PHYS 101-Concepts of Physics-Fall 2002
Solutions to Homework #2
100 points possible
(1.-8pts 2.- 14 pts 3.-10 pts 4.-10pts 5.-10 pts 6.-10 pts 7.-5pts 8.-10pts 9.-10pts 10.-13 pts)

1. You should be getting good enough at measuring the angle of the sun to get it correctly within one, or at most two, degrees. Here are some sample numbers: Oct. 3rd, 48.5 degrees; Oct. 10th, 45.7 degrees; Oct. 17th, 43 degrees.

2. (a) 8 mph

   (b) sidewalk: at rest
   air: at rest
   runner: 8 mph to the left

   (c) yes, this is a valid reference frame, because you are moving at constant speed in a straight line, which constitutes constant velocity

   (d) sidewalk: 8 mph to the right
   air: 8 mph to the right
   runner: at rest

   (e) This is much like being on a treadmill, because the runner is at rest, and the "sidewalk" (the conveyer belt) is moving. HOWEVER, the air is not moving, so this aspect of the treadmill is not the same as the reference frame of part (d).

   (f) You would need to make the air move (relative to you) at 8 mph. You could easily do this by putting a fan in front of the treadmill to blow air in your face at 8 mph.

   (g) It's easier to run on a treadmill, because there's no air resistance. It may seem more *boring* than running outside, but boredom doesn't burn calories (as far as I know).

3. If the hood is slippery, there is little or no friction to change the horizontal motion of the person on the hood. So, in both the "before" and "after" sketches the person should be going in a straight line. It's the car whose motion changes. From inside the car, it looks like the person has been "thrown off the hood." But this is not a valid frame of reference, since it's accelerating, and thus gives a misleading observation.

4. In this problem, ignore air resistance.
   (a) Free fall is acceleration because of the influence of gravity, with no other unbalanced forces to interfere with this.
   (b) Yes, while over the gap the car is in free fall, if there is no air resistance. Even though there is some initial vertical and horizontal velocity, this doesn't matter, because they don't change the downward acceleration. Another way to say this is that the velocities are dependent on your frame of reference, and are therefore arbitrary, whereas the acceleration is an absolute. (We discussed this in class, when I threw a tennis ball across the room in an arc. If you can find a frame of reference in which the motion looks like dropping an object from rest, then it is definitely in free fall. The initial velocity of the ball is such a frame.)
   (c) The driver feels weightless, so there is no force from the seat.
   (d) It doesn't matter if the gap is filled in as long as the car doesn't feel any force from it. So the driver will still feel weightless whenever the car is just barely touching the road (i.e not feeling any force from the road.)
   (e) If you're driving fast enough when going over a hill, you may lose contact with the road, and feel weightless. Even if you don't lose contact, the force from the road will be reduced, and then you'll feel lighter. The faster your speed, the greater the effect.

5. Your car gains gravitational potential energy by driving to the top of the hill. So the gasoline must supply at least this much energy.

   PE = mgh, which in this case is (900 kg)(9.8 m/s^2)(100 m) = 882,000 Joules.

   If gasoline supplys 133,000,000 Joules per gallon, it will take 882,000/133,000,000

   or about .0066 gallons of gas. In reality, your car engine and other sources of friction will generate heat, which is not helping you gain potential energy. So it will actually take more gas than this (around 4 or 5 times as much).

6. The momentum of the wallet forward will be the same magnitude as the momentum of you backward. You must convert the 40 mph to 17.88 meters per second. Then:

   (mass of wallet)(velocity of wallet) = (mass of you)(velocity of you)

   or (0.5 kg)(17.88 m/s) = (60 kg)(velocity of you)

which gives the velocity of you to be 0.149 m/s. At this rate of speed, to go 25 meters takes about 168 seconds, or 2 minutes and 48 seconds. Of course this is assuming there is no friction from the ice.

7. 3 trillion is 3×10^{12} five thousandths is 5×10^{-3} 730,000,000,000,000 is 7.3×10^{14}

   0.000000000082 is 8.2×10^{-11}

8. The pennies are taking a "random walk", and this is a mathematical model of what happens to, say, molecules of perfume as they are randomly pushed around by air molecules.

9. Use the definition of velocity, which is (change in distance)/(change in time).
   Solving for time: time = distance/ velocity = (2)(3.8×10^8 m)/3×10^8 m/s which gives the time to be about 2.53 seconds for the roundtrip.

10. Use $H = 1/2\ g\ t^2$, with $g = 9.8$ m/s^2. With $t = 6$ s, this gives $H = 176.4$ meters, assuming no air resistance. In reality, there is always some air resistance. If we could eliminate the air and make a measurement, we would get a shorter time and therefore discover that the actual height of the cliff is less than 176.4 meters. So the cliff is actually lower than our calculated answer.

    To find the velocity, multiply the time by 9.8 m/s^2. This gives a velocity of 58.8 m/s.