Level I Key Pd 1

Kinematics Test

AT Kinematics (13)

Directions: Solve the following problems. Each problem is worth 5 points (total of 50 points). You will be graded on how well you communicate your problem solving ability. Show all work including units. Please circle your answer.

1) A cart accelerates down a hill at a rate of 1.54 m/s^2. If the cart was rolling at a speed of 0.85 m/s before going down the hill, and the cart is rolling at 4.1 m/s at the bottom, determine the length of the hill.

$a = 1.54\ m/s^2$

$v_0 = .85\ m/s$

$v = 4.1\ m/s$

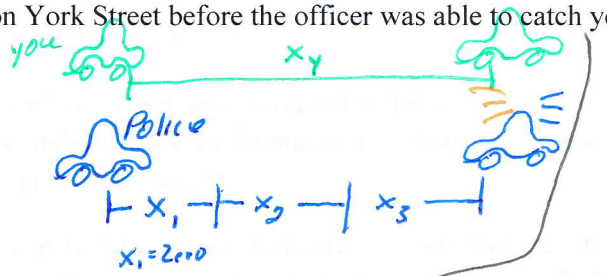
$x = ?$

$v^2 = v_0^2 + 2ax$

$\frac{v^2 - v_0^2}{2a} = x$

$\frac{(4.1\ m/s)^2 - (.85\ m/s)^2}{(2)(1.54\ m/s^2)} = 5.2\ m$

2) While driving out York Street, leaving Mechanicsburg, you are distracted slightly by a phone call from Level I. You cross the bridge over the turnpike doing 51 mi/hr (22.8m/s). You fail to see the police officer watching for speeders on the other side of the bridge. The officer takes 20 seconds to call in the pending traffic violation, and then accelerates at 3.1 m/s^2. Once the officer reaches a top speed of 62 mi/hr (27.8m/s), he travels at a constant speed until you are caught. Determine how far you have traveled on York Street before the officer was able to catch you.



Police

Part I - Delay - 20s

Part II
$a = 3.1\ m/s^2$
v_0 = Zero
$v = 27.8\ m/s$

Part III
$v = 27.8\ m/s$
a = Zero

you
a = Zero
$v = 22.8\ m/s$

Part I

You Create A Distance Between You And The Police For 20s.

$(22.8\ m/s)(20s) = 456m$

If We Set $t=0$ when the officer Pulls Out, then the officer must Drive 456m Farther than You.

Part II

officer
$a = 3.1\ m/s^2$
v_0 = Zero
$v = 27.8\ m/s$
t = ? 8.97s
x = ? 125m

$v^2 = v_0^2 + 2ax$

$\frac{v^2 - v_0^2}{2a} = x$

$\frac{v^2}{2a} = x$

$\frac{(27.8\ m/s)^2}{2(3.1\ m/s^2)} = x = 125m$

$v = v_0 + at$

$v = at$

$\frac{v}{a} = t$

$\frac{27.8\ m/s}{3.1\ m/s^2} =$

you Drive $(22.8\ m/s)(8.97s) = 204m$ while the officer Accelerates

part III

So Far, You Drove 456m + 204m = 660m Since You Passed the Police Car. The Police Car Drove 125m. Now That the Police Car Is At A Constant Speed, You And The Police Car Are Separated by 660m - 125m = 535m.

Police
$v_p = 27.8\ m/s$
$x_p = x_y + 535m$
t = ?
a = Zero

you
$v_y = 22.8\ m/s$
x_y = X (while officer Is At Const. speed)
t = ?
a = Zero

$x_y = v_y t$

$x_p = v_p t$

$\frac{x_y}{v_y} = t$

$x_p = \frac{v_p x_y}{v_y}$

$x_y + 535m = \frac{v_p x_y}{v_y}$

$535m = \frac{v_p x_y}{v_y} - x_y$

$535m = x_y\left(\frac{v_p}{v_y} - 1\right)$

$\frac{535m}{\left(\frac{v_p}{v_y} - 1\right)} = x_y$

$\frac{535m}{\left(\frac{27.8\ m/s}{22.8\ m/s} - 1\right)} = x_y$

$2442m = x_y$

The Officer Drives ~~2442m To Catch You At A Const Speed.~~ you Drive 2442m While the Officer Is At A Const. Speed. Add the Distance you Drove While the Officer Was On the Radio (456m) And while the Officer Accelerated (204m)

2442m + 456m + 204m = **3100m**

To Check; Add the Times.

3) You are driving at 57 mi/hr (25.5m/s), attempting to catch your friend that is 0.5 miles in front of you. Your friend is driving at 45 mi/hr (20.1m/s). How far do you drive until you catch them?

