Physics 42 Homework
From Tipler, 5th edition

Instructions: Do all assigned problems. Please try to use the *Method of Three Passes*, attached. Read over this for other general comments and instructions in any event.

Note that bonus questions have to be solved *without the direct help* of Kristine or me. You may still work in groups, you can solve them with discussion on the class list (where Kristine or I *might* reply to help out the entire class with our answers), you can ask other faculty or graduate students, you can look online or in other texts or in the library for solutions, but *you* have to build your problem solving skills and confidence by attacking them. They are often worth quite a lot of credit!

Chapter 21: 41,47,56,61,62,72,78,81,85

Chapter 22: 29,47,50,56,61,66,77,88,92,93,94

Chapter 23: 16,59,73,85,87,88,89,90,91,92,93.

Bonus questions, worth three points each:

Find the potential of an electric dipole at an arbitrary point in space as follows. Put $\pm q$ at $\pm a/2$ on the z-axis. Pick a point $\boldsymbol{r} = (r, \theta, \phi = 0)$ (the latter just means "in the plane of your picture). Write down the potential at that point. This is your answer. Now let $r \gg a$. Do a binomial expansion of both denominators, set $p_a = qa$, and tell me the *potential of a point dipole* at an arbitrary point in space relative to the dipole axis. Pretty cool! This is a really important thing to understand – just ask Kristine!

Problem 95. When you solve this you are actually deriving an important theorem that says that the potential at any point in space that is free from charge is the average over a spherical surface around that point. A related theorem tells you that both the maximum and minimum potential inside any charge-free volume must occur on the surface. Both of these are consequences of Gauss's Law expressed as the *Poisson equation* (the inhomogeneous Laplace equation). You won't learn all of this for several years, but you'll learn it much more *easily* then if you solve this problem now, which isn't *that* difficult!

Chapter 24: 51, 56, 57, 84, 92, 93, 94, 97, 104, 112

Bonus: Problem 110.

Chapter 25: 30, 56, 57, 97, 116, 118, 133, 144, 145

Bonus. Suppose you have are handed a "infinite" flat piece of metal screening consisting of thin wires in a rectangular mesh. Each bit of wire between two adjacent intersections in the screen has a resistance R. *From symmetry,* find the *total* resistance between to adjacent intersections. Note that this quantity is bound to be less than R because there are other pathways that current can take between the interactions. Note also that if you try to actually sum the resistance network, you'll go mad. There's a trick, so think about it and see if you can figure it out.

This is an example of a problem where clear conceptual thinking can sometimes do a problem that cannot, literally, be algebraically solved. Give your left brain a rest and let your right brain drive. Visualize what the currents and so on must be doing. Think about superposition, and boundary conditions at infinity on the mesh. Don't think about series and parallel sums.

Any group that honestly gets this on their own gets two pieces of candy each (plus points, of course)! Any group that gets it with some help – finding the answer on the web, getting help from a group that figured it out, getting a hint from Christine, whatever – gets one piece of candy and points. Groups that don't get it get to watch other people eat, awwww. Maybe the first group(s) will share – their solutions, not the candy, so you can qualify for the second group.

Chapter 26: 34,36,37,49,51,57,64,65,80,81,87

Bonus: Suppose you have an object (like a simple model for a proton or electron) that has a mass distribution that is directly proportional to its charge distribution:

$$\rho_{\text{charge}} = \frac{Q}{M}\rho_{\text{mass}}$$

Suppose that the object is rotating about some fixed axis parallel to an axis of symmetry of the object so that

$$\boldsymbol{L} = I\boldsymbol{\omega}$$

Show that its magnetic moment must satisfy:

