the semester. A satisfactory completion of an honors dissertation provides three benefits:

  1. You learn more physics and have some fun and gain satisfaction doing so. As a major, physics should be something you really like playing with, and this is an opportunity to play.
  2. You will get a 1/3 of a letter grade promotion (if possible) and hence insurance against failure.
  3. I will tell the world about your good qualities in recommendations in the future. Don't underestimate the importance of demonstrated initiative and any sort of research experience to those seeking admission into summer or graduate programs, or even just looking for a job.

4 Personal Availability and Methods of Contact

I will usually be available for questions on any given day either immediately after class or immediately after recitation. Beyond that, while I am nearly always here and would be happy to see you on a drop-in basis, it is best to make appointments to see me via e-mail or at least verify by phone that I'm around and in my office when you want to drop by.

I welcome feedback and suggestions at any time during the year. I would prefer to hear constructive suggestions **early** so that I have time to implement them this semester.

This syllabus is being provided via the department WWW server to Duke students as a convenience. Set your WWW client (e.g. Netscape) to point to:

http://www.phy.duke.edu/∼rgb/Class/phy42.php

I will, from time to time, add content to this site. Likely content includes a list of all homework problems, a class schedule (approximate), and links to useful resources. Check back to it from time to time or as I suggest that you do so in class.

5 How to Do Your Homework Effectively

By now in your academic career it should be very apparent just where homework exists in the grand scheme of (learning) things. Ideally, you attend a class where a warm and attentive professor clearly explains some abstruse concept and a whole raft of facts in some moderately interactive way. Alas, there are *too many* facts to fit in short term/immediate memory and *too little time* to move most of them through into long term/working memory before finishing with one and moving on to the next one. As a consequence, by the end of lecture you've already *forgotten* many if not most of the facts, but if you were paying attention, asked questions as needed, and really cared about learning the material you *would* remember a handful of the most important ones, the ones that made your brief understanding of the material hang (for a brief shining moment) together.

Studies show that you are only likely to retain anywhere from 5% to 30% of what you are shown in lecture. Clearly this *is not enough* to make the information conceptually useful, to *learn* it. In order to actually learn, you must *stop* being a passive recipient of facts. You must *actively* develop your understanding, by means of *discussing* the material and kicking it around with others, by *using* the material in some way, by *teaching* the material to peers as you come to understand it.

Medical schools have long been aware of this. In the year 1907, medical schools had two years of coursework to prepare a student to be a physician. In the year 2007, they are *still* two years of coursework – but the amount of science and medicine that is taught in those two years has *exploded*. They have developed the following mantra to help their students understand the only way the process can still work:

- See one. (E.g. a procedure)
- Do one. (with a mentor standing by)
- Teach one. (still with a mentor, but a more advanced one still)

That's it! We will use our own version of this same process in this course. Lecture (seeing it done) is important – it sets the stage for the learning, but by itself it teaches little. Homework (doing it yourself) is far more important.

This is when you *begin* to really learn. Recitation (where you teach each other where you have learned) is where you solidify this learning by articulating it, working with the concepts in your mind at a high level to do so.

To help facilitate this process, associated with lecture your professor gave you an *assignment*. Amazingly enough, its purpose is not to torment you or to be the basis of your grade (although it may well do both). It is to give you some concrete stuff to *do* while thinking about the material to be learned, while discussing the material to be learned, while using the material to be learned to accomplish specific goals, while teaching some of what you figure out to others who are sharing this whole experience while being taught by them in turn.

In other words, to learn you must *do your homework*, ideally at least partly in a *group* setting. The only question is: *how* should you do it to both finish learning all that stuff you sort-of-got in lecture and to re-attain the moment(s) of clarity that you then experienced, until eventually it becomes a permanent characteristic of your awareness and you *know* and *fully understand* it all on your own?

There are two general steps that need to be *iterated* to finish learning anything at all. They are a lot of work. In fact, they are far *more* work than (passively) attending lecture, and are *more important* than attending lecture. You can learn the material with these steps without *ever* attending lecture, as long as you have access to what you need to learn in some media or human form. You in all probability will *never* learn it, lecture or not, without making a few passes through these steps. They are:

1. Review the whole (typically textbooks and/or notes)

2. Work on the parts (do homework, use it for something)

(iterate until you thoroughly understand whatever it is you are trying to learn).

