Homework #2

Due Friday, Feb. 11

1. Sketch a graph of the position as a function of time, velocity as a function of time, and acceleration as a function of time for each of the following situations. For each situation, draw 3 separate graphs above each other, so that equal times are directly above each other on the page. Don't forget the diagram and coordinate system!

(a) An elevator is initially moving down at a constant speed, then slows down and comes to a stop.

(b) A car is initially going at constant speed on a highway. It speeds up to pass, and then slows down to its initial speed, and keeps going steadily.

(c) A raindrop falls from rest from a cloud. It initially falls with a constant acceleration, but air resistance causes it to approach a constant final velocity ('terminal velocity').

2. A car an a motorcycle are having a drag race. The motorcycle reaches the finish line before the car, but the car crosses the finish line at a faster speed than the motorcycle. This is true even though both the car and the motorcycle are speeding up during the entire race. Show that this is possible by sketching a possible graph of position as a function of time for both the motorcycle and the car, on the same graph. Clearly indicate the following important events on your graph:

A: the motorcycle starts moving
B: the car starts moving
C: the motorcycle crosses the finish line
D: the car crosses the finish line

3. Galileo decides to have some more fun while he as at the top of the leaning tower of Pisa, which is 35 m high (vertical distance). He first drops one canonball. One second later, he throws another ball directly downward after it. How fast does he have to throw the second ball so that they both hit the ground at the same time?

4. A typical car has a maximum deceleration of 7 m/s^2, and a typical reaction time is 0.5 s. A town in Canada (where they use the metric system) sets the speed limit so that a typical driver should be able to stop at a crosswalk if

the driver notices a pedestrian in the crosswalk from 4 m away. What speed limit (in km/hr) should the town impose?

5. Batman is standing next to a window that is 1.5 m high. He observes a flower pot falling past the window and notes that it takes 0.2 s for the falling pot to pass the window. (Batman has very fast bat-reflexes!) He realizes that his arch-enemy the Joker has dropped it from a ledge above. Using his bat-physics skills, he quickly computes how far above the top of the window the pot was dropped from. Now it's your turn to do the calculation.

6. Captain Kirk and Spock land on a mysterious planet whose gravitational pull is increasing steadily. In the space of 1 hour, Spock determines that the acceleration due to gravity has increased from 8.78 m/s^2 to 9.43 m/s^2. (Spock always gives 3 signficant digits, and always uses the metric system.) Spock makes the assumption that the increase of the acceleration is linear in time.

(a) According to Spock's assumption, find the corrected version of the constant acceleration kinematic equations

$$v = v_0 + at, \qquad x = x_0 + v_0 t + \frac{1}{2}at^2. \tag{1}$$

Introduce symbols to write these equations in a useful symbolic form.

(b) If a rock is thrown upward with a speed of 25 m/s at a time when gravity is 8.78 m/s^2. With what speed does it come back to its original height? Is this faster or slower compared to the speed it would have if gravity were constant?