Physics 203: Quiz 1 solutions

September 12, 2012

1. What are the units of *(a)* displacement, and *(b)* acceleration? If you were to come up with a formula (equation) for velocity in terms of displacement and acceleration, what would it be, based purely on dimensional analysis? Recall that the dimensions (or units) on both sides of an equation have to be the same!

   Solution Displacement is a length and has the standard units of meters. Acceleration is rate of change of velocity and has the units of $\mathrm{m/s^2}$. For the second part of this problem, we need to find a relation between velocity, acceleration, and displacement based on their units. Velocity has the units of m/s. In order to obtain something like m/s from m and $\mathrm{m/s^2}$, note that

   $$\mathrm{m} \times \frac{\mathrm{m}}{\mathrm{s^2}} = \frac{\mathrm{m^2}}{\mathrm{s^2}} = \left(\frac{\mathrm{m}}{\mathrm{s}}\right)^2 \tag{1}$$

   which are the units of velocity squared. So the relation we are looking for is

   $$\text{velocity}^2 = \text{displacement} \times \text{acceleration}. \tag{2}$$

   This is almost the third kinematic equation, but the factor of 2 is missing. Such numerical factors can never be obtained via analyzing the units on both sides of an equation, but one can always get an idea of how different physical quanitites are related!

2. You're standing in an elevator that is about to move downwards. If you jump up **just before** it starts moving downwards, what acceleration do you *feel* when the elevator starts moving downwards at 1 $\mathrm{m/s^2}$? To another person standing in the elevator, what acceleration do you seem to have (when you're still in the air i.e.)?

   Solution When you're in the air, you are in free fall, and so experience or *feel* the acceleration due to gravity, i.e, $9.8\mathrm{m/s^2}$ downward. You're friend standing in the elevator would see you in free fall accelerating downwards at 9.8 $\mathrm{m/s^2}$ *if the elevator itself wasn't accelerating.* But since the elevator is also accelerating downwards (at $1\mathrm{m/s^2}$), and he's standing on the floor of the elevator, he sees you accelerating at 9.8-1=$8.8\mathrm{m/s^2}$. How do we know it's a minus sign and not a plus sign? Well, if the elevator was accelerating downwards at $9.8\mathrm{m/s^2}$, then both of you would be in free fall and according to him you wouldn't be accelerating at all! i.e., 9.8-9.8 = 0. Which means at some other value of downward acceleration, he sees you have a smaller acceleration than if the elevator wasn't moving, so the minus sign makes sense.