Homework Week #1

Ch #1

(P8) $(2.079 \times 10^2 \, m)(0.072 \times 10^{-1}) = 0.150 \times 10^1 \, m$

$= 1.50 \, m$

* This makes sense because really this is

$(207.9 \, m)(0.0079)$

which is like taking 0.8% of 210 m

1% would be about 2 m so 1.50 seems reasonable

* 0.072×10^{-1} has the fewest significant figures (3 sig figs) so our answer should also have 3 significant figures.

(P31) * Population of San Francisco $\approx 1.0 \times 10^6$ people

* Estimate only 3/4 of people visit the dentist $\approx 7.5 \times 10^5$ people

* Each dentist can see 1 patient every half hour and keeps regular business hours 8 hrs/day $\approx$ 16 patients per day

* 52 weeks/year $\times$ 5 business days/week $= 260 \frac{\text{business days}}{\text{year}}$

→ Each patient visits the dentist twice a year

$$\frac{\left(16\ \frac{\text{patients}}{\text{day}}\right)\left(260\ \frac{\text{days}}{\text{year}}\right)}{2\ \text{visits}/\text{year}} = 2080\ \frac{\text{patients}}{\text{year}}$$

* If each Dentist sees approximately 2100 patients per year then San Francisco can support

$$\frac{7.5 \times 10^5\ \text{people}}{2100\ \text{patients}/\text{dentist}} \approx 360\ \text{dentists}$$

(P33)

* A single tire has a diameter of about 0.5 m so circumference is $\pi D \approx (3)(0.5\,m) = 1.5\,m$
width of a tire is about 10 cm so the volume of rubber from a tire is $(1.5\,m)(0.1\,m)(0.01\,m) = 1.5 \times 10^{-3}\ m^3$

* Mass of rubber available from a tire is

$$(1.5 \times 10^{-3}\ m^3)(1200\ kg/m^3) = 1.8\ kg$$

* Each car has 4 tires, and tires need to be replaced about every 10 years. So only 1/10 of the total rubber is used during the year

$$\left(1.8\ kg/tire\right)\left(4\ tires/car\right)\left(\frac{1\ tire}{10\ years}\right) = 0.7\ kg \text{ of rubber per car per year}$$

* The U.S. population $\approx 2\times10^8$ people

Estimate 1 car for every 5 people $\rightarrow$ 4×10^7 cars in the U.S.

* So, the amount of rubber put into the atmosphere is roughly

$$\left(\frac{0.7\text{ kg}}{\text{car year}}\right)\left(4\times10^7\text{ cars}\right) = 2.8\times10^7\text{ kg/year}$$

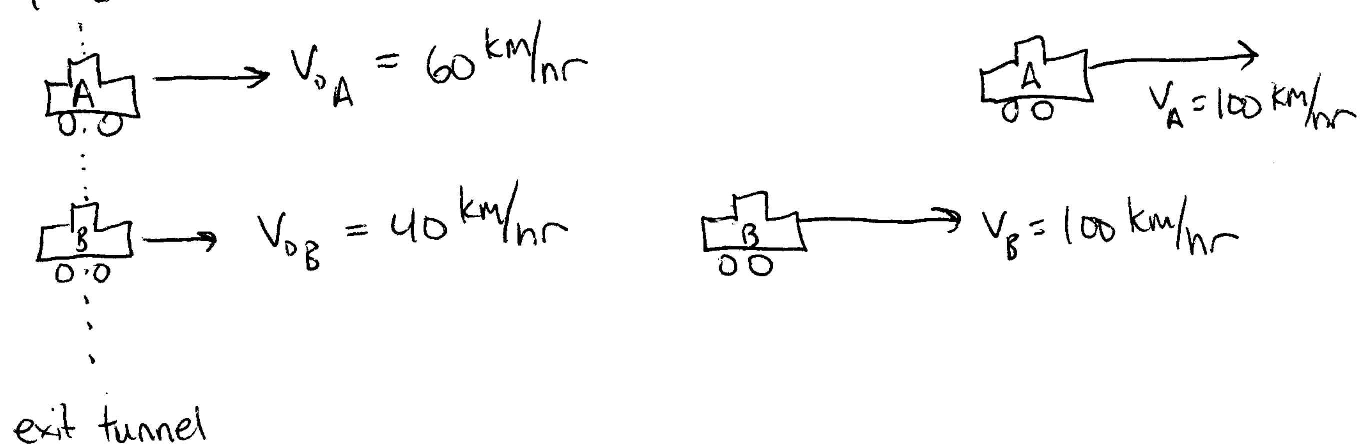
That's a lot! (Is that reasonable?)

