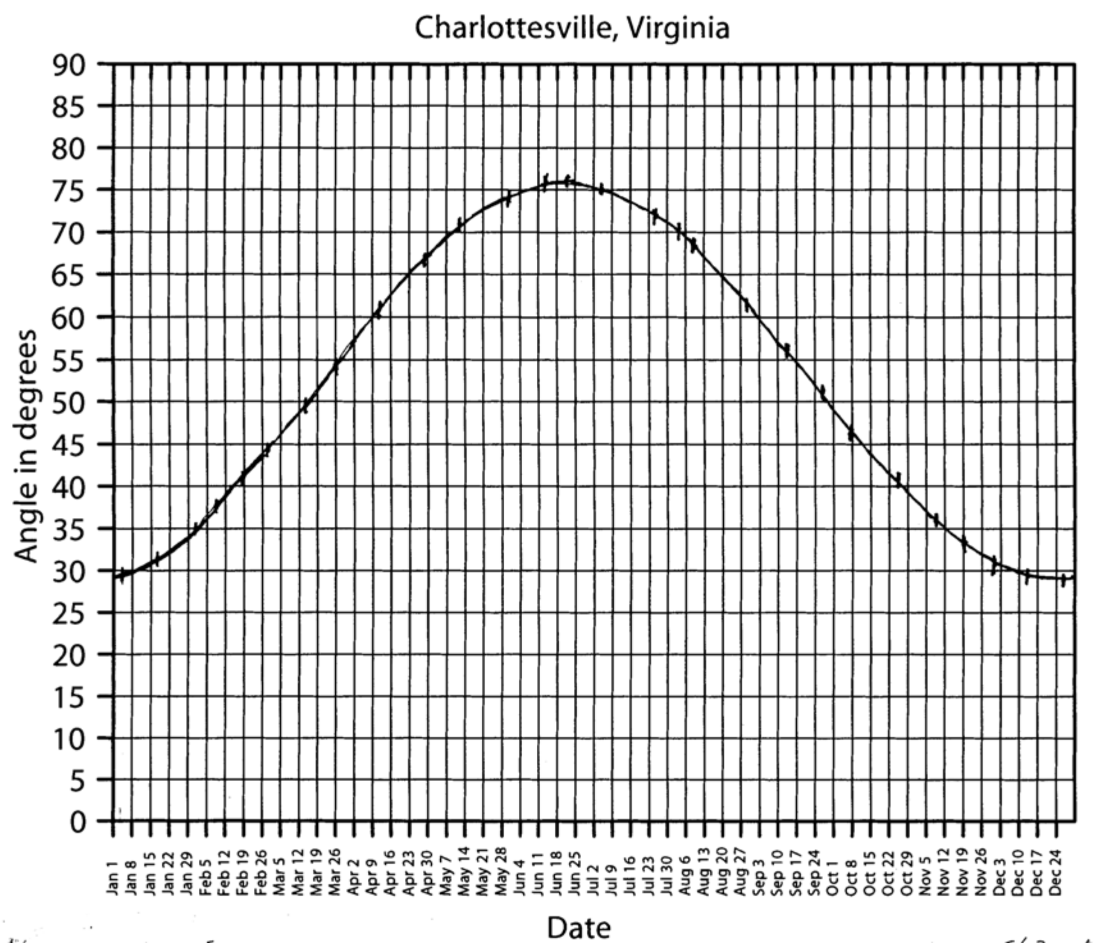
PHYS 101, Fall 2006, HW # 3 solutions--100 points possible.
[1.—10 pts, 2.--15 pts, 3.--15 pts, 4.--20 pts, 5.—5 pts, 6.—15 pts, 7.—10 pts., 8.---10pts.]

1. Measure angle of sun. Must state location, date, and time. Sample answer: Nov. 8, 35.3 degrees; Nov 11, 34.5 degrees; Nov 14, 33.5 degrees.

2. (a) see graph below--must be neat and carefully drawn, with points connected by a smooth curve, and the uncertainty of each data point indicated.



(b) plot your data point, and comment on its accuracy
(c) most rapidly spring and fall; least summer and winter. You can tell by looking at the slope of the graph--where it's steep, the angle of the sun is changing rapidly.
(d) for Charlottesville, max = 75.5 degrees, min = 28.5 degrees; these agree with the plotted data, as long as the uncertainty is taken into account. These max and min numbers are found from: Angle = 90 – 38 ± 23.5 degrees.

