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1. a) The problem notes that you begin from rest ($v_0 = 0$ cm/s) and that the velocity is increasing at a constant rate of 10 cm/s per mallet strike. This indicates a constant acceleration, calculated below using dimensional analysis which accounts for the rate of 1 mallet strike per second:

$$a = \frac{1 \text{ strike}}{1 s} \times \frac{10 \text{ cm/s}}{1 \text{ strike}} = 10 \text{ cm/s}^2$$

The change in position can then be calculated for the 6 seconds.

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 \qquad v_0 = 0 \text{ cm/s} \quad a = 10 \text{ cm/s}^2$$

$$x - x_0 = \Delta x = v_0 t + \tfrac{1}{2}at^2 \qquad t = 6 s$$

$$\Delta x = (0 \text{ cm/s})(6s) + \tfrac{1}{2}(10 \text{ cm/s}^2)(6s)^2$$

$$\Delta x = 5 \text{ cm/s}^2 (36 s^2) = \boxed{180 \text{ cm}}$$

b) The expression can be derived from $\Delta x = v_0 t + \frac{1}{2}at^2$ as follows, assuming the object begins from rest:

$$\Delta x = v_0 t + \tfrac{1}{2}at^2$$

$$\Delta x = (0 \text{ cm/s})t + \tfrac{1}{2}(10 \text{ cm/s}^2)t^2$$

$$\boxed{\Delta x = (5 \text{ cm/s}^2)t^2}$$

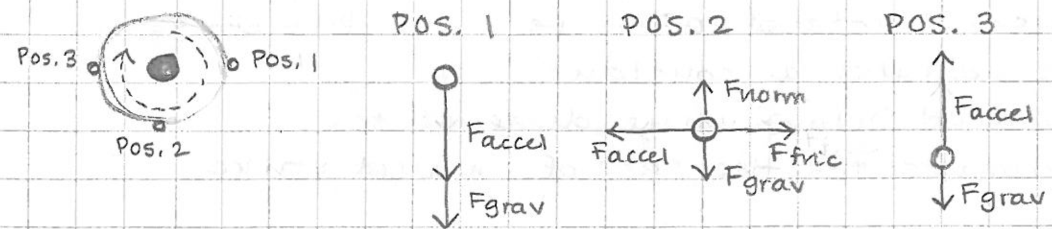
c) In this new scenario, both the rate at which the velocity changes per mallet strike and the rate at which the ball is struck with the mallet are different. It can be proven, however, that the acceleration remains the same, as calculated below:

$$a = \frac{1 \text{ strike}}{0.5 s} \times \frac{5 \text{ cm/s}}{1 \text{ strike}} = 10 \text{ cm/s}^2$$

This means that the ball will once again move $\boxed{180 \text{ cm}}$ in the specified 6 seconds.

2. a) For this problem, I considered left to be the negative direction and right to be the positive.
In terms of the instantaneous velocity of the pebble, it is at a velocity of 0 mph at the moment it contacts the pavement. This is true because all involved forces balance at that point. The downward pull of gravity is balanced by the normal force from the road below and frictional force from the road balances the acceleration of the forward motion of the car. This fits into the context of the pebble's motion when not in contact with the road (meaning that there is

no normal force or frictional force). See the free-body diagrams below:



In terms of directionality, the pebble would be moving to the left overall because the wheel is rotating clockwise, pulling the pebble toward the back of the wheel as it rolls forward. At the exact moment of contact with the pavement it would not be moving in either direction.

b) One could argue that the pebble, stuck in the wheel, is part of a single unit with the rest of the car. Because the car is noted as travelling at 60 mph toward the right (the positive direction, one could argue that the pebble is also travelling to the right at 60 mph.

c) The flaw in the logic of Part B is considering the car and the pebble stuck in its wheel to be a single unit. The wheel, however, moves independently clockwise, not in the same direction as the car. Thus, the pebble must also be considered on its own, having a speed and directionality that are not necessarily the same as that of the entire car.

3. a) The expression can be derived from $v = v_0 + at$, know that $v_0 = 40\,m/s$ and it is decreasing at a rate of 10 m/s per second, making $a = -10\,m/s^2$. See derivation below:

$$v = v_0 + at$$
$$v = 40\,m/s + (-10\,m/s^2)t$$
$$\boxed{v = (-10\,m/s^2)t + 40\,m/s}$$

b) The time it takes for v to be equal to 0 m/s is calculated below:

$$0\,m/s = (-10\,m/s^2)t + 40\,m/s$$
$$(-10\,m/s^2)t = -40\,m/s$$
$$t = \boxed{4\,s}$$

c) Average velocity is equal to the change in position over the change in time. To find this, final position must be calculated as follows, knowing that $x_0 = 0\,m$, $v_0 = 40\,m/s$, $a = -10\,m/s^2$, and $t = 4\,s$:

