Course Syllabus and Description

General Course Information

Instructor: Robert G. Brown
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Lab Instructor: Zach Corse
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Text:

(Free!) Online Textbook: at http://www.phy.duke.edu/∼rgb/Class/intro_physics_2

Course Website:

http://www.phy.duke.edu/∼rgb/Class/phy54_summer

Wikilinks

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 as you study, at your 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

Course Description

In this course we will cover the following basic topics:

0.0.1 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.

Your grade will be based on *approximately* the following scheme:

20% of grade Homework.

20% Quizzes

20-30% Hour Exams (3)

20-30% Final

10% Lab

Optional, 1/3 letter grade Extra Credit Project

Here's how the scheme works. First of all, note that there will be *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 to at least skim-read the chapters before we cover them in class. Remember, we're doing close to a chapter a day, so falling behind is not an option! I will sample-grade homework – grade degree of completeness and effort and one problem I pick out of the assignment (which you will *not* know beforehand).

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.

In most years, if you get below a 50 (and the curve is otherwise reasonable) 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, though, very little consideration will be given!

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 Ed if for any reason we feel that this grade does not correctly reflect your degree of learning.

The Rules

- You **may** collaborate with your classmates in any permutation on the **homework**. In fact, I *require* you to work in groups whenever possible, as you will 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 of mine (there is at least one handy right now even at the Marine Lab:-), 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 in the Marine Biology program, 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.* They must work *with* you collaboratively to solve the problem, not give you a solution to copy. 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) and **cite your source**. 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.

- Ed and I are important resources. You can *always* ask us how to solve a problem, and if we can see that you've at least tried it on your own we'll almost always be happy to walk you through it.

- **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 or in your cell phone or other personal electronic device(s) 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 human 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 not 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, or else it reflects a problem with your learning methodology or preparation that needs to be urgently addressed.

In the latter case especially, 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!

Structure and Expectations

The primary expectation I have of you is that you will all work *hard* to learn physics this summer, even as you have a great time studying and learning in this fabulous location and enjoying your weekends at the beach, the aquarium, or doing any of the many fun things the area offers. I'll be working just as hard with you, and hopefully having just as good a time (because physics is *fun*, actually). Hard work leads to great rewards in *anything* you put your hand and mind to, and I don't just mean in physics.

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.

- We'll be covering close to a chapter a day. This leaves very little time to "get" a difficult concept, if you wait until each one is taught in class. Get used to *skim reading* each chapter on your own **before** the relevant lectures, and skim it again to start every pass through the homework, and again in recitation where we go over the homework, and again when you go over your homework and quizzes after they are handed back, and again before the hour exam, and again before the final. You will need to overlap this in order to get enough "views" of the material to make learning relatively easy. See later in this syllabus for the motivation of this particular pattern.

- 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, and its *purpose* is to convey *at least once* a "moment of clarity" on each subject we study that can be transformed into real understanding by additional review and problem solving. However, the problem solving methology itself will primarily be *self-taught* with close support during recitation. Learning is an active process on your part not a passive process!

- 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. I (and Ed) will move from group to group and provide tutorial support. A graded short quiz will generally terminate recitation.

- There will be 3 hour exams over the course of the summer. This is roughly every week and a half, on average.

- Lab. Lab is an important "hands on" part of the course, and Ed has a selection of labs that cover the primary topics. On lab afternoons when we don't have a lab per se, we will improve the shining hour with more recitation, hour exams, or problem solving and study "catch-up" time.

  Lab meets on Monday and Wednesday afternoons in the Repass Ocean Conservation Center (where we have lecture and my office is). The approximate lab schedule (by topic and week, not necessarily specific lab(s) or day) will be:

Date	Topic
July 12	I. Electrostatics
July 19	II. E-field and Equipotential Surfaces
July 26	III. DC Circuits
Augus 2	IV. Faraday and EKG
August 9	V. Optics

- Extra Credit Project. If you (with my help and project approval and with Ed's help) can think up any sort of project that explores some aspect of physics covered in this course, especially in the context of Marine Biology, and complete the project by the end of the session will be awarded 1/3 of a letter grade promotion over the grade they would otherwise have received. This is a significant boost, and is "non-failure insurance" for students that are struggling for any reason, as a promotion from an F is to a D, from a D to a C-.

  We'll all have to do some work to look for suitable projects – they need to require enough work to be worthy of a promotion while not distracting you too much from the course proper, and *good* projects that focus on some aspect of Marine Biology will be considered for an even greater promotion.

Projects you might think of include: Building a crystal radio, a microscope, a telescope, an electromagnetic motor. Studying the response of marine creatures to applied EMFs. Studying the optical properties of seawater and associating it with the shape of the eyes of fish. Projects can be experimental/laboratory, constructional (building something), simulational (programming something), or paper/library/web research (term papers).

Projects *must be approved ahead of time to receive credit!* Projects are graded in *binary* – either you're promoted or you aren't. If the project is handed in in time for me to look at it and give you feedback with some time remaining in the session to fix problems, you will have a chance to repair any weaknesses and still get promoted. Projects handed in at the last minute get what they get (which may be nothing at all).