$$\boldsymbol{m} = \frac{1}{2}\frac{Q}{M}\boldsymbol{L}$$

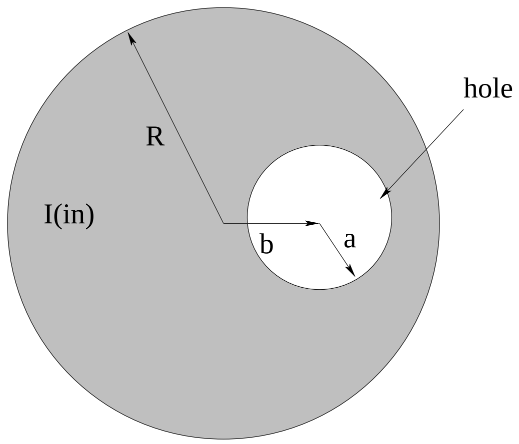
Note well that this is an *easy* way to solve *all four* of the three dot problems 64-68 at one time. To help you get started, remember that you have the following three relations:

$$\begin{aligned} Q &= \int \rho_{\text{charge}} dV \\ M &= \int \rho_{\text{mass}} dV \\ I &= \int r^2 dm \end{aligned}$$

Bonus: Do question 69. This will require that you review torgue and precession of a gyroscope from last semester, but this problem is *very important* to understand as it is the basis of nuclear magnetic resonance, electron magnetic resonance, MRI scans in medicine, photon and spin echos and various aspects of resonance in quantum optical or spin systems – it is just plain important! It also isn't *that* difficult, so give it a try...

Chapter 27: 67, 70, 105, 125, 126.

Bonus 1:



A long straight cylindrical wire of radius R that has a long straight cylindrical hole in it of radius a centered a distance b from the center as shown. The wire is carrying a current I presumed to be uniformly distributed across the wire (but not in the hole).

Show that the electric field inside the hole is *uniform* and find its magnitude and direction in terms of the givens.

Bonus 2:

A long straight cylindrical wire of radius R is carrying a current density that is *not* uniformly distributed but is rather given by $J = J_0(1 - e^{\frac{-r}{a}})$ (which you may orient into or out of the page as you wish when you draw it, but indicate your choice). Find the magnetic field for all $r > R$ and $r < R$.

Chapter 28: 5, 24, 25, 41, 45, 52, 59, 87, 88, 94

Chapter 29: 48, 55, 97, 98, 99, 100, 106, 111

Bonus 1: Write up a *complete* solution to the parallel LRC circuit problem, with comments, as if you were going to lecture on it.

Bonus 2: Write up a short (1-2) page description of how a "crystal" AM radio that would pull in AM 620 (Voice of the Blue Devils) might be designed and built either from scratch or from a kit. Include both half-wave and full-wave rectifier versions of the design. Note that "from scratch" requires a real crystal of some kind (what kind?) and a handmade inductor and capacitor, while "from a kit" can use diodes in place of the crystal diode(s).

Chapter 30: 23, 52, 53, 62, 65, 66, 67, 68

Bonus 1: Problem 69

Chapter 31: 39, 40, 46, 78, 87

Only a few problems, but they are pretty difficult (love that geometry).

Chapter 32: 66, 67, 90, 84, 96, 101, 102, 124, 125

Chapter 33: 21, 27, 33, 38, 42, 49, 52, 60, 76, 86, 89

The Method of Three Passes

This method is pretty much guaranteed to radically improve your learning comprehension (and incidentally your grade:-) in any class where you employ it. It may need small tweaks for other classes (the specific layout below is customized for physics the way I teach it) but its essential advantages hold for any class. Multiple passes provide *time* for your brain to build a *network* of factoids and connect them into a solid body of understanding, and working from a rapid, shallow but broad review of *all* the material to a slow, deliberate study of specific chunks of the material is a truly excellent way to learn something deeply and rapidly.

This method gets you past the "bootstrapping" problem – it is often difficult to understand *this* problem or concept until you understand *those other three* problems or concepts as well – both ways! If you work through things sequentially and deliberately from the beginning you may be intensely frustrated until you work back and forth enough times to see the connections. Repitition is essential to forming long term memory. Working in a "comfortable" environment with friends improves memory formation. Hands on group learning experiences, especially mututal teaching, move you *way* down the learning pyramid. The synthetic, synergistic power of a group literally makes you smarter! Real humans work this way in real life – it is actually *rare* for a human to work in complete isolation, and few people work efficiently in that way.