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

$x = 0\,m + (40\,m/s)(4s) + \frac{1}{2}(-10\,m/s^2)(4s)^2$

$x = 160\,m + (-5\,m/s^2)(16s^2)$

$x = 160\,m - 80\,m = 80\,m$

The average velocity can then be calculated:

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x - x_0}{t - t_0} = \frac{80m - 0m}{4s - 0s} = \frac{80\,m}{4s} = \boxed{20\,m/s}$$

d) The distance travelled when the velocity reaches $0\,m/s$ is $\boxed{80\,m}$, as calculated above.

e) The reason this is an incorrect assumption is because the ball not only travels at a faster average velocity overall, but remains in the air for twice as long, more than doubling (in fact, quadrupling) the distance travelled, as it takes longer for the velocity to slow to $0\,m/s$. This can be shown first by finding the time the ball takes to reach $0\,m/s$, as done above:

$v = v_0 + at \quad v_0 = 80\,m/s \quad a = -10\,m/s^2$

$v = 80\,m/s + (-10\,m/s^2)t$

$v = (-10\,m/s^2)t + 80\,m/s$

$0\,m/s = (-10\,m/s^2)t + 80\,m/s$

$(-10\,m/s^2)t = -80\,m/s$

$t = 8s$

The final position when $v = 0\,m/s$ can then be calculated:

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

$x = 0m + (80\,m/s)(8s) + \frac{1}{2}(-10\,m/s^2)(8s)^2$

$x = 640\,m + (-5\,m/s^2)(16s^2)$

$x = 640\,m - 320\,m = 320\,m$

$320\,m - 80\,m = \boxed{240\,m \text{ higher}}$

It is worth noting that the average velocity can now be calculated:

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{320m - 0m}{8s - 0s} = \frac{320\,m}{8s} = 40\,m/s$$

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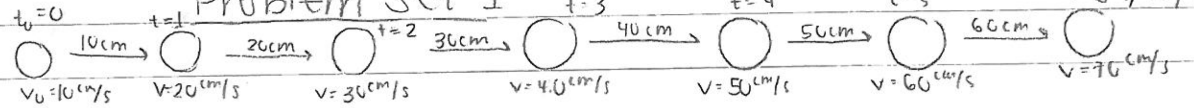
Phy 11 - 01
Hammer

Problem Set 1

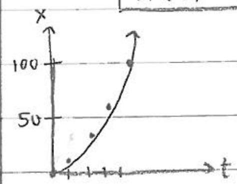
1/21/16

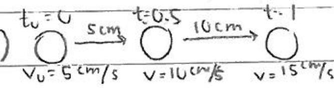
1) 

a) distance at t = 6 = 10 + 20 + 30 + 40 + 50 + 60 = $\boxed{210\text{cm}}$

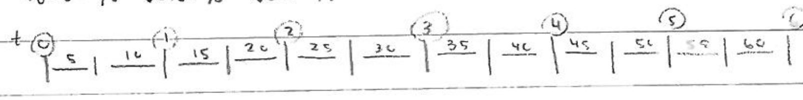
b) x(t) = distance after t seconds   acceleration = 10 cm/s²

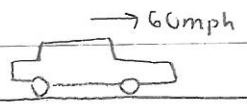
$\boxed{x(t) = 5t^2 + 5t}$

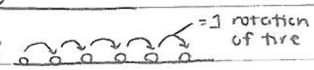


c) 

$\boxed{\text{at } t = 6,\ \text{distance} = 390\text{ cm}}$



2) 

path of pebble: 

a) To a person on the street, the pebble would appear to be moving at 60mph in the same direction as the car (in my drawing, to the right). In the "path of pebble" picture above, it shows that even though the pebble hits the ground once per wheel rotation, it appears to move further right with each touch because it moves with the car, which is travelling right. I determined its speed to be 60mph because I am considering the pebble as a part of the car. Therefore, if the car is moving at 60mph, then the pebble is too.

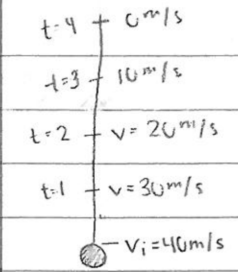
b) Another answer that someone else might believe is that the pebble is moving in the opposite direction at a speed of 0mph. This would be because at the instant the pebble touches the ground, its speed appears to be 0mph because it is a snapshot in time. The direction of motion could be perceived as opposite to the car based on looking at the wheel. If the wheel moves like this: O, then at the moment of impact, the pebble would appear to be moving like this: O, opposite the direction of the car.

c) I believe that the reasoning in section b is incorrect because it only looks at the pebble in a snapshot moment, rather than taking in the big picture.