Let's examine these steps.

The first is pretty obvious. You didn't "get it" from one lecture. There was too much material. If you were *lucky* and well prepared and blessed with a good instructor, perhaps you grasped *some* of it for a *moment* (and if your instructor was poor or you were particularly poorly prepared you may not have managed even that) but what you did momentarily understand is fading, flitting further and further away with every moment that passes. You need to review the entire topic, as a whole, as well as all its parts. A set of good summary notes might contain all the relative factoids, but there are *relations* between those factoids – a temporal sequencing, mathematical derviations connecting them to other things you know, a topical association with other things that you know. They tell a *story*, or part of a story, and you need to know that story in *broad* terms, not try to memorize it word for word.

Reviewing the material should be done in layers, skimming the textbook and your notes, creating a *new* set of notes out of the text in combination with your lecture notes, maybe reading in more detail to understand some particular point that puzzles you, reworking a few of the examples presented. Lots of increasingly deep passes through it (starting with the merest skim-reading or reading a summary of the whole thing) are *much* better than trying to work through the whole text one line at a time and not moving on until you understand it. Many things you might want to understand will only come clear from things you are exposed to *later*, as it is not the case that all knowledge is ordinal, hierarchical, and derivatory.

You especially do *not* have to work on *memorizing* the content. In fact, it is *not* desireable to try to memorize content at this point – you want the big picture *first* so that facts have a place to live in your brain. If you build them a house, they'll move right in without a fuss, where if you try to grasp them one at a time with no place to put them, they'll (metaphorically) slip away again as fast as you try to take up the next one. Let's understand this a bit.

Your brain is fabulously efficient at storing information in a *compressed associative* form. It also tends to remember things that are *important* – whatever that means – and forget things that aren't important to make room for more important stuff. There are lots of experiments that demonstrate this – the simplest being trying to memorize a string of ten or so numbers at a glance (more than the 7 one can typically get into short term memory).

Try memorizing 1357902468 from just the *one* glance you got reading this sentence. No fair going back and repeating it to yourself, at least while looking at it! Now look at it and try to remember it. One strategy is to just repeat it to yourself until you get it right, but if you stare at it a while and *think*, you'll see that it has a very simple pattern embedded in it.

In fact, this number "compresses" to a single two-step rule – all the odd digits in ascending order followed by all the even digits ditto. You *already know* what a "digit" is, what odd and even numbers are, what ascending versus descending order is. You only need to remember "ascending" and "odd followed by even digits" – everything else is compressed. You will almost certainly be able to remember the digit string *tomorrow* without further rehearsal because of this rule and the fact that it illustrates an interesting point, where if you didn't notice the pattern and just memorized it as a string of "random" numbers, devoid of any meaning, your brain would have little reason to retain it as it is "unimportant". Even if you *forget* this particular string, you may well remember the point and use a *different* string like 1212121212 (five repetitions of 12) to illustrate the *same* point when teaching it to someone else. This is fine! My goal, too, is to teach you *this*, not some particular patterned set of numbers neither of us really cares about.

This ability to compress goes far beyond what I can explain or you can easily imagine. When I play a game of chess, I've forgotten my first five moves by the time I've made my tenth move. By the time the game finishes, I have no idea how I got into the mess I'm probably in. A chess *master*, on the other hand, can *finish* the game and then can recontruct the *entire game* in order, and can criticize each move as they do so. In fact, they can probably remember the entire game they played yesterday, or the one they played last week. They've built a complex structure of associative memory so that they don't remember moves the same way you or I do.

On the other hand, *I* can often remember what mistakes a student of mine made a week after grading one of their papers. I many not remember the student's *name* (no good associative memory there) but I've got great structures for remembering how to solve or not solve physics problems and remember only what the student did *wrong* – I already know how to do what they did right.