3. (Geosynchronous satellite question)

(a) To point at a geosynchronous satellite with the same longitude as Dallas, Texas, a satellite dish in Charlottesville will point approximately southwest.

(b) To find the angle above the horizon to which you must point the satellite dish, pretend the satellite has the same longitude as Charlottesville. In other words, pretend that the dish is pointed directly south, instead of southwest.(see next page for calculation and scale drawing) This makes the math easier, but of course does not give exactly the correct answer. The dish will actually be pointed southwest, and at a somewhat lower angle than calculated.

(c) You should have found a satellite dish to confirm the above answers, and have stated its location. The large dishes behind Zehmer hall, for example, do point approximately southwest, and at an angle somewhat less than 45 degrees above the horizon.

4. (a) They can take a coin out of their pocket and release it in front of them. If it stays stationary, relative to them, the ship is not accelerating.

(b) They feel weightless. All directions are equivalent, so up and down have no meaning.

(c) The coin test again--this time the coin will drift towards the end of the ship away from B.

(d) If they are sitting in seats and facing B, they will feel pushed against the back of their seats. If they're not in a chair or anything, the wall at the end of the ship away from B will come towards them, and they will eventually feel pushed by it.

(e) Now the ship slows down, which is acceleration in the opposite direction. Using the coin test, the coin will drift towards the end of the ship facing B. The passengers will feel pushed against a seat-back or wall on the end of the ship facing B. (Or "thrown" out of their seats if facing B and not strapped in)

(f) From the side, we can't see the laser. All the laser light is going towards B, and there is nothing in space to scatter any of the light to our eyes.

(g) Light does exert a pressure, as we discussed in class. So, ship A will feel a reaction force away from B as it fires the laser, and so will move away from B, although very slowly.

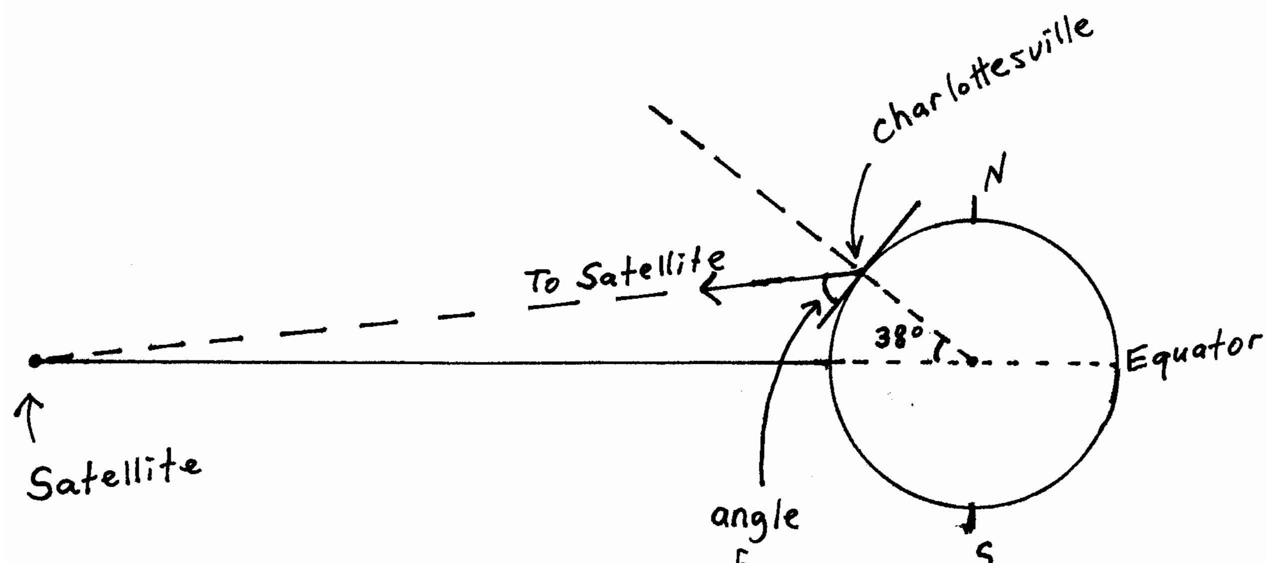
(h) Ship B feels a force away from A, and so will move away from A, although, again, the amount will be very small.