#3 on back →

1/21/16

3)



$\vec{a} = -10\ m/s^2$

a) $\boxed{v(t) = 40 - 10t}$

b) $v = 0$ @ $\boxed{t = 4}$

c) $V_{avg} = \frac{\Delta x}{\Delta t}$

$\Delta t = 4s \quad \Delta x = 80m$

$V_{avg} = \frac{80m}{4s} \boxed{= 20\ m/s}$

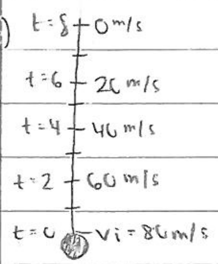
d) $x = x_0 + V_0 t + \frac{1}{2} a t^2$

$x = 0 + 40(4) + \frac{1}{2}(-10)(4^2)$

$x = 160 - 80 = 80$

@ v = 0 m/s, ball has moved 80m up

e)



$\vec{a} = -10 m/s$

$x = x_0 + V_0 t + \frac{1}{2} a t^2$

$x = 0 + 80(8) + \frac{1}{2}(-10)(8^2)$

$x = 640 - 320$

$\boxed{x = 320m}$

The ball does not just go twice as high as the first example because since the ball is going twice as fast, it will take twice as long to slow down. Also, because the ball is traveling faster, the space it travels in 1s is much more than in the first example. Because the ball is in the air for so much longer, it has the time to go much further than just double the distance of the first ball.

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Physics 11 - Problem Set 1

1. a. $t=0$, 10 cm/s
$t=1$, 20 cm/s
$t=2$, 30 cm/s
$t=3$, 40 cm/s
$t=4$, 50 cm/s
$t=5$, 60 cm/s
$t=6$, 70 cm/s

$10+20+30+40+50+60+70 = 280$ cm

the velocity increases by 10 cm/s every second, so every second the ball moves 10 cm more than in the previous second

b. cubic function

$\boxed{y = at^2 + bt + c}$

$t=0$, $10 = c$

$t=1$, $30 = a+b+10$, $a+b=20$, $a=20-b$

$t=2$, $60 = 4a+2b+10$, $4a+2b=50$

$4(20-b)+2b=50$, $80-4b+2b=50$

$-2b=-30$ $b=15$ $\rightarrow a=5$

$\boxed{y = 5t^2 + 15t + 10}$

↳ I knew it would be a quadratic equation because the second difference between the y-values is constant. Then, I created a system of equations to solve for my unknown variables.

c. $t=0$, 5 cm/s
$t=.5$, 10 cm/s
$t=1$, 15 cm/s
$t=1.5$, 20 cm/s
$t=2$, 25 cm/s
$t=2.5$, 30 cm/s
$t=3$, 35 cm/s
$t=3.5$, 40 cm/s
$t=4$, 45 cm/s
$t=4.5$, 50 cm/s
$t=5$, 55 cm/s
$t=5.5$, 60 cm/s
$t=6$, 65 cm/s

$\frac{1}{2}(5+10+15+20+25+30+35+40+45+50+55+60+65)$
$= 227.5$ cm

Every time t increased by .5, the speed increased by 5cm/s. I added all the speeds for every time between $t=0$ & $t=6$ by half second. Then, I divided by 2 because the ball is only moving at that speed for half a second before it is hit again.

2. a. At that moment, the pebble is moving in the opposite direction as the car. It will appear to be moving faster than the car is moving because the wheels have to spin fast enough for the car to move 60 mph.

b. Someone standing on the side of the road would say that the pebble looks like it's not moving. The wheel is moving in the opposite direction as the car, at the same speed. therefore, the pebble would appear to not be moving.

c. The reasoning in part b makes more sense. The reasoning in part a makes sense if you don't consider the fact that the person is not moving.

3. a. $v(t) = -10t + 40$

$v(0) = 40$, $v(1) = -10 + 40 = 30$, $v(2) = -20 + 40 = 20$

the initial velocity is 40 m/s and decreases by 10 m/s every second

b. $0 = -10t + 40$, $-40 = -10t$, $t = 4$ seconds

c. avg velocity $= \frac{\Delta v}{\Delta t} = \frac{0-40}{4-0} = -10$ m/s

↳ this makes sense because the velocity decreases at constant rate of 10 m/s

d. $t=0$, $v=40$ m/s
$t=1$, $v=30$ m/s
$t=2$, $v=20$ m/s
$t=3$, $v=10$ m/s
$t=4$, $v=0$ m/s

$40+30+20+10 = 100$ m

↳ if the velocity = 40 m/s, it has moved 40 m before t increases by one; therefore, I added the velocities to get the total distance

e. $t=0$, $v=80$ m/s
$t=1$, $v=70$ m/s
$t=2$, $v=60$ m/s
$t=3$, $v=50$ m/s
$t=4$, $v=40$ m/s
$t=5$, $v=30$ m/s
$t=6$, $v=20$ m/s
$t=7$, $v=10$ m/s
$t=8$, $v=0$ m/s

$80+70+60+50+40+30+20+10 = 360$ m

↳ it does not equal double the distance because the first 4 seconds are faster than the second 4 (which are equal to part d)