Name _____

Kinematics Equations, assuming a = constant:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2 \tag{1}$$

$$v = v_0 + at \tag{2}$$

$$v^2 = v_0^2 + 2a(x - x_0) \tag{3}$$

Note: If $a = 0$, we recover $x = vt$ from equation (1) and the other 2 just say $v = v_0$, i.e. speed is constant.

1. An airplane starts from rest and accelerates with an acceleration of $+6 m/s^2$ and it moves in the positive direction. It needs to reach a speed of about $25 m/s$ before taking off.

   (a) How long (in s) will it take for the airplane to take off?

   (b) How long (in m) must the runway be?

2. If an object initially moving with a speed of $+15 m/s$ travels a distance of $+15 m$ before coming to rest, what was the object's acceleration?

3. In his record 100m dash, Usain Bolt accelerated $2.5 m/s^2$ until reaching his top speed of 12.2m/s. Let's assume his acceleration was constant and that he maintained his top speed for the remainder of the race.

   (a) Where did he reach his top speed?

   (b) What was his speed at 50m?

   (c) What was his speed at 5m?

   (d) How long does it take him to run the 100m dash, given our assumptions? (It actually took him 9.58s)

   (e) If he could accelerate for the entire 100m dash, how long would it take and what would be his final speed after 100m?

4. A car is speeding at $25m/s$ ($90km/hr$ or $56mi/hr$) in a school zone. A police car starts from rest just as the speeder passes and accelerates at a constant rate of $5m/s^2$ in hot pursuit.

   (a) When does the police car catch the speeding car?

   (b) How far has the police car traveled when it catches up?

   (c) How fast is the police car traveling when it catches up with the speeder?

   (d) Sketch position vs time plots on the same plot for the speeder and the police car. Also sketch velocity vs time plots for both.