So sure, consider studying *philosophy* this way, by making a quick pass over the assigned reading, maybe doing a google search and skimming some stuff "about" the work on the Internet. Make a second pass where you read it more deeply. Make a third pass where you get together with classmates at a coffee shop and you kick the ideas around. Or invent a similar approach for studying history, psychology, whatever you like. You'll be glad you did!

1. Work 1-1.5 hours on the homework alone, ideally right before bed (and not too late at night or tired). Review all notes and text first, then work *no more* than five minutes per problem (use a timer if necessary). Obviously this won't be enough to solve most of them, but you should be able to "set up" many of them with a page, a drawing or two, and some trial relations. *Think* at this point about what physics is being tested. What's the problem all about? Even in this short time, you'll probably be able to solve 3 problems or so as there are always a few relatively easy ones. Stop. Go to bed and sleep at least one full night.

2. Work 1-1.5 hours on the homework either with a group of fellow students or alone, right before bed. Start again by reviewing notes and text *and* any problems you solved in the first pass, then work *no more* than *ten* minutes per still-undone problem (plus a minute or two on reviewing done ones). You should find that several of the problems you were completely confused by the first pass now make sense and you can at least attempt a

solution, and that this is enough time to end up having made it through as many as half the problems. The hard ones will likely stump you, though. Don't worry. Quit and go to bed and sleep at least one full night.

3. This pass is a good one to do the night before recitation. Work 1-1.5 hours on the homework in the late evening. Work if at all possible in a group – ideally with your recitation group, basically getting a jump on the recitation process. This is an excellent time to include your tutor in your group, if you have one. Note that the Academic Resource Center: http://aaswebsv.aas.duke.edu/skills/ can provide peer tutors, and that you can "bundle" your time with them if you work in groups of three or more and actually get a *better* learning experience than you might one on one. Talk to me if you need help arranging this. Also note that the ARC is a *great* place to go to improve your ability to learn at constant effort and a net reduction of time in *all* your courses – give them a visit!

   Go over the ones you've solved, discuss the ones you can't yet solve, review notes and text as necessary. This time you should spend *no more* than *fifteen* minutes per problem on the ones you haven't been able to get yet. Again you should find that one or two of the difficult ones just "give up" – that you have sudden insight into how to solve them even when the night before you were completely confused. Eat pizza or salad, drink decaf tea (avoid alcohol), have fun, chat, don't be TOO compulsive about the homework. Quit, go to bed as soon as possible thereafter, and sleep.

If you do this religiously, you should have no more than 3-4 problems that you haven't completely solved and that you don't understand pretty well when you come to recitation. Recitation is then a *fourth* pass, this time in groups and with direct tutorial teaching support by a professional teacher. If you have worked correctly beforehand, you and your group should have *no difficulty* completing all the homework problems so that you thoroughly understand *all* of them, no matter how difficult they at first appeared, well before the quiz. You can spend the remainder of the time exploring the problems and thinking about how they might be changed on (say) a quiz or exam.

You then have two days to write up the homework in a neat form to hand in (a fifth pass, if you choose to make it such) and seek help from the TA (Kristine) or myself to resolve any problems that remain iffy after the first four passes. When you get the homework back, of course you should go over it and the quiz and learn from your mistakes (a sixth pass). When the time comes to study for an hour exam or final, you should find that – possibly for the first time in your life – you will go into the test *knowing* that you know the material and are thoroughly prepared. Even if you encounter a *difficult* problem on the exam, you are very unlikely to come up empty – at the very least you should be able to draw the right figure, correctly identify the physics required, and set it up. At that point you've already got most of the credit, and you have a fighting chance of being able to completely solve it.