

## Physics 214b-2008 Walter F. Smith Assignment 1 (revised)

**Due:** 4 pm Wednesday 1-20-08

**Reading:** Ch. 1

### Exercises

All problems are group problems, unless otherwise marked; you are encouraged to work in small groups on these.. For the individual problems, you are not allowed to consult any other students, but you may ask me for help. [For this particular assignment, there are no individual problems.]

You are always welcome to use Mathematica on assignments. However, you should employ good judgement about this -- don't let it become a crutch that you use even for rather easy algebra and derivatives. Do use it for messy algebra and integrals.

Here are the groundrules: When working in a small group on a problem, you may jointly use Mathematica. HOWEVER, I require that each of you INDIVIDUALLY re-enter the Mathematica stuff on your own, even if you are transcribing from a printout of the joint Mathematica effort. The reason I impose this requirement is that Mathematica is very picky about punctuation and other details, so I want each of you to have the experience of actually entering (NOT just cutting and pasting) the equations into Mathematica.

When you are writing up your problem set, you should include an arrow with "Mathematica" written above it to indicate that a bunch of steps were done here by Mathematica. Then, you MUST append a printout of the Mathematica output. If the printout is at all confusing, you should notate it by hand to make it clear.

On this particular assignment, I strongly suggest that you use Mathematica for problem 1D. In particular, you will need to use the multiple simultaneous equation solver. Here's an example:

```
Solve[{x == 4b, b == 3y, y == 2}, {x,b}]
```

This means: "Solve the system of equations  $x = 4b$ ,  $b = 3y$ , and  $y = 2$  for  $x$  and  $b$ ."

Notes:

- 1) Use a capital S in "Solve"
- 2) Use square brackets around the arguments of the Solve function.
- 3) Use curly braces around the set of equations and around the set of variables to be solved for.
- 4) Use double equal signs in each equation.
- 5) You can define complicated things in previous lines of Mathematica, and then employ them in the Solve line. For example:

```
g = 1/(1+b^2)  
Solve [ g b == 2, b]
```

(In this case, I've omitted the curly braces, since there is only one equation, and only one variable to be solved for.)

I usually use Mathematica instead of a calculator for plugging in numbers, even though I may have done the algebra by hand. I find this results in fewer errors than using a calculator, because I can see everything on the screen and see that I've entered it correctly. However, this is a personal preference. You are very welcome to use a calculator.

Also, I will warn you that, on exams you will not be allowed to use Mathematica or a calculator to do

symbolic algebra or calculus, not even to check algebra that you've done by hand. The exam questions will be designed so that you should be able to do all the algebra and calculus by hand.

If you've never used Mathematica before, please let me know right away.

**1A.** At what speed does the kinetic energy of a particle equal its rest energy?

**1B.** What is the velocity of an electron that starts at rest and is then accelerated through a potential difference of 1.6 V?

**1C.** A particle of mass  $M$  is at rest, and then decays into two identical particles of mass  $m$ . What is the speed of each of these particles?

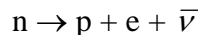
**1D.** The rest masses for particles are often quoted in units of MeV (one million electron volts). Using  $E = mc^2$ , it is easy to convert these to kg, if needed:

$$E = 1.6 \text{ eV} = (1.6 \text{ e})J \Rightarrow m = \frac{E}{c^2} = \frac{(1.6 \text{ e})J}{c^2},$$

where  $e = 1.60217653 \cdot 10^{-19} \text{ C}$  is the magnitude of charge of an electron. For example, an electron has a mass of 0.511 MeV (sometimes quoted as  $0.511 \text{ MeV}/c^2$ ), which corresponds to

$$\frac{(0.511 \text{ e})J}{c^2} = 9.11 \cdot 10^{-31} \text{ kg}$$

Two other important particles are the proton (938.27 MeV) and the neutron (939.57 MeV). Neutrons are stable only inside nuclei. An isolated neutron will eventually decay into a proton, an electron, and an antineutrino:



For this problem, neglect the energy and momentum of the antineutrino, and assume that the neutron was at rest before the decay. What is the velocity of the electron?

**Townsend problem 1.10.** Assume that the metal is 1.00 m away from a 1.00 W source of the 1 eV photons, and that the area per atom is  $(1 \text{ \AA})^2$ .

**1E.** (Taken from Taylor & Wheeler, 2<sup>nd</sup> Ed.) A positron (the anti-particle of an electron, having the same mass, but opposite charge) of mass  $m$  and kinetic energy equal to its mass strikes an electron at rest. They annihilate, creating two high-energy photons. One photon enters a detector placed at an angle of  $90^\circ$  with respect to the direction of the incident positron, as shown, and the other travels at an angle  $\theta$  relative to the direction of the incident positron, as shown.

a) What are the energies of both photons (in units of mass of the electron)?

b) What is the value of the angle  $\theta$ ?