(i) Momentum, mv, will be conserved, so ship A will move to the right. (mass of fuel)(speed of fuel)=(mass of ship)(speed of ship). So (1000)(4000)=(99,000)(speed of ship) which gives the speed of ship to be about 40 meters per second.

(j) The frequency, which our eyes see as color, of the light depends on the relative speed of the source and observer. This is called the "Doppler" effect. Since they are moving towards each other, the green light will appear bluer to the passengers of A. So, blue.

(k) There is no air in space to propagate the sound, so the passengers of ship A will not hear the explosion.

Aiming at a Geosynchronous Satellite having the same longitude as Charlottesville



angle of Satellite above horizon = about 46° { measure with protractor, or see trigonometry below

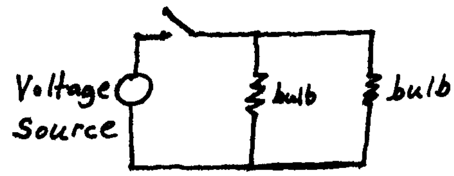
If satellite orbits at a different longitude, receving dish will be aimed at a lower angle above the horizon, and not directly south.

Angle of satellite above horizon

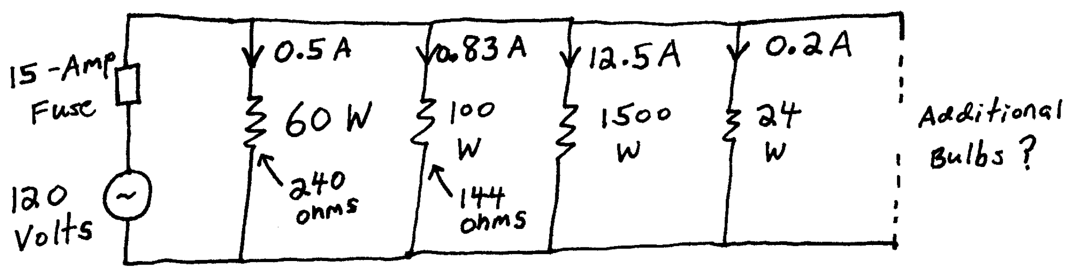
$$= \tan^{-1}\left(\frac{\frac{H}{R} + 1 - \cos 38^\circ}{\sin 38^\circ}\right) - 38^\circ$$

where
$H = 22{,}200$ miles
$R = 4000$ miles

5. See sketch to right for one possibility.



6. (Parallel circuit with 15-amp fuse)



(a) see sketch above
(b) To find the current, use (Power) = (Volts)(Amps). For the 60-watt light bulb for example, (60) = (120)*I, which gives I = 0.5 amps. See other values on sketch.
(c) We expect that the larger-wattage bulb will have a <u>lower</u> resistance, because this will allow more current to flow through it, and therefore make it glow brighter. To find the exact value, use V = IR. For the 60-watt bulb, this gives (120) = (0.5) *R, so R = 240 ohms. By the same method the 100-watt bulb has a resistance of 144 ohms, which agrees with our expectation.
(d) Since the fuse is 15-amps, the total current of the circuit must remain less than this, or the fuse will "blow" (melt), thus switching off the circuit. There are already 14.03 amps in the sketch above. If we add one more 100-watt bulb, the total will increase to 14.86 amps, which is fine, but no more 100-watt bulbs can be tolerated beyond that.

7. This question is worded strangely, so if you explain your answer carefully enough you will still get full credit, even if you interpreted the question differently than intended.

The principle of relativity says that all observers in valid frames of reference will observe the same laws of physics (although not necessarily exactly the same data).

However, observers in <u>invalid</u> frames of reference (those which are accelerating) will <u>not</u> necessarily observe the same laws of physics, and that's the point that the authors of this question are attempting to address.

8. According to Newtonian physics, an electron with 8×10^{-14} Joules of kinetic energy will have the speed implied by setting it equal to ½ mv^2. Putting in numbers gives:

   $v = \text{sqrt}\,(2*(8 \times 10^{-14}\text{ Joules})/(9.1 \times 10^{-31}\text{ kg}))$

   which gives $v = 4.2 \times 10^8$ meters per second. This is faster than the speed of light (3×10^8 meters per second), and experiment (for example as seen in the video during class) clearly shows that this is not possible.