This is the goal of your iterated review process. At first you are memorizing things the hard way, trying to connect what you learn to very simple hierarchical concepts such as this step comes before that step. As you do this over and over again, though, you find that absorbing new information takes you less and less time, and you remember it much more easily and for a longer time without additional rehearsal. Sometimes your brain even *outruns* the learning process and "discovers" a missing part of the structure before you even read about it! By reviewing the whole, well-organized structure over and over again, you gradually build a greatly compressed representation of it in your brain and tremendously reduce the amount of work required to flesh out that structure with increasing levels of detail *and remember them and be able to work with them* for a long, long time.

Now let's understand the second part of doing homework – working problems. As you can probably guess on your own at this point, there are good ways and bad ways to do homework problems. The worst way to do homework (aside from not doing it at all, which is *far too common* a practice and a *bad idea* if you have any intention of learning the material) is to do it all in one sitting, right before it is due, and to never again look at it.

It is left as a *homework exercise* for the student to work out why this is a bad idea from the discussion and facts given above. So take a minute and think about it, then turn the page.

Let's see, doing your homework in a single sitting, working on it just one time *fails to repeat and rehearse the material* (essential for turning short term memory into long term in nearly all cases). It *exhausts the neurons in your brain* (quite literally – there is metabolic energy consumed in thinking) as one often ends up working on a problem far too long in one sitting just to get done. It *fails to incrementally build up* in your brain's long term memory the *structures* upon which the more complex solutions are based, so you have to constantly go back to the book to get them into short term memory long enough to get through a problem. Even this simple bit of repetition does *initiate* a learning process. Unfortunately, by not repeating them after this one sitting they soon fade, often without a discernable trace in long term memory.

Just as was the case with memorizing the number above, the problems almost invariably are *not* going to be a matter of random noise. They have certain key facts and ideas that are the basis of their solution, and those ideas are used over and over again. There is plenty of pattern and meaning there for your brain to exploit in information compression, and it may well be *very cool stuff to know* and hence *important* to you once learned, but it takes time and repetition and a certain amount of meditation for the "gestalt" of it to spring into your awareness and burn itself into your conceptual memory as "high order understanding".

You have to *give* it this time, and perform the repetitions, while maintaining an optimistic, philosophical attitude towards the process. You have to do your best to have *fun* with it. You don't get strong by lifting light weights a single time. You get strong lifting weights repeatedly, starting with light weights to be sure, but then working up to the *heaviest weights you can manage*. When you *do* build up to where you're lifting hundreds of pounds, the fifty pounds you started with seems light as a feather to you.

As with the body, so with the brain. Repeat broad strokes for the big picture with increasingly deep and "heavy" excursions into the material to explore it in detail as the overall picture emerges. Intersperse this with sessions where you *work on problems* and try to *use* the material you've figured out so far. Be sure to *discuss* it and *teach it to others* as you go as much as possible, as articulating what you've figured out to others both uses a different part of your brain than taking it in (and hence solidifies the memory) and it helps you articulate the ideas to *yourself!* This process will help you learn more, better, faster than you ever have before, and to have fun doing it!

Your brain is more complicated than you think. You are very likely used to *working hard* to try to *make* it figure things out, but you've probably observed that this doesn't work very well. A lot of times you simply *cannot* "figure things out" because your brain doesn't yet know the key things required to do this, or doesn't "see" how those parts you do know fit together. Learning and discovery is not, alas, "intentional" – it is more like trying to get a bird to light on your hand that flits away the moment you try to grasp it.

People who do really hard crossword puzzles (one form of great brain exercise) have learned the following. After making a pass through the puzzle and filling in all the words they can "get", and maybe making a couple of extra passes through thinking hard about ones they can't get right away, looking for patterns, trying partial guesses, they arrive at an impasse. If they continue working hard on it, they are unlikely to make further progress, no matter how long they stare at it.

On the other hand, if they *put the puzzle down* and *do something else for a while* – especially if the something else is go to bed and sleep – when they come back to the puzzle they often can *immediately see* a dozen or more words that the day before were absolutely invisible to them. Sometimes one of the *long theme answers* (perhaps 25 characters long) where they have no more than *two letters* just "gives up" – they can simply "see" what the answer must be.