Ch #2

(Q10) Car A is passing Car B as they exit the tunnel

→ Both cars have the same position as they exit the tunnel

at $t=0$ @ $t=1$ min



After 1 minute, both cars will be travelling at the same speed

$$v = v_0 + at$$

$$V_A = 60\text{ km/hr} + \left(40\frac{\text{km/hr}}{\text{min}}\right)(1\text{ min}) = 100\text{ km/hr}$$

$$V_B = 40\text{ km/hr} + \left(60\frac{\text{km/hr}}{\text{min}}\right)(1\text{ min}) = 100\text{ km/hr}$$

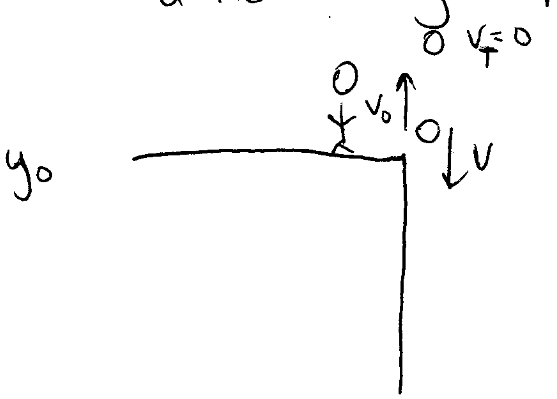
After 1 min, Car A has gone farther → up until that time it has been travelling faster so it has gone farther

* Therefore, at the time the cars exit the tunnel Car A is passing Car B

(Q13) As a falling object speeds up, its acceleration due to gravity remains a constant. An increase in velocity does not change the objects acceleration that is caused by gravity.

(Q15) The two rocks will have the same speed when they hit the ground.

* Consider the rock that is initially thrown upward
As it goes up, its speed decreases until it reaches it max. height, instantaneously comes to rest, and then falls downward with increasing speed. When it reaches its initial height again, the speed is the same as the initial speed, but the direction of the velocity is opposite



From beginning to top:

$$v_f^2 = v_i^2 + 2a\Delta y$$

$$0 = v_0^2 + 2a y_T$$

From top back to starting height

$$v_f^2 = v_i^2 + 2a\,\Delta y$$

$$v^2 = 2a(0 - y_T) = -2a y_T$$

$$0 = v^2 + 2a y_T$$

So v (speed on the way down) is the same as v_0 in magnitude, but opposite in direction

Now, we can consider the change in speed from the cliff edge (at $y=0$) to the ground (at $y = y_B$)

$$v_f^2 = v_i^2 + 2a\Delta y$$

Well, during this portion of the motion, the initial velocities are the same for the two rocks, the acceleration is the same, and the change in height is the same. Therefore, the speed at the ground of both rocks is the same.

(P7) 5 seconds corresponds to 1 mile

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

$$v_s = \frac{1\,\text{mile}}{5\,s} = \frac{1609\,m}{5\,s} = 321.8\ m/s$$

(at sea level, the speed of sound in air is 340 m/s)

(P12) a) Velocity = constant from $t = 0s$ until $t = 22s$

you can tell because the slope of x vs. t plot is linear (slope = constant)

b) v is max where the slope is steepest

@ $t = 27$ seconds

c) Velocity = 0 where slope is zero @ $t = 37$ seconds

d) The rabbit runs in both directions along the tunnel

→ the graph has portions with both positive and negative slopes.

(P23) $\left(100\ \mathrm{km/hr}\right)\left(\frac{1000\,\mathrm{m}}{\mathrm{km}}\right)\left(\frac{1\,\mathrm{hr}}{3600\,\mathrm{s}}\right) = 27.8\ \mathrm{m/s}$

$$v_f^2 - v_i^2 = 2a\Delta x$$

$$a = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{0 - (27.8\ \mathrm{m/s})^2}{2(55\,\mathrm{m})}$$

