PHYS 101-Concepts of Physics-Fall 2002
Solutions to Homework #3
100 points possible
[1.--10 pts, 2.--24 pts, 3.--15 pts, 4.--14 pts, 5.--20 pts, 6.--7 pts, 7.--10 pts]

1. You should be within 1 or 2 degrees, and have shown your work. Sample numbers: Oct. 31, 2002: 38.5 degrees; Nov. 6, 2002: 36.5 degrees.

2.
   (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 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, it will be very minute.
   (i) Since outer space is a vacuum, the astronaut would have to wear a pressure suit to survive. Without one, some of his cells and blood vessels would certainly burst, and he would die. (Recall the demo in class of the balloon in the vacuum chamber.)
   (j) 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.
   (k) 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.
   (l) There is no air in space to propagate the sound, so the passengers of ship A will not hear the explosion.

3.

(a) I'll use 150 lbs, which is probably around average for the class.
(b) Use the conversion 2.2 lbs = 1 kg, which gives about <u>68 kg</u>.
(c) Using the conversion given, 1 meter = 3.28 feet, gives about <u>1524 meters</u>.
(d) PE gained = mgh= (68)(9.8)(1524) = about one million Joules.
(e) At least that much energy must be supplied by the food you eat, which gives 243 food calories. (This is the minimum. Actually, a lot of energy is converted to heat, so you'll burn a lot more calories than that.)

4.

(a) According to the sheet given out in class, a 76-kg male needs 1.2 food calories for each minute of sleeping. For 8 hours of sleeping he needs (1.2)(60)(8) which gives 576 food calories. For 16 hours of sitting at rest he needs (1.7)(60)(16)=1632, for a total of 2208 food calories per day.
(b) Calculation is similar to above and gives 3048 food calories.
(c) Prorate these for your own mass.

5. (a) "Giga" means "billion", which is 10^9, so 2.45 Gigahertz is 2.45×10^9 Hertz.
(b) On the page 234 chart in Hobson, this frequency is said to lie in the "Radar" or "TV, FM radio" regime, although not too far from the "Microwave" regime. On the chart reprinted on the homework set, it is in the "Microwaves" region.
(c) We know that (frequency)(wavelength)=(speed of wave) [see bottom of page 201 in Hobson]. All electromagnetic waves, including microwaves, travel at the speed of light, 3×10^8 meters per second. So wavelength = $(3 \times 10^8)/(2.45 \times 10^9)$ = 0.122 meters, or 12.2 cm.
(d) If the hole diameter should be at most (wavelength)/10, this gives a maximum diameter of 1.22 centimeters, or 0.48 inches (about half an inch).

6. All electromagnetic waves, including radio waves, travel at the speed of light, 3×10^8 meters per second. Using (speed)(time) = (distance), the time to travel 5000 km is 0.0167 seconds (which can be rounded to 0.02 seconds).

7. To communicate with someone on Mars, you would use some type of electromagnetic wave, say radio waves, which travel at the speed of light. If you said "How are you?" it would take 20 minutes for that to reach Mars, a second or two for the person to respond "I am fine", and then another 20 minutes for this reply to get back to Earth. So there would be a 40-minute delay after every piece of the conversation!

   Using a telescope wouldn't help at all, because light travels at the same speed as the radio waves, so there would still be a 40-minute delay between visual signals.