Physics 201
Quiz #3

NAME : SOLUTIONS

Do **YOUR OWN WORK** and **SHOW ALL OF IT!** (Continue on back, clearly labeled, if necessary)

This quiz does NOT require the use of a calculator. You may write answers as algebraic expressions (that is, write that x = 33.7 and y = 108.4, and that the answer is (x/y) kg m/s^2). Trig functions and square roots may be left in that form (that is sin 25° or $\sqrt{30}$).
All answers **MUST** include appropriate **units and dimensions**.

1. Mark (the guy in the picture below) is bungee jumping, which is to say he has just jumped off of a tower with stretchy cables attached to his ankles. As this picture was snapped, the slack in the stretchy cables was just about to run out at which time the cables would begin slowing him to a stop and sending him bouncing back up again. Call the time *t = 0* when the cables begin to stretch and slow him down. **Choose "up" to be your positive direction.**

a) Just after t = 0, when Mark is still moving down, the velocity of Mark is (choose one):
positive *negative* *zero*

b) Later, when the Mark is as low as he will go, his velocity is:
positive *negative* *zero*

c) Just after t = 0, when Mark is still moving down, his acceleration is:
positive *negative* *zero*

d) Later, when the Mark is as low as he will go, his acceleration is:
positive *negative* *zero*

e) Still later, when the cables are still pulling on his ankles and Mark is moving back up, his acceleration is:
positive *negative* *zero*

To answer c, d, and e you have to notice that as soon as there is tension in the cables Mark begins to slow down. This means that his acceleration points in the opposite direction from his velocity (up, which is the positive direction). To answer d, remember that even though his velocity is zero, his velocity is changing so his acceleration is still not zero. His velocity is going from negative to positive so his acceleration is positive.

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2. During a five second period, a sailboat was constantly moving in the positive direction. The sailboat moved forward at a constant speed of 1.00 m/s for the first three seconds. At that time a large gust of wind pushed it forward with a ***constant acceleration*** for two more seconds. The boat traveled a total of 9.0 meters during those five seconds.

a) What was the acceleration of the boat during the last two seconds?

In the first three seconds, the displacement of the sailboat was

$$\Delta x_1 = (1.00\ m/s)(3.0\ s) = 3\ m$$

During the last two seconds the sailboat was accelerating in the positive direction, but it is important to remember that it already had a velocity of 1.0 m/s.

$$\Delta x_2 = (1.00\ m/s)(2.0\ s) + \tfrac{1}{2} a\ (2.0\ s)^2 = 2.0\ m + \tfrac{1}{2} a\ (2.0\ s)^2$$

The total displacement was nine meters, so

$$\Delta x = \Delta x_1 + \Delta x_2 = 3.0\ m + 2.0\ m + \tfrac{1}{2} a\ (2.0\ s)^2 = 9.0\ m$$

$$9\ m = 5\ m + \tfrac{1}{2} a\ (2.0\ s)^2 \qquad \text{so} \qquad \tfrac{1}{2} a\ (2.0\ s)^2 = 4\ m$$

$$a = 2\ m/s^2$$

b) During the same five-second period, a rowboat was moving in the same direction as the sailboat at a steady speed of 1.25 m/s. The rowboat and the sailboat started out side by side but then the rowboat pulled ahead since it had the greater speed (1.25 m/s vs. 1.00 m/s). Since the sailboat went 9.0 meters and the rowboat only went (1.25 m/s)(5 s) = 6.25 m, the sailboat must have passed the rowboat. When did the sailboat catch the rowboat?

There are lots of perfectly good ways to solve this. You could make two tables of position and time data and look for the time when the positions are equal. You could make graphs on a graphing calculator and look for the place where they intersect. Here is an algebraic solution…

For the rowboat: In three seconds the rowboat has moved 4.75 m, so if we start our stopwatches at that time the position of the rowboat is given by:

$$x_R = 4.75\ m + (1.25\ m/s)\ t$$

The sailboat moves 3.0 m in the first three seconds and after that it moves like something with an initial velocity of 1.0 m/s and a constant acceleration of two meters per second squared (or whatever answer you got in part a). So again if we start our stopwatches after the first three seconds, the position of the sailboat is:

$$x_S = 3.0\ m + (1.0\ m/s)\ t + \tfrac{1}{2}(2.0\ m/s^2)\ t^2$$

The sailboat catches up to the rowboat when these two are equal:

$$3.75\ m + (1.25\ m/s)\ t = 3.0\ m + (1.0\ m/s)\ t + \tfrac{1}{2}(2.0\ m/s^2)\ t^2$$

$$(1.0\ m/s^2)\ t^2 - (0.25\ m/s)\ t - 0.75\ m = 0$$

$$\text{factoring: } \left[(1.0\ m/s^2)\ t + (0.75\ m/s)\right]\left[t - (1.0\ s)\right] = 0$$

So whether through factoring or use of the quadratic formula we find:

$t = 1.0\ s$ or $t = -0.75\ s$.

We want the positive answer, so the sailboat catches the rowboat 1.0 s after the start of the gust of wind, which is 4.0 seconds after the rowboat first pulled ahead.