Physics 303K: Midterm 1 Corrections

Question #1:

We know that the following units are:

X = displacement / distance = meters (m)
a = acceleration = meters per second squared (m/s^2)
v = velocity = meters per second (m/s)
s = time = seconds

Solving symbolically both my incorrect and correct answers:

$x = t \rightarrow [x] = [s][t]$
$m \neq s$ ✗
$\therefore x \neq t$ since they do not have matching units; as we have meters on one side and seconds on the other. True, the answer is incorrect. Also time cannot equal displacement/distance.

$x = 3vt \rightarrow [x] = [v][t]$
$m = \frac{m}{s} \cdot s$ [s cancel out]
$m = 3m$ [Both sides are in meters]
$\therefore x = 3vt$ ✓ This is one of the correct as both units correspond to each other. Thus, this is one of the correct answers.

$v = 5at \rightarrow [v] = [a][t]$
$\frac{m}{s} = \frac{5m}{s^2} \cdot s$ [The second cancels out the s^2 to s]
$\frac{m}{s} = 5\frac{m}{s}$ [Both sides are in meters per second]
$\therefore v = 5at$ ✓ This is one of the correct as both units correspond to each other. Thus, this is one of the correct answers.

$v = \frac{x^2}{at^2} \rightarrow [v] = [x^2]/([a]\cdot[t^2])$
$\frac{m}{s} = \frac{m^2}{\frac{m}{s^2} \cdot s^2}$ [The s^2 can cancel out s^2 in the function to second]
$\frac{m}{s} = \frac{m^2}{m^2 \cdot \frac{1}{s}}$ [The meter cancels out the m^2 as m]
$\frac{m}{s} = \frac{m}{\frac{1}{s}}$ ✓
$\therefore v = \frac{x^2}{at^2}$ This is also another of the set of correct answer as both units of both correspond correctly.

$a^3 = \frac{x^2 v}{t^2} \rightarrow [a^3] = ([x^2][v])/[t^2]$
$\left(\frac{m}{s^2}\right)^3 = \frac{m^2 \cdot \frac{m}{s}}{s^2}$ [The m^3 merge into m^3]
$\frac{m^3}{s^6} = \frac{m^3}{s^3} \rightarrow \frac{m^3}{s^3} \cdot \frac{1}{s^3}$ [Use keep-change-flip to manipulate the fraction].
$\frac{m^3}{s^6} = \frac{m^3}{s^6}$ ✓
$\therefore a^3 = \frac{x^2 v}{t^2}$; This is also another correct answer as both sides of the equation have the same corresponding units. Therefore, a^3 equals to or is equivalent to: $\frac{x^2 v}{t^2}$

$Xa^2 = \frac{x^2 v}{t^2} \rightarrow [x][a^2] \neq ([x^2][v])/[t^2]$
$m \cdot \frac{m}{s^2} = \frac{m^2 \cdot \frac{m}{s}}{s^2}$
$\frac{m}{s^2} = \frac{m^3}{s^3} \rightarrow \frac{m^3}{s^3} \cdot \frac{1}{s^3}$
$\frac{m^3}{s^5} \neq \frac{m^3}{s^6}$ ✗

This is an incorrect answer as the units on the left does not correspond to the units on the right side of the equal sign. Thus, this answer is incorrect and not equivalent.

Question #2

Gas tank of 47.5kg (mass)

$V = w \cdot l \cdot h$, the volume of the gas tank
$\rho = \frac{m}{V}$, for density

Solve symbolically

$\rho = \frac{m}{V}$ and $V = w \cdot l \cdot h$
$(V)\rho = \frac{m}{V}(V)$ $\quad \frac{m}{\rho} = w \cdot l \cdot h$
$\frac{V\rho}{\rho} = \frac{m}{\rho}$
$V = \frac{m}{\rho}$ $\quad \frac{(kg)}{(kg/m^3)} = (m^3)$ → (V)

Where m is meters

$V = m \cdot m \cdot m = l \cdot w \cdot h$
$V = m^3$

Where as density is:

$\rho = \frac{m}{V} = \frac{kg}{m^3}$
$\rho = \frac{m}{V}(V)$
$\frac{V\rho}{\rho} = \frac{m}{\rho} = V = \frac{m}{\rho} = \frac{kg}{\left(\frac{kg}{m^3}\right)}$

