PHYS 102-Concepts of Physics II-Spring 2003
Solutions to Homework #2
100 points possible

1. (15 pts)
   (a) I ran 12 laps upstairs at Mem Gym, which is 1 mile.
   (b) It took me 7 minutes and 40 seconds.
   (c) 7 minutes and 40 seconds is 7.666 minutes, so my speed was (1 mile)/(7.666 minutes), which is 0.13 miles per minute.
   (d) 1 mile is 1609.3 meters, and 7 minutes and 40 seconds is 460 seconds, so my speed was 3.50 meters per second.
   (e) My mass is about 73-kg, so my kinetic energy is 1/2 mv^2, which is (1/2)(73 kg)$(3.5\ m/s)^2$ = 447 Joules.
   (f) If no energy were wasted, the food energy needed would exactly equal the kinetic energy I obtained, which was 447 Joules. This translates to 0.10 food calories. (Note: you must continue to use food calories to continue running even after you have quickly reached your running speed)
   (g) 1 mile = 1609.3 meters, so my speed of 3.5 m/s translates to 7.8 mph.
   (h) 70 mph is about 9 times greater than my speed! I'm slow and cheetahs are fast.

2. (15 pts) Yes, the airplane will crash. You can not "trick" the airplane into not feeling the weight of the bumblebee. This is for the following reason. The bumblebee stays aloft just like a helicopter does--by throwing air downwards. But the floor of the airplane is beneath the bumblebee, so this air collides with the floor and therefore exerts a force on the floor. This force turns out to be exactly the weight of the bumblebee.

   Another interesting case of the same thing is walking across a bridge with three tennis balls. Suppose the bridge is only strong enough for you and two tennis balls. You might think you could juggle the balls, keeping one in the air at all times, and walk the bridge safely. But it won't work. In the process of throwing a ball upwards, you exert a force on it greater than its weight. It therefore exerts a force back on you (and the bridge) greater than its weight. So the bridge feels, at some points in time, a force actually <u>greater</u> than your weight plus three tennis balls, and sometimes less than this. Averaged over time, it feels exactly your weight plus the weight of the three balls.

3. (30 pts)

   (a) (The 20-lb child is not yet on the plank). The 40-lb child starts at the center, so that the center of mass of the system is between the supports. The board will not tip until the child moves to the right of the right support. As the board just begins to tip clockwise, the force exerted by the left support is zero, so we only need to balance the torques about the right support: (40 lbs)(x) = (10 lbs)(2 ft), which gives x = 0.5 feet. Thus the child will be 0.5 feet to the right of the right support.

(b) It SEEMS like it won't tip, but we have to prove it. To do this, check the total torque about each pivot. If the total torque is clockwise about the left pivot, it won't tip, and if it's counterclockwise about the right pivot, it won't tip. The latter statement is certainly true, because all the torques are counterclockwise about the right pivot. But what about the left pivot? The clockwise torques are (10 lbs)(2 ft) [the plank] and (40 lbs)(2 ft) [the heavy child], and the counterclockwise torque is (20 lbs)(3 ft) [the light child]. The clockwise torques add to 100 ft*lbs, which is more than 60 ft*lbs, therefore it won't tip.

(c) The plank will certainly not tip to the left, because it didn't tip before, and now the clockwise torques are actually increasing as the heavy child walks to the right. So we only have to worry about it tipping about the right pivot. Check the most extreme case, with the 40-lb child all the way at the end: Clockwise torques = (40 lbs)(3 ft), Counterclockwise torques = (10 lbs)(2 ft) + (20 lbs)(7 ft). The clockwise torques add to 120 ft*lbs, which is not enough to overcome 160 ft*lbs counterclockwise. So the 40 lb child can walk all the way to the right end, and the plank still won't tip.

(d) The question is, can the plank tip counterclockwise about the left pivot? Yes, it can, and if you calculate the torques, you'll find it does so when the 40-lb child is 1 foot to the **right** of the left pivot. In other words, the heavy child can not even walk all the way to the left pivot from the center, because the plank starts to tip before he gets there.

4. (20 pts)
   (a) Both balloons have weight, and both balloons experience an upward force due to greater air pressure at the bottom of the balloon than at the top of the balloon (this upward force is often called "buoyancy"). In the case of the helium balloon, the buoyancy force is greater than its weight, so it rises.
   (b) On the surface of the Moon, there is no air, so no buoyancy force, so the balloon will fall. There is also less gravity, so the weight of the helium balloon is less. To calculate the time to fall, use $H = 1/2\ gt^2$, but use the value of "g" on the Moon.
   (c) There IS air inside the ship, but with no gravity there is no difference in air pressure with height, so no buoyancy force. There is also no weight to the balloon, so it will just hover.

5. (20 pts)
   (a) 108,350 is about 7.3% more than 101,000, and 87,000 is about 13.9 % less.
   (b) 760 mm of mercury is the same as about 29.92 inches of mercury. On Feb. 24, 2003 at 1:53 pm, atmospheric pressure in Charlottesville was 29.99 inches of mercury. This is about 0.23 % above the standard.
   (c) "120/80" means gauge pressure in mm of mercury equivalent. The top number is when your heart is contracting, and the bottom number when it's resting. Gauge pressure is the amount above the outside pressure, which is almost always near 760 mm Hg.

So there are two possibilities. If your body automatically adjusts to the outside pressure, so that the gauge pressure is always the same, then your blood vessels certainly will not collapse, because your blood pressure would increase as the outside air pressure increases. (This is apparently the case, since you can go under water and experience high pressure without your blood vessels collapsing.)

If, on the other hand, your lowest blood pressure is always a total of 80+760 mm of mercury, for a total of 840 mm Hg, which translates to 111,632 N/m^2, independent of outside air pressure, then we have to compare to that record-setting day. On that day, atmospheric pressure was 108,350 N/m^2, which is still less than 111,632 N/m^2, so apparently your blood vessels would not collapse even if your body did not adjust. However, your blood pressure is measured near the level of your heart, and it decreases at greater heights, such as in your brain. So it's not out of the question that a high-air-pressure day could be dangerous to your blood vessels somewhere in your body. To answer for sure, we'd need to know more about how your blood pressure varies throughout your body, and whether or not it adjusts to external conditions.