Department of Physics
Physics 2048 (Rabson) Fall semester, 1998

Homework for Week 3
Nominal due date: Friday, 11 September

1. A charged particle (such as a proton) in a uniform magnetic field moves with constant velocity in the direction of the magnetic field while describing (at constant speed) a counterclockwise circle in the plane perpendicular to the field. This trajectory is called a helix. To put the same thing another way, the proton twists around a straight line that points in the same direction as the field; a line drawn perpendicularly from that line to the proton always has the same length but twirls about. Choosing appropriate axes, express (symbolically) the particle’s position, velocity, and acceleration in Cartesian (e.g., $x$-$y$-$z$ or $i$-$j$-$k$) coordinates. You do not need to relate any of the parameters to the strength of the field or the charge; that’s next semester. Imagine you’ve simply observed the motion described and wish to describe it.

2-4.
Questions 4.5Q, 4.10Q, and 4.12Q on page 72. In the first of these, assume that the ground is level.

5-21.
4.5E, 4.14P, 4.18E, 4.24E, 4.32P, 4.39P, 4.56P, 4.57E (charged particles radiate energy when accelerated; if an electron really did what the problem says, all the matter in the universe would have collapsed in a tiny fraction of a second), 4.64E, 4.65E, 4.67P, 4.73E, 4.75E (comment on the relation between the two parts of the answer), 4.79E, 4.83P, 4.85P, 4.87P.

22. Read §4.10 about relative velocities in one dimension close to the speed of light, although I am not going to test you on it. Does anything interesting happen in equation 4-32 if observer B observes that a particle is moving at exactly $c$, the speed of light in vacuum?

Homework for Week 4
Nominal due date: Friday, 18 September

Quiz 1 on 18 September will cover Motion, chapters 1–4.

1-4.
Questions 5.2Q, 5.3Q, 5.7Q, 5.10Q on pp. 99-101.

5-14.
5.3P, 5.8E, 5.15E, 5.17E, 5.29E, 5.30E, 5.32E, 5.33E, 5.34E, 5.36P.

15. An elevator accelerates freely in a constant and uniform gravitational field. Does the elevator constitute an inertial reference frame? Hints: do you recognize the gentleman in figure 5-25? How could the occupant perform an experiment analogous to that in figure 5-1?

Information on computer: http://bardeen.cas.usf.edu
E-mail: drabson@chuma.cas.usf.edu
Answers to questions from week 1 not from Halliday and Resnick

*Note: Answers to H8R questions are available on reserve in the library.*

1. The question asked you to determine the density of earth. This, naturally, depends on the *kind* of earth: rock may be far denser than coal or sand. In all cases, the average density of the Earth is inappropriate, since the deep and inaccessible core is very much denser than the crust, where the mining operation is taking place. I used a density of 1750 kg/m$^3$ (based on sand), but if the earth is rich in coal it may be lighter: one student looked up the density of coal, and discovered that it’s actually lighter than water (which has a density of 1000 kg/m$^3$). With my figure, the mine moves about $3.5 \times 10^{10}$ kg, or 35 million metric tonnes, a year. You can easily imagine that the person in charge of renting and scheduling dump trucks for the mine would want to go through this sort of exercise.

2. What I’m really asking is why we don’t yet use an atomic definition of the kilogram as we do of the second and (derived from it) the meter. Whereas the electronics of an atomic clock can effectively count the number of oscillations required by the yellow box on page 6 of the textbook (not directly, perhaps), there is no machine that can count and measure the mass of a specified number of atoms. Scanning-tunneling microscopes can, at best, move a few dozen atoms, but such a collection has far too little mass to measure.

2. (cont.)

As an alternative that might seem reasonable, we could use a single crystal of a solid of given dimensions. Since interatomic spacings in crystals are known very accurately, this solid would contain a known number of atoms. An actual representation, of course, would have some error in the machining and so in the number of atoms and mass, but as something that could be built anywhere, it would eliminate the need for an international standard kilogram. My guess is that the errors in machining such a thing to given dimensions, and from internal defects, must still exceed those in copying and carefully comparing to the standard.