$\frac{kg}{\left(\frac{kg}{m^3}\right)} \cdot m^3$
$\frac{kg}{1} \cdot \frac{m^3}{kg} \equiv \frac{kg}{1} \cdot \frac{m^3}{kg}$
$\therefore \frac{kg}{1} \cdot \frac{m^3}{kg} = m^3$
$\frac{kg \cdot m^3}{kg} = m^3$
$m^3 = m^3$

Numerical Analysis

Let: $m = 47.5kg$
$l = 0.85m$
$w = 0.45$
$h = h$
Density: $\rho = 0.680 \cdot 10^3 kg/m^3 = 680 kg/m^3$

$V = 0.85m \cdot 0.45m \cdot h(m)$
$V = 0.383m^2 h(m)$
$\rho = \frac{m}{V}$
$680\frac{kg}{m^3} = \frac{47.5kg}{V} \cdot V$
$\frac{V \cdot 680\frac{kg}{m^3}}{680\frac{kg}{m^3}} = \frac{47.5kg}{680\frac{kg}{m^3}}$
$V = \frac{47.5kg}{680\frac{kg}{m^3}}$

$\frac{47.5kg}{1} \cdot \frac{1m^3}{680kg} = \frac{47.5m^3}{680}$
$V = 0.0698$
$\frac{0.0698m^3}{0.383m^2} = \frac{0.383m^2 \cdot h(m)}{0.383m^2}$
$0.1822m = h$

Question #6:

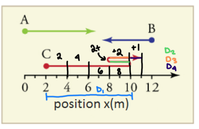
Part A

We want to know the total distance traveled via

$\sum D_i$ = total distance traveled

$\sum_{n=1} D_i = D_1 + D_2 + D_3 + D_4$ [all in meters]
$= 8 + 2 + 2 + 1$
$= 13$ meters

We know that the total distance is everything from start of Point C to end of the arrow of Path C. In addition, we know that distance is a scalar quantity as it is the magnitude; no direction.



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Part B

What is the magnitude of displacement from start to finish, in meters, for path C?

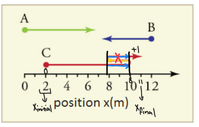
We know that the equation for displacement according to the textbook is:

$d = \Delta x = x_{final} - x_i$ [Vector Quantity]
$|d| = |\Delta x| = |x_{final} - x_i|$ [Magnitude of the vector]

We know that our x_{final} is 11 and our x_i is 2; thus:

$|d| = |\Delta x| = |11 - 2|$
$= |9|$
$\therefore |d| = |\Delta x| = 9$ meters

Therefore, the correct solution to Question 6b is 9 meters.



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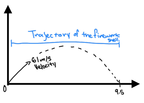
Question #7:

A firework shell has a constant acceleration from rest to a velocity of 61 m/s over a distance of 9.5 m.

How long, in seconds, does the acceleration last? [Part A]

Calculate the acceleration, in meters per second squared [Part B]



We know the shell has the following:
- Velocity of 61 m/s [final]
- Trajectory distance of 9.5 meters.
- Velocity of 0 m/s (rest)
- Constant acceleration

Part B, lets find acceleration first; as it will be easier in finding time, in part A.

We know that we are given velocity final and initial; and the distance. Therefore we use

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

To look for acceleration, thus we solve symbolically for accel.

$v_f^2 = v_i^2 + 2a\Delta x \rightarrow [v_f^2] = [v_i^2] + [2a][\Delta x]$
$v_f^2 - v_i^2 = \frac{2a\Delta x}{2a\Delta x}$
$\frac{v_f^2 - v_i^2}{2\Delta x} = a$ [Now that we solved for a; we can now numerically "plug-and-chug" to solve for acceleration]

Let: $v_f = 61 m/s$
$v_i = 0 m/s$
$\Delta x = d = 9.5$

$\frac{61^2 - 0^2}{2 \cdot 9.5} = \frac{3721}{19} = \boxed{195.8421 m/s^2} = a$ ✓ The acceleration

Part A: Now that we have found acceleration, we can now symbolically and numerically solve for time, using the following kinematic equation:

$(+)a = \frac{v - v_i}{t}$ (+)
$\frac{at}{a} = \frac{v - v_i}{a}$
$t = \frac{v - v_i}{a}$ [We have symbolically found an equation for time when given velocity and acceleration]

Now we can numerically solve for time (t)

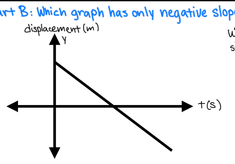
$t = \frac{61 - 0}{195.8} = \frac{61}{195.8} = \boxed{0.31282} = t$ This our time

Given velocity [final and initial] and acceleration we are able to find time using the equations above.