Where do these answers come from? The person has not "figured them out", they have "recognized" them. They come all at once, and they don't come about as the result of a logical sequential process.

Often they come from the person's *right brain*. The left brain tries to use logic and simple memory when it works on crosswork puzzles. This is usually good for some words, but for many of the words there are *many possible answers* and without any insight one can't even recall *one* of the possibilities. The clues don't suffice to connect you up to a word. Even as letters get filled in this continues to be the case, not because you don't *know* the word (although in really hard puzzles this can sometimes be the case) but because you don't know how to *recognize* the word "all at once" from a cleverly nonlinear clue and a few letters in this context.

The right brain is (to some extent) responsible for *insight* and *non-linear thinking*. It sees *patterns*, and *wholes*, not sequential relations between the parts. It isn't intentional – we can't "make" our right brains figure something out, it is often the other way around! Working hard on a problem, then "sleeping on it" is actually a *great* way to develop "insight" that lets you solve it *without really working terribly hard* after a few tries. It also utilizes more of your brain – left and right brain, sequential reasoning and insight, and if you articulate it, or use it, or make something with your hands, then it exercieses these parts of your brain as well, strengthening the memory and your understanding still more. The learning that is associated with this process, and the problem solving power of the method, is *much greater* than just working on a problem linearly the night before it is due until you hack your way through it using information assembled a part at a time from the book.

The following "Method of Three Passes" is a *specific* strategy that implements many of the tricks discussed above. It is known to be effective for learning by means of doing homework (or in a generalized way, learning anything at all). It is ideal for "problem oriented homework", and will pay off big in learning dividends should you adopt it, especially when supported by a *group oriented recitation* with *strong tutorial support* and *many opportunities for peer discussion and teaching*.

6 The Method of Three Passes

Pass 1 Three or more nights before recitation (or when the homework is due), make a *fast* pass through all problems. Plan to spend 1-1.5 hours on this pass. With roughly 10-12 problems, this gives you around 6-8 minutes per problem. Spend *no more* than this much time *per problem* and if you can solve them in this much time fine, otherwise move on to the next. Try to do this the last thing before bed at night (seriously) and *then go to sleep*.

Pass 2 After at least one night's sleep, make a *medium speed* pass through all problems. Plan to spend 1-1.5 hours on this pass as well. Some of the problems will already be solved from the first pass or nearly so. *Quickly* review their solution and then move on to concentrate on the still unsolved problems. If you solved 1/4 to 1/3 of the problems in the first pass, you should be able to spend 10 minutes or so per problem in the second pass. Again, do this right before bed if possible and then go immediately to sleep.

Pass 3 After at least one night's sleep, make a *final* pass through all the problems. Begin as before by quickly reviewing all the problems you solved in the previous two passes. Then spend fifteen minutes or more (as needed) to solve the remaining unsolved problems. Leave any "impossible" problems for recitation – there should be no more than three from any given assignment, as a general rule. Go immediately to bed.

This is an *extremely powerful* prescription for deeply learning nearly *anything*. Here is the motivation. Memory is formed by repetition, and this obviously contains a lot of that. Permanent (long term) memory is actually formed in your sleep, and studies have shown that whatever you study right before sleep is most likely to be retained. Physics is actually a "whole brain" subject – it requires a synthesis of both right brain visualization and conceptualization and left brain verbal/analytical processing – both geometry and algebra, if you like, and you'll often find that problems that stumped you the night before just solve themselves "like magic" on the second or third pass if you work hard on them for a short, intense, session and then sleep on it. This is your right (nonverbal) brain participating as it develops intuition to guide your left brain algebraic engine.

Other suggestions to improve learning include working in a study group for that third pass (the first one or two are best done alone to "prepare" for the third pass). Teaching is one of the best ways to learn, and by working in a group you'll have opportunities to both teach and learn more deeply than you would otherwise as you have to articulate your solutions.

