PHYS 101- Concepts of Physics - Fall 2006
Homework # 3
Due in class Thursday November 16th

You must type your work. You may hand-write equations and drawings as needed-just please be neat.

You should write enough for each problem so that we know you've done some work and understand the principles involved. In other words, **show your work**. Numerical answers alone will receive only partial credit.

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1. Measure the angle of the sun above the horizon around noontime (between 11:30 am and 12:30 pm now that we are back on standard time). Be sure to state your location, date, and time, and show your work.

2. The data below shows the maximum angle, in degrees, of the sun above the horizon for Charlottesville on various dates. All numbers have an uncertainty of plus or minus 1 degree.

Jan 3	29.5	Mar 14	49.8	Jun 14	76.0	Sept 13	56.2	Dec 1	30.7
Jan 17	31.5	Mar 26	54.9	Jun 21	76.0	Sept 27	50.7	Dec 12	29.5
Jan 31	35.0	Apr 11	60.9	July 6	75.0	Oct 8	46.7	Dec 27	29.1
Feb 9	37.7	Apr 29	67.0	July 25	72.1	Oct 25	40.4		
Feb 19	41.3	May 12	71.0	Aug 9	68.7	Nov 8	36.0		
Feb 27	44.3	May 31	74.8	Aug 29	61.5	Nov 19	33.2		

   (a) On the pre-formatted graph supplied on a separate sheet, plot each of the data points above. After you plot all of the points, go back and draw a thin vertical line extending 1 degree above and 1 degree below each point. This is to show the uncertainty in the data. Then draw a smooth curve that connects the points.
   (b) Plot your data point from question #1 above, with a vertical line to denote whatever uncertainty you think appropriate. Label your data as "my data point" in some obvious way so it can be distinguished from the data in the chart above. [You are welcome to also plot other data you have taken this semester if you wish.] How well does your data agree with the data in the chart?
   (c) At what times of the year does the angle of the sun change most rapidly (i.e. gain or lose a lot of degrees in a small number of days)? least rapidly? Explain how you can discern this from the graph.
   (d) Using what you know about the latitude of Charlottesville and how to calculate the angle of the sun above the horizon (see HW # 1 to refresh your memory), what should the maximum and minimum angles of the sun at noontime be? On which dates should they occur? Does the graph agree (within data uncertainty) with your prediction? Explain.

3. In order to broadcast television signals to a fixed satellite dish here on Earth, the orbiting satellite must have an orbit known as "geosynchronous." This means the satellite must orbit above the equator, move towards the east, and have an altitude of 22,200 miles above the surface of the Earth. A satellite with such an orbit will take exactly 1-day to orbit the Earth, and thus appear to have a fixed location in the sky.

   Imagine that there is a geosynchronous satellite with the same longitude as Dallas, Texas towards which satellite dishes here in Charlottesville point. (I believe this is approximately correct.)

   (a) Based on this, in what direction must one point a satellite dish to receive television signals in Charlottesville (North? Northeast? West? …Etc.) Explain your answer.

   (b) At approximately what angle above the horizon must the dish point? To answer this question, make a scale drawing of the Earth (the radius of which is 4000 miles). Be sure to show the poles, the equator, Charlottesville, and the satellite the correct distance above the equator. Then point out which angle you

are trying to determine, and either measure it directly from your drawing with a protractor, or do some trigonometry to determine it. Be sure to explain your method.

(c) Then, find a satellite dish on or near grounds to check your answer. (There used to be several large dishes behind Zehmer Hall—they are probably still there.) Be sure to state its location, and the direction in which it's pointing (you may need to check a map of UVA online to confirm the direction).

4. Two spaceships A and B are far out in outer space, so that gravity is negligible. The two ships are engaged in some maneuvers. We are viewing the ships from the side. For each question below, decide what will happen and answer as precisely as you can. Be sure to explain at least briefly.

(a) At first, neither ship is accelerating. Describe a simple test the passengers of each ship can perform to determine that their ship is not accelerating.
(b) What do the passengers experience in the situation of part (a)? Describe this briefly. Do "up" or "down" have meaning?
(c) To get closer to B, A accelerates to the right. Describe a simple test the passengers of ship A can perform to determine that their ship is accelerating towards B.
(d) What do the passengers of A experience during the acceleration in part (c)?
(e) Ship A now decelerates back to zero velocity relative to B. How can the passengers of A test for this deceleration, and what do they feel?
(f) Ship A fires a powerful laser at ship B. From our side point of view, what do we see of the laser blast?
(g) Does ship A show any motion, however small, as it fires the laser? Explain.
(h) Does ship B show any motion, however small, as it receives the laser blast? Explain.

(i) Assume ship A is now back at rest relative to ship B. The original mass of ship A, including fuel, is 100,000 kg. The ship now expels 1000 kg of fuel (in the form of a gas) to the left at 4,000 m/s. In what direction, and at what speed, does ship A move?

(j) Ship B is brightly lit by green light bulbs. Ship A, having accelerated even more, is now moving very, very quickly toward ship B. What color are passengers of ship A likely to observe: red, green, or blue? Explain.

(k) Ship B explodes. Do passengers of ship A hear the explosion? Explain.

5. Make a sketch of an electric circuit that contains a switch and two light bulbs connected in such a way that if either bulb burns out the other still functions, but if the switch is turned off, both bulbs go out.

6. A parallel electric circuit contains a 120-volt generator, a 15-amp fuse which limits the total current supplied by the generator, and four devices: a 60-watt light bulb, a 100-watt light bulb, a 1500-watt hair dryer, and a 24-watt cell-phone charger. (Assume that these wattages are correct.)

   (a) Sketch the circuit, showing all six items listed above. Also, leave enough room to label your circuit with values calculated in the subsequent parts of this problem.
   (b) Find the electric current, in amps, through each of the four devices, and label these on your sketch.
   (c) Find the resistance, in ohms, of each of the light bulbs, and label these on your sketch. Do your answers make sense? In other words, which do you expect to have the larger resistance, and why?
   (d) How many additional 100-watt light bulbs can be added to the circuit without blowing the fuse? Explain.

7. Exercise # 8 on page 245 of Hobson 4^{th} edition.

8. According to "classical" (Newtonian) physics, an electron (mass = 9.1×10^{-31} kg) accelerated through 500,000 volts will have a kinetic energy of 8×10^{-14} Joules. Continuing to follow Newtonian theory, calculate the speed of this electron. In what way does your answer disagree with experiment? Explain.

Maximum angle of sun above horizon

Charlottesville, Virginia