3. See figure at left.

4. It is poor practice to omit units. The authors ought to have written something like \(x = 3\text{(m/s)}t - 4\text{(m/sec}^2)\text{t}^2 + 1\text{(m/sec}^3)\text{t}^3\). Sometimes in research work, theoretical physicists will scale their variables in a way I can explain to anyone interested. Doing so may result in prettier formulas but at the cost of losing dimensional checks on intermediate results.
Solutions from week 2

3. A three-dimensional vector transforms in predictable ways under spatial operations such as rotations. In particular, its length is the same no matter how we define the coordinate system. With an unrestricted collection of three numbers [for example, $(number\ of\ apples, \ weight\ of\ an\ orange, \ x\ component\ of\ my\ velocity)$], it is not clear what a coordinate rotation would mean. If one even could make sense of that idea, applying it would not preserve any “length” that one might define for the three numbers.

4. The dot product between two arbitrary vectors gives the projection of one on the other times the length of the second. Alternatively, it gives the cosine of the angle between the vectors times the product of their lengths.

25. True. Note that both expressions represent the volume of a parallelepiped defined by the three vectors; the only remaining work is to verify that the sign does not change. Now one easily verifies (with a right or left hand) that if $\mathbf{a}$, $\mathbf{b}$, and $\mathbf{c}$ form a right-handed or a left-handed triplet, so do $\mathbf{b}$, $\mathbf{c}$, and $\mathbf{a}$. Thus the sign of the triple products is the same.

Some good physics habits

1. Start the reading and homework early.

2. If you get stuck, try a different problem. Once you’re stuck on all remaining problems, talk to your friends. Chances are, you’re stuck in different places and will be able to unstick each other.

3. Instead of memorizing a formula, you can often figure out what it must be just based on how the dimensions (e.g., meters, seconds, kilograms) have to work out to get what you want. Usually you know whether increasing some quantity (e.g., the mass) will increase or decrease the result (e.g., the acceleration). Then it’s easy to tell whether the quantity goes on top or on the bottom.

4. Visualize the ideas and the problems. For example, if the book talks about a falling body, close your eyes and watch it fall. Then see if the math describes what you saw in your head.

5. Make the connection between the physical ideas on the one hand and the mathematical tools on the other. You need both.

6. If an idea or equation seems too abstract at first, try plugging in specific numbers to see how it behaves.

7. To see if a result makes sense or not, try plugging in extremal values, such as zero or plus and minus infinity. For example, in a problem with constant acceleration, try zero acceleration. Does it do what you expect?

8. If there are two symmetrical bodies acting on each other—call them $x$ and $y$—try reversing them. Does the equation do what you expect?

9. Think about how some of what we’re doing might help you in possible future careers.

10. To help improve the accuracy of your algebra, write neatly and slowly from left to right and top to bottom. Don’t skip steps. Once you have the result, copy the algebra neatly onto your final submission. Go through every step twice to make sure you haven’t lost a sign or a factor of 2. (In extreme cases of not being able to track down a factor of 2, place your homework under your pillow before going to sleep. During the night, the two-fairy may correct it.)

Some bad physics habits

-1. Plug and chug (finding a formula that seems to have all the variables you need and plugging in numbers).

-2. Acting like a hermit, never discussing physics with your friends.

-3. Believing that every chapter has five different types of problems, and that as soon as you’ve memorized how to do them, you’re home free.

-4. Concentrating on formulas, ignoring physical ideas and derivations.

-5. Thinking it’s all obvious.

-6. Getting discouraged because it isn’t all obvious.

-7. Omitting units.

-8. Waiting until the last minute to try the homework.

-9. Trying to memorize formulas.

-10. While doing algebra, trying to conserve paper by writing in every conceivable direction, with arrows and curly shapes going all around the sheet until you can’t even figure out where you are any more.