$$a = 7.0\ \mathrm{m/s^2}$$

$$a = \frac{7.0\ \mathrm{m/s^2}}{9.8\ \mathrm{m/s^2}/g} = 0.72\ g$$

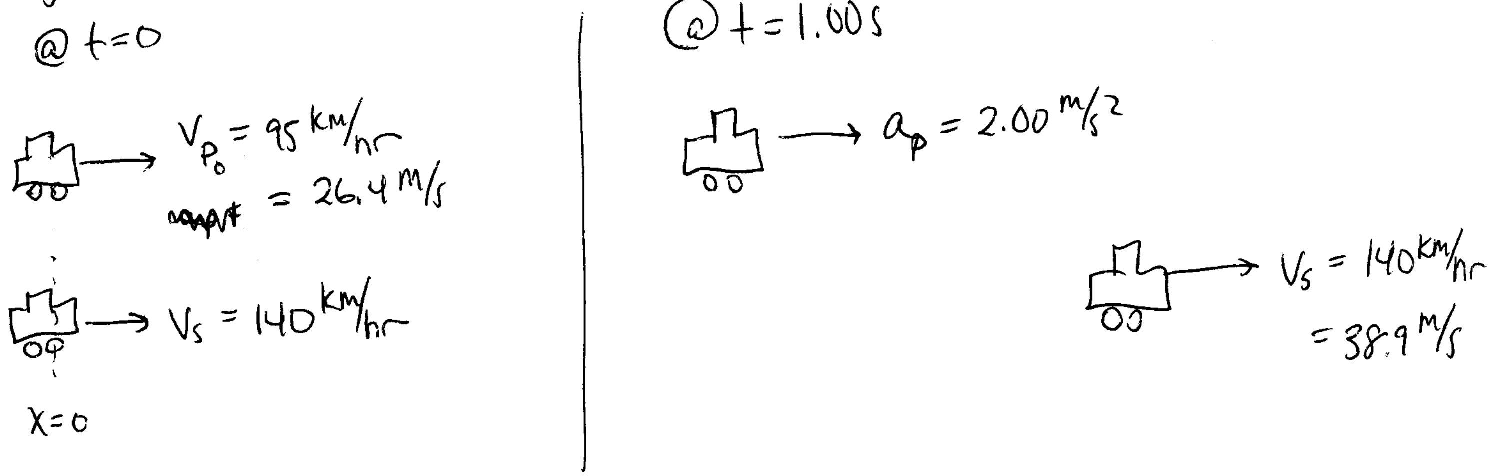
(P33) $v_f^2 - v_i^2 = 2a\Delta x$

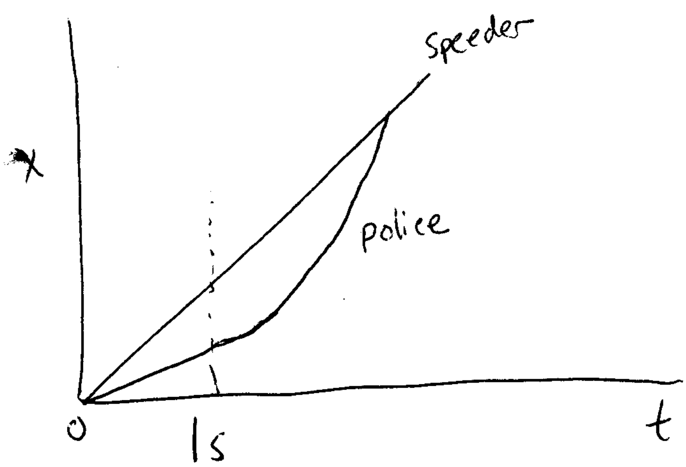
$$\bar{a} = \frac{v_f^2 - v_i^2}{2\Delta x} = \frac{(11.5\,m/s^2)}{2(15.0m)} = 4.41\,m/s^2$$

$$\bar{a} = \frac{\Delta v}{\Delta t} \rightarrow \Delta t = \frac{\Delta v}{a} = \frac{11.5\,m/s}{4.41\,m/s^2} = 2.61\,s$$

(P44)

Diagram





When the cop catches the speeder they have both travelled the same distance, and for the same amount of time.

@ t=1s $\quad x_{p_0} = (v_{p_0})(1s)$

$\quad x_{s_0} = (v_s)(1s)$

$$\left.\begin{aligned} d_p &= x_{p_0} + v_{p_0}t + \tfrac{1}{2}a_p t^2 \\ d_s &= x_{s_0} + v_s t \end{aligned}\right\} \text{Total distances travelled}$$

$$x_{s_0} + v_s t = x_{p_0} + v_{p_0} t + \tfrac{1}{2} a_p t^2$$

$$0 = \tfrac{1}{2} a_p t^2 + (v_{p_0} - v_s)t + (x_{p_0} - x_{s_0})$$

$$= \tfrac{1}{2}(2.00\,m/s^2)t^2 + (26.4\,m/s - 38.9\,m/s)\,t$$

$$+ (26.4m - 38.9m)$$

$$0 = (1\,m/s^2)t^2 - (12.5\,m/s)t - 12.5\,m$$

using the quadratic formula to solve

$$t = \frac{+12.5 \pm \sqrt{(12.5)^2 + 4(1)(12.5)}}{2}$$

$$t = 13.4\,s$$

It takes 13.4 seconds from when the police car starts to accelerate and when it overtakes the speeder.