Make the learning *fun* – the *right* brain is the key to forming long term memory and it is the seat of your *emotions*. If you are happy studying and make it a positive experience, you will increase retention, it is that simple. Order pizza, play music, make it a "physics homework party night".

Use your whole brain on the problems – draw lots of pictures and figures (right brain) to go with the algebra (left brain). Listen to quiet music (right brain) while thinking through the sequences of events in the problem (left brain). Build little "demos" of problems where possible – even using your hands in this way helps strengthen memory.

Avoid “memorization”. You will learn physics far better if you learn to *solve* problems and *understand* the concepts rather than attempt to *memorize* the umpty-zillion formulas, factoids, and specific problems or examples covered at one time or another in the class.

Be sure to review the problems one last time when you get your graded homework back. Learn from your mistakes or you will, as they say, be doomed to repeat them.

If you follow this prescription, you will have seen *every assigned homework problem* a minimum of five or six times – three original passes, recitation itself, a final write up pass after recitation, and a review pass when you get it back. At least three of these should occur after you have solved *all* of the problems correctly, since recitation is devoted to ensuring this. When the time comes to study for exams, it should really be (for once) a *review* process, not a cram. Every problem will be like an old friend, and a very brief review will form a *seventh* pass or *eighth* pass through the assigned homework.

With this methodology (enhanced as required by the physics resource rooms, tutors, and help from your instructors) there is no reason for you do poorly in the course and every reason to expect that you will do well, perhaps very well indeed! And you'll still be spending only the 3-6 hours/week on homework that is expected of you in any course of this level of difficulty!

7 Tentative Schedule

The following is a *tentative* schedule for the *current* semester (Spring 2011). It probably will not survive intact, as I tend to slow down when people have trouble and speed up when it is smooth sailing, which varies year to year. But it is *a* schedule that will carry us through the material in a timely way, and complete all the required work in the allotted time.

Note that this has all the assignments for the semester, at least as of now. The assignment rule is simple – as we complete each chapter, do all of the homework at the end (all unstarred problems for 54, all problems for 42). Use the method of three passes to do the homework if at all possible. The homework will be reviewed, in groups, with tutorial assistance in recitation, followed by a quiz of similar difficulty to upper-third problems (but usually not starred problems). You then have *two days* to write up your homework and hand it into the box, where you are welcome to contact me or the TA for help finishing any problem(s) that were still not clear at the end of recitation.

Students are *strongly urged* to come to recitation with their homework at least *70% completed* in several work passes prior to recitation, so that they have a good chance of getting through the last few (usually quite difficult) problems *in* recitation with the help of your group members and the course mentors. If this does not occur, your quiz grade will inevitably reflect it, and your final grade will thereby suffer. Also, you won't have as much *fun* in recitation if you aren't participating as a *contributor* to the discussions on each problem. So please invest the time needed to make recitation a pleasant and productive experience for yourself and your fellow group members!

Day	Chapter	Assignment
January 12-14	Week 1	Week 1 HW (Due 01/28)
January 17-21	Week 2	Week 2 HW (02/4)
January 24-28	Week 3	Week 3 HW (02/11)
January 31-Feb 4	Week 4	Week 4 HW (02/18)
February 7-11	Week 5	Week 5 HW (02/25)
February 14-18	Week 6	Week 6 HW (03/4)
Feb 21	Hour Exam 1 (Weeks 1-4)	In Lab
Feb 21-25	Week 6	Week 6 HW (03/11)
Feb 28-Mar 4	Week 7	Week 7 HW (03/18)
March 7-11	Spring Break	Spring Break
March 14-18	Week 8	Week 8 HW (03/25)
March 21-25	Week 9	Week 9 HW (04/1)
March 28	Hour Exam 2 (Weeks 5-8)	In Lab
March 28-April 1	Week 10	Week 10 HW (04/8)
April 4-8	Week 11	Week 11 HW (04/15)
April 11-15	Week 12	Week 12 HW (04/22)
April 18-22	Week 13	Week 13 HW (04/27)
April 25	Hour Exam 3	In Lab
April 25-27	Complete Week 13	Last Day of Class
May 7	Final Exam, 9:00-12:00 a.m.	Room 150