Personal Availability and Methods of Contact

During the day M-Th I will usually be lecturing you, eating or hanging out with my son(s) on the island, or at recitation or in my office while you are in lab. The rest of the time I will have my cell phone (919-280-8443) with me and/or will be working at a computer. Call me to find me stat, or send me email if you have a more liesurely problem, or come look for me in person. Note that some afternoons, especially if you have a lab, I may be out kayaking and/or fishing but I will have my bluetooth on and can probably answer questions over the phone (no kidding!) from "somewhere out at sea"...

I will be available evenings (and much of the weekends) in one of three places:

- In the **Repass Ocean Conservation Center** (where we have class) in my office or the workspace. This year I'm going to try the schedule of being there consistently the night before recitation (Sunday night and Tuesday night) probably all evening from 8 pm to midnight or whenever) but *not* being there the rest of the week.
- In my house at *352 Causeway*, which is the access road you cross to get onto Pivers Island. My door there will rarely be closed to a student seeking help during the week or wanting to fish off of a dock or hang out with dogs. On Friday evening, Saturday, and Sunday morning, I might be out and about with my wife and kids and you'll have to take your chances. It is a good idea to call my cell phone to make sure I'm home before coming over, though because I could be...
- Somewhere in the bay **fishing** from my kayak. I will have my cell phone with me, and once again may be able to answer questions on the spot (while fishing) via my hands-free bluetooth earpiece. I probably cannot answer text messages at this time, though, because I keep my phone sealed in a waterproof container as phones and salt water are mortal enemies with the phone on the losing end. Feel free to leave a text message (or voicemail in the event that I don't answer) and I'll call you back or come around to help you in the Repass center when I get a chance.

Ed will set his own hours, but will certainly be around most afternoons during the lab period and recitation; he will likely *not* be here in the evenings. His email address is given above, and you should feel free to contact him directly if you have problems with the lab(s) or homework that you wish to discuss with him instead of me.

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 *only* in lecture and fail to reinforce with more active learning methodologies. 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 continue...

* * *

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 information above is provided to help you figure out how to learn as effectively as possible with a limited amount of time to study. In a regular course, I'd direct you to try "the method of three passes" to achieve the repetition required spread out over a week, but in summer school that is difficult. Here we're *all* going to have to experiment with patterns. In one sense this is easy enough – we will be repeating material two or three times across a couple of days no matter what, as that's all the time we'll spend on most subjects bnefore moving on. On the other, it is very difficult to get the *time* interval in between each pass through the material (with that good night's sleep) unless you make at least *one more pass* through the material *after* you've handed it in and gotten it back.

This is the pass that most students never make, but I think you should give it a try. So here is a modified method of three passes for summer school It may not work quite as well, or it may be close enough that one of you discovers an even more effective pattern. Be sure to tell me if you do!

The Method of Three Passes (Overlapping)

This is presented "backwards", as you'll be doing pass 3 (for yesterday's homework), pass 2 (for today's homework) and pass 1 (for tomorrow's homework) *all on the same day.* I'm assuming that you'll typically be working 4 hours every evening on physics homework, spread out over six hours total from 6 pm to midnight. Here's how I suggest breaking it up.

Pass 3 Make a *final* pass through all the problems you solved and handed in *yesterday* (final before you study for the hour exam or final exam, anyway). This pass should consist of rereading the text and notes to refresh your understanding, then going over all the homework. Note and correct your mistakes. Recall in your mind (and maybe put once again on paper) how to solve each problem as you go over it. I'd suggest spending thirty minutes to an hour on this, seriously. Do this *first* every night, as it will "warm you up" for doing the current day's homework.

Pass 2 Now do *today's* homework assignment. Reread the chapter(s). Review the notes. Tackle the problems, working in groups. If you don't get a problem after ten or fifteen minutes of work, go on to the next one, then come back to the problem at the end. Get help on anything you are REALLY stuck on from me (919-280-8443 to find me, if I'm not handy). It is OK to take 1-3 of the hardest problems still unsolved to recitation, if you've really worked on them for a while and been unable to get them, but you should be able to get 70% of the homework (at least) done before recitation. This pass will take you a couple of hours of work, maybe more.

Pass 1 The night *before* lecture on a chapter, make a *fast* pass through the chapter and all the problems assigned for the chapter. Plan to spend 30 minutes to an hour on this pass. With roughly 10-12 problems, this gives you around five minutes per problem. Spend *no more* than five minutes *per problem* (including the chapter skim/review). If you and your group can solve them in this much time even before lecture (often you won't be able to) that's *great*, but if you can't don't worry about it. Just get the problem 'in your mind' for consideration the next day, and move on.

Remember, you'll learn more if you're having fun than if you hate what you're doing. Working in groups is social and more fun. Ordering pizza makes it more fun. Working out on the lawn in fine weather is better than working in a dark room all alone, as long as you can concentrate. If you're unhappy and not having fun, talk to me and we'll see if we can't come up with strategies that make it fun for you.