(P60) a) $v_f^2 = v_i^2 + 2a\Delta y$

$$v_f = \sqrt{2a\Delta y} = \sqrt{2(3.2\,m/s^2)(1200m)}$$

$$v_f = 88\,m/s$$

b) $a = \frac{\Delta v}{\Delta t} \rightarrow \Delta t = \frac{\Delta v}{a} = \frac{88\,m/s}{3.2\,m/s^2} = 28\,s$

c) $v_f^2 = v_i^2 + 2a\Delta y$

$$\Delta y = \frac{v_f^2 - v_i^2}{2a} = \frac{0-(88\,m/s)^2}{-2(9.8\,m/s^2)} = 400\,m$$

$\rightarrow$ Highest altitude $= 1200\,m + 400\,m = 1600\,m$

d) $$\Delta t = \frac{\Delta v}{a} = \frac{88\,m/s}{9.8\,m/s^2} = 9.0\,s$$

$t_{ascent} = 28\,s + 9.0\,s = 37\,s$

e) $V_f = \sqrt{2a\Delta y} = \sqrt{2(9.8\,m/s^2)(1600\,m)} = 180\,m/s$

f) $$t_{descent} = \frac{\Delta v}{\Delta t} = \frac{180\,m/s}{9.8\,m/s^2} = 18\,s$$

$t = t_{ascent} + t_{descent} = 37\,s + 18\,s = 55\,s$

(P74) a) negative slope → negative direction of motion

b) Slope is getting more negative → Speed is increasing

c) curve is concave down → acceleration is negative

d) positive slope → positive direction

e) Slope is getting steeper → speed is increasing

f) Curve is concave up → acceleration is positive

g) object is not moving (position is constant)

there is no acceleration

(P80)

a) Can I pass through the last intersection in 13 s

$d = 10m + 15m + 50m + 15m + 70m + 15m$

$d = 175\ m$

$$t = \frac{d}{v} = \frac{175m}{(50\ km/hr)\left(\frac{1000m}{3600s}\right)} = 12.6s$$

b) How long does it take to get to the speed limit?

$$t = \frac{\Delta v}{a} = \frac{13.9\ m/s}{2\ m/s^2} = 7.0s$$

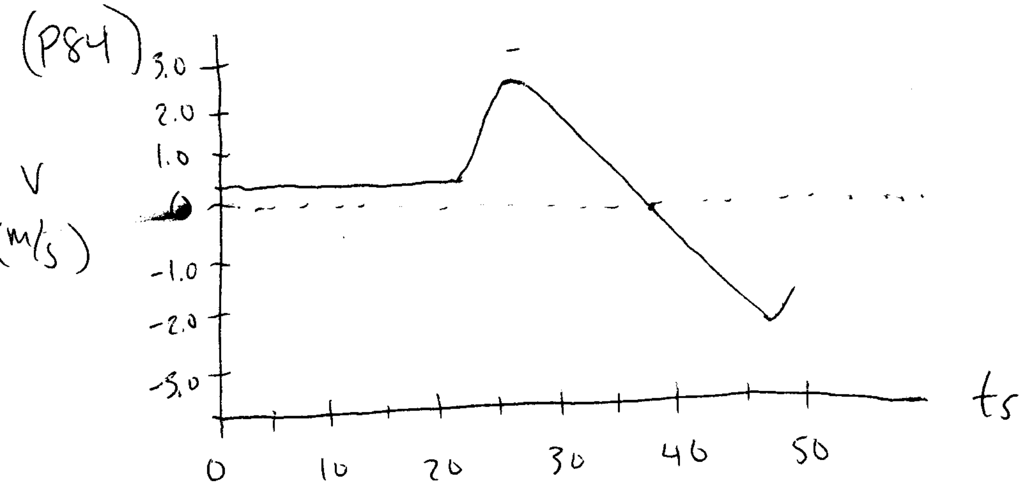
How far has it gone?

$$\Delta x = \frac{1}{2}at^2 = \frac{1}{2}(2.0\ m/s^2)(7.0s)^2 = 49m$$

Still needs to go $175m - 10m - 49m = 116m$

$$t = \frac{116m}{13.9\ m/s^2} = 8.3s$$ → The second car won't make it.

(P84)



* t = 0 to 22s

$$V = \frac{7m}{22s} = 0.32\ m/s$$

* t = 27 to 29

$$V_{max} = \frac{5m}{2s} = 2.5\ m/s$$

* t = 37 V = 0