$v = 25.5\ m/s$

$t = ? = t$

$x = ? = x + 800m$

$v = 20.1\ m/s$

$x = ?$

$t = t$

$v_y = \frac{x_y}{t_y}$

$t_y = \frac{x_y}{v_y}$

$t_y = \frac{x_f + 800m}{v_y}$

~~$x_f + 800m$~~

$v_f = \frac{x_f}{t_f}$

$t_f = \frac{x_f}{v_f}$

$\frac{x_f}{v_f} = \frac{x_f + 800m}{v_y}$

$x_f = \left(\frac{x_f + 800m}{v_y}\right) v_f$

$x_f = \frac{x_f v_f + (800m) v_f}{v_y}$

$x_f = \frac{x_f v_f}{v_y} + \frac{(800m) v_f}{v_y}$

$x_f - \frac{x_f v_f}{v_y} = \frac{(800m) v_f}{v_y}$

$x_f \left(1 - \frac{v_f}{v_y}\right) = \frac{(800m) v_f}{v_y}$

$x_f = \frac{(800m)(v_f)}{v_y\left(1 - \frac{v_f}{v_y}\right)}$

$x_f = \frac{800m\,(20.1\ m/s)}{(25.5\ m/s)\left(1 - \frac{20.1\ m/s}{25.5\ m/s}\right)}$

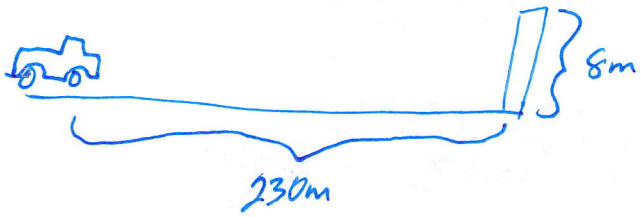
$x_f = 2980m$

$x_y = 2980m + 800m$

$x_y = 3800m$

Note Using Relative Motion, this Problem gets Real Easy...

4) You stand on a tower that is 8 m above a road. A truck, initially at rest, is on a road that will pass directly under the tower. The truck is 230m away from the base of the tower. Determine how long after the truck begins accelerating at 2.4 m/s^2 that you should release a water balloon so that it lands on the truck.



Time To Fall

$y = -8m$
$a = -9.8 m/s^2$
$t = ?$
$v_{0y} = \text{Zero}$

$y = \frac{1}{2} a t^2$

$\sqrt{\frac{2y}{a}} = t$

$\sqrt{\frac{(2)(-8m)}{(-9.8 m/s^2)}} = t = 1.28 s$

Speed of Truck @ 230m Mark

$v_0 = \text{zero}$
$v = ?$
$a = 2.4 m/s^2$
$x = 230m$

$v^2 = 2ax$

$v = \sqrt{(2)(2.4 \frac{m}{s^2})(230m)}$

$v = 33.2 m/s$

Working Backward...

How Fast Was the Truck Traveling When the Balloon Is Dropped?

$v = v_0 + at$

$\frac{v - v_0}{a} = t$

$v - at = v_0$

$33.2 m/s - (2.4 \frac{m}{s^2})(1.28s) = v_0$

$30 m/s = v_0$

How Long Does It Take To Get To 30 m/s? This Will Be the Time Passed From the Start of the Truck.

$a = 2.4 m/s^2$
$v = 30 m/s$
$t = ?$
$v_0 = \text{zero}$

$v = v_0 + at$

$v = at$

$\frac{v}{a} = t$

$\frac{30 \frac{m}{s}}{2.4 \frac{m}{s^2}} =$ 12.6 s After It starts

5) As a secret agent, you are to "drop" a hand grenade from a 24m tall cliff onto a pallet of "Secret stuff to be destroyed." The hand grenade has a three second fuse, and to be most effective, the hand grenade should explode 4 m above the ground. Determine the initial velocity that would need to be given to the hand grenade.

$y = -20m$

$a = -9.8 m/s^2$

$t = 3s$

$v_0 = ?$

$$y = v_0 t + \frac{1}{2} a t^2$$

$$\frac{y - \frac{1}{2} a t^2}{t} = v_0$$

$$\frac{-20m + \left(\frac{1}{2}\right)\left(+9.8 \frac{m}{s^2}\right)(3s)^2}{3s} = v_0$$

$8 m/s = v_0$

Throw Upward @ $8 \frac{m}{s}$

6) Leaving Mechanicsburg and driving to Camp Hill, a distance if 8.5 miles, determine how long it will take to get there averaging 48 mi/hr. Answer in minutes.

$\frac{8.5\,mi}{48\,\frac{mi}{hr}} = .177\,hr = 10.6\,min$