Physics 2414, Spring 2008
Group Exercise 2, Jan 31, 2008

Name 1: Solutions OUID 1: _____

Name 2: _____ OUID 2: _____

Name 3: _____ OUID 3: _____

Name 4: _____ OUID 4: _____

Section Number: ____

1-Dimensional Kinematics

The 4 Kinematic equations:

$$v = v_o + at$$

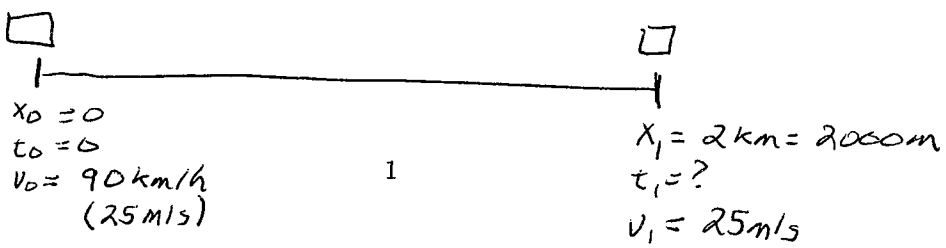
$$x = x_o + 1/2(v + v_o)t$$

$$x = x_o + v_o t + 1/2at^2$$

$$v^2 = v_o^2 + 2a(x - x_o)$$

A motorcycle cop is parked on the side of the road when a woman driving a red Ferrari zooms by at 90.0 km/h. After a few attempts to get his cycle started, the officer roars off 2.00 seconds later. The officer has a top speed of 100 km/h and the state line is only 2.00 km away. The cop wishes to reach the speeder just as she reaches the state line.

1a) Draw a picture for the case of the woman in the Ferrari. Show 2 important points on the x-axis. The starting point(x_o, t_o, v_o) and the points when she reaches the state line(x_1, t_1, v_1)



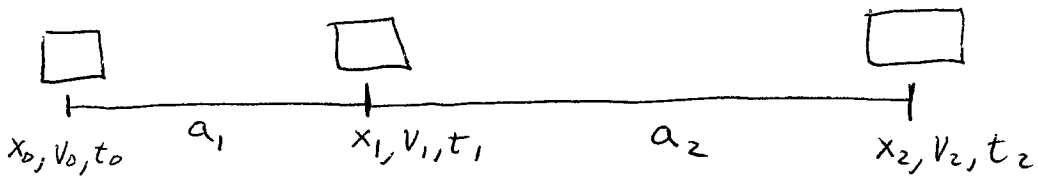
1b) How long will it take the woman to reach the state line?

$x = x_0 + vt \Rightarrow t = \frac{x}{v} = \frac{2000\ m}{25\ m/s} = \boxed{80\ s}$

1c) Based on your answer of part 1b) how long does the cop have to reach the Ferrari?

$80\ s - 2\ s = \boxed{78\ s}$

2) Draw a picture for the cop. Show 3 important points on the x-axis. The starting point (x_o, t_o, v_o), the point where he reaches 100 km/hour (x_1, t_1, v_1) and the point where he catches the speeder(x_2, t_2, v_2) . At each point, label the time, the position and the velocity of the cop. Label the acceleration between the first 2 points as a_1 and the accceleration between the last two points as a_2.



3a) Write down all of the quantities and fill in their values if they are known. Identify the quantities which are unknown (note there are only 3).

$x_0 = 0\ m$ $\quad x_1 = ?$ $\quad x_2 = 2\ km = 2000\ m$ $\quad a_1 = ?$

$v_0 = 0\ m/s$ $\quad v_1 = 100\ km/h\ (27.8\ m/s)$ $\quad v_2 = 100\ km/h\ (27.8\ m/s)$ $\quad a_2 = 0\ m/s^2$

$t_0 = 0\ s$ $\quad t_1 = ?$ $\quad t_2 = 78\ s$

3b) If you have 3 unknown quantities, how many equations will you need to solve this problem?

3

4) The question is: If the officer is to reach the woman right at the state line, how fast must he accelerate? Solve this using the steps below.

4a) Write an equation for the officer's motion during the time when his acceleration is zero.

$$x_2 = x_1 + v_1 (t_2 - t_1)$$

4b) Which quantities in the above equation are not known?

$$x_1, t_1$$

4c) Write an equation for the officer's motion while he is accelerating. Write this equation so that it involves only one of the unknown variables in part 4b) as well as the cops unknown acceleration.

$$v_1^2 = \cancel{v_0^2}^{\,0} + 2a_1 (x_1 - \cancel{x_0}^{\,0})$$

4d) Write another equation for the cop's motion while he is accelerating that involves the other unknown variable in 4b) as well as the cop's unknown acceleration.

$$v_1 = \cancel{v_0}^{\,0} + a_1 t_1$$

4e) Using your previous results, write down the 3 equations you need to solve in order to find the acceleration of the officer.

(1) $x_2 = x_1 + v_1 (t_2 - t_1)$

(2) $v_1^2 = 2a_1 x_1$

(3) $v_1 = a_1 t_1$

4f) **If you have time** Do the algebra to find the officer's acceleration. i.e solve the equations in 4c) and 4d) for the quantities in 4a). Then plug them into 4a) to solve for the acceleration.

(1) $X_2 = X_1 + v_1 (t_2 - t_1)$

(2) into this (3)

$$X_2 = \frac{v_1^2}{2a_1} + v_1\left(t_2 - \frac{v_1}{a_1}\right)$$

$$X_2 = \frac{v_1^2}{2a_1} + v_1 t_2 - \frac{v_1^2}{a_1}$$

$$X_2 = v_1 t_2 - \frac{1}{2}\frac{v_1^2}{a_1}$$

$$\frac{1}{2}\frac{v_1^2}{a_1} = v_1 t_2 - X_2 \Rightarrow a_1 = \frac{v_1^2}{2(v_1 t_2 - X_2)}$$

$$= \frac{(27.8\,m/s)^2}{2(27.8\,m/s \cdot 78s - 2000m)} = 2.29\,m/s^2$$

4g) **If you still have time** Based on the acceleration you found in part 4f) determine x_1 and t_1 to show that your answer makes sense.

$$t_1 = \frac{v_1}{a_1} = \frac{27.8\,m/s}{2.29\,m/s^2} = 12.14s$$

$$X_1 = \frac{1}{2} a_1 t_1^2 = \frac{1}{2} \cdot 2.29\,m/s^2 \cdot (12.14s)^2 = 169\,m$$

so officer travels 169 m in 12.14s. This leaves him $(78s - 12.14s) = 65.86s$ to travel $(2000m - 169m) = 1831\,m$

to travel 1831 m in 65.86s requires a velocity of $v = \frac{1831\,m}{65.86s} = 27.8\,m/s = 100\,km/h$