Therefore, our acceleration is 195.8421 m/s^2 and the time for the projectile is 0.31282 seconds.

Question 8:

Part B: Which graph has only negative slope?



We know this represents negative velocity since we have a negative slope of the function:

$V = -c \cdot \frac{s}{t} \rightarrow [v] = \frac{[s]}{[t]}$

while a positive slope/velocity would be written with a positive slope:

$V = c \cdot \frac{s}{t}$

Therefore, this graph is correct; as the slope is determined by some positive or negative scalar/constant.

Question #9:

A point on the second hand of a clock has a centripetal acceleration of 0.079 cm/s²

We know the formula of centripetal acceleration is: $a_c = \frac{v^2}{r}$ where v is velocity and r is radius

Question: How far is this point, in cm, from rotational axis?

In other words, we are looking for r; so in that we symbolically manipulate the equation for centripetal acceleration:

$a_c = \frac{v^2}{r} = \frac{1}{\frac{1}{r}}$
$\frac{a_c}{v^2} = r$

Now to solve numerically we have a_c and v to solve for r:

$\frac{0.079 cm/s^2}{\left(\frac{2\pi}{60}\right)^2} = \boxed{7.2039 cm}$ as our correct and final radius

$a_c = 0.079 cm/s^2$
v & $\omega \rightarrow \omega = \frac{2\pi}{t}$
$\theta = 2\pi$
$t_f = 60$ sec.

In other words, we are looking for r; so in that we symbolically manipulate the equation for centripetal acceleration:

We also know that v & v such that $\omega = \frac{v}{r}$; $\omega = \frac{2\pi}{t}$

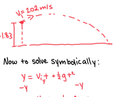
Thus $\theta = 2\pi$ for full rotation which takes 60 seconds which is t for time.

Question #10:

A bullet is shot horizontally over level ground. The initial height is 1.83 m and its initial speed is 202 m/s.

[Part A] How much time, in seconds, elapses before the bullet hits the ground?

[Part B] How far does the bullet travel horizontally, in meters, before hitting the ground?



Now to solve symbolically:

$y = v_i y + \frac{1}{2}gt^2$
$-y \qquad -y$
$0 = v_i y + \frac{1}{2}gt^2 - y$

Given the structure and and terms of the equation at this point looks similar to the quadratic formula.

$\therefore a = \frac{1}{2}g$
$b = v_i \rightarrow t$
$c = -y$

Plug in the values:

$t = \frac{-v_i \pm \sqrt{v_i^2 - 4ay}}{g}$

Now that we have our equation for time; we can now numerically solve.

Let $y = 1.83$ meters
$g = 9.81 m/s^2$
$v_{iy} = 0 m/s$

$\frac{-0 \pm \sqrt{0^2 + 2(9.81)(1.83)}}{9.81} = \boxed{0.6108 sec.}$

In our case, we want the positive representation of time. So the operand before the radicand must be positive.

∴ Based on the numerical and symbolic problem-solving; the time elapsed before the projectile hits the ground is 0.6108 seconds.

[Part A] We know that we are given the following:
- v_y (initial here) is 202 m/s and $v_{ix} = 0$ m/s [vertical velocity initial]
- Our initial height (y) is 1.83 meters
- And our acceleration is 9.81 m/s since the bullet is travelling horizontally level to the ground

Thus, we can use the following kinematic equation:

$y = v_i y + \frac{1}{2}at^2$ where $a = g = |g|$

Which is somewhat similar and is related to $x(t) = x_0 + v_0 t + \frac{1}{2}at^2$

Part B:

We know that to get the distance that the bullet traveled we use the following equation:

$v = \frac{d}{[t]} \rightarrow [v] = \frac{[d]}{[t]}$
$\cancel{t} \cdot v(t) = \frac{d}{\cancel{t}} \cdot \cancel{t}$
$v = v$
∴ In order to find the distance; we use $v \cdot t = d$ where v is our velocity and t is our time. Such that:

$202 m/s \cdot 0.6108 s = d$
$\boxed{123.3836 = d}$ ✓

Is the correct answer as it is within a reasonable measure for a respective distance.