Name____

Physics 110 Quiz #1, September 16, 2016

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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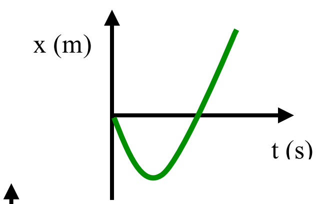
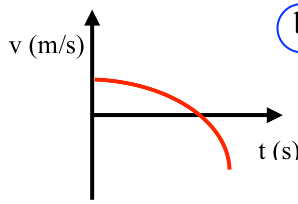
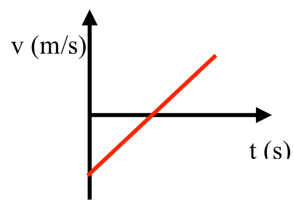
1. An object is observed moving along a horizontal axis and its position as a function of time is shown in the graph on the right. Which of the graphs below represents the velocity of the object as a function of time?



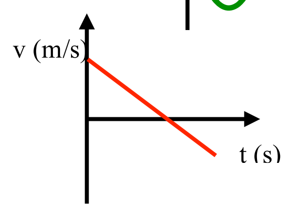
a.



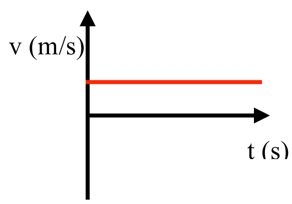
b.



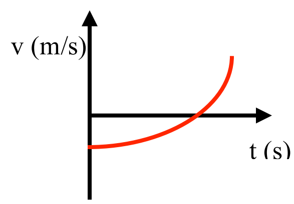
c.



d.



e.



2. A rock is dropped from rest off of the edge of a cliff of unknown height. The rock hits the water below the cliff $6.2s$ after it was released. What is the height of the cliff?

$y_f = y_i + v_{iy} + \frac{1}{2}a_y t^2 = -\frac{1}{2}\times 9.8\frac{m}{s^2}(6.2s)^2 = -188.4m$ or $188.4m$ below where the rock was dropped.

3. Suppose now, that another rock were thrown off of the same cliff but this time with an unknown initial velocity. The rock is observed to hit the water $4.5s$ after it was thrown. What are the magnitude and direction of the initial velocity that the stone was thrown off of the cliff with?

$$y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2$$
$$-188.4m = v_{iy}(4.5s) - \frac{1}{2}\times 9.8\frac{m}{s^2}(4.5s)^2 = -188.4m$$
$$v_{iy} = -19.9\frac{m}{s}$$

The rock was thrown in the vertically downward direction (the negative sign) with a magnitude of $19.9\frac{m}{s}$.

4. For the case in part 3, what is the impact velocity (magnitude and direction) of the rock just before it struck the water?

$$v_{fy} = v_{iy} + a_y t = -19.9\tfrac{m}{s} - 9.8\tfrac{m}{s^2} \times 4.5s = -64\tfrac{m}{s}$$

5. Suppose that you are driving down a road at $60mph\ (\sim 26.8\tfrac{m}{s})$. Exactly $300m$ ahead of you, you notice a sign that says the speed limit in town is $30mph\ (\sim 13.4\tfrac{m}{s})$. You put on your brakes and decelerate at a rate of $5\tfrac{mph}{s}\ (\sim 2.2\tfrac{m}{s^2})$. Unfortunately, a cop sees you, pulls you over and says that when you crossed into the $30mph$ zone, you were speeding and gives you a ticket. You of course think that you were not speeding. When you go to court you argue your case. Were you speeding when you crossed into the $30mph$ zone or can you convince a judge that you were not speeding? Defend your answer with a calculation.

One method is to calculate how far you've gone in changing your speed by the values given. Calculating how far, clearly you weren't speeding since you had approximately $177m$ to spare.

$$v_{fx}^2 = v_{ix}^2 + 2a_x\Delta x$$

$$\left(13.4\tfrac{m}{s}\right)^2 = \left(26.8\tfrac{m}{s}\right)^2 - 2\times 2.2\tfrac{m}{s^2}\Delta x$$

$$\Delta x = 122.4m$$

A second method is to see what your final speed is when you've traveled the given distance. We have

$$v_{fx}^2 = v_{ix}^2 + 2a_x\Delta x = \left(26.8\tfrac{m}{s}\right)^2 - 2\times 2.2\tfrac{m}{s^2}\times 300m = -601.8\tfrac{m^2}{s^2}$$

$$v_f = \text{not defined}$$

This result means that (keeping this deceleration) you would have stopped well before $300m$.

Useful formulas:

Motion in the r = x, y or z-directions

$$r_f = r_0 + v_{0r}t + \tfrac{1}{2}a_r t^2$$

$$v_{fr} = v_{0r} + a_r t$$

$$v_{fr}^{\ 2} = v_{0r}^{\ 2} + 2a_r\Delta r$$

Uniform Circular Motion

$$a_r = \frac{v^2}{r}$$

$$F_r = ma_r = m\frac{v^2}{r}$$

$$v = \frac{2\pi r}{T}$$

$$F_G = G\frac{m_1 m_2}{r^2}$$

Geometry /Algebra

Circles $C = 2\pi r$, $A = \pi r^2$

Triangles $A = \tfrac{1}{2}bh$

Spheres $A = 4\pi r^2$, $V = \tfrac{4}{3}\pi r^3$

Quadratic equation : $ax^2 + bx + c = 0$,

whose solutions are given by : $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

$$magnitude\ of\ a\,vector = \sqrt{v_x^{\ 2} + v_y^{\ 2}}$$

$$direction\,of\ a\,vector \rightarrow \phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$$

Useful Constants

$g = 9.8\ ^{m}/_{s^2}$ $\quad G = 6.67\times10^{-11}\ ^{Nm^2}/_{kg^2}$

$N_A = 6.02\times10^{23}\ ^{atoms}/_{mole}$ $\quad k_B = 1.38\times10^{-23}\ ^{J}/_{K}$

$\sigma = 5.67\times10^{-8}\ ^{W}/_{m^2K^4}$ $\quad v_{sound} = 343\ ^{m}/_{s}$

Linear Momentum/Forces

$$\vec{p} = m\vec{v}$$

$$\vec{p}_f = \vec{p}_i + \vec{F}\Delta t$$

$$\vec{F} = m\vec{a}$$

$$\vec{F}_s = -k\vec{x}$$

$$F_f = \mu F_N$$

Work/Energy

$$K_t = \tfrac{1}{2}mv^2$$

$$K_r = \tfrac{1}{2}I\omega^2$$

$$U_g = mgh$$

$$U_S = \tfrac{1}{2}kx^2$$

$$W_T = FdCos\theta = \Delta E_T$$

$$W_R = \tau\theta = \Delta E_R$$

$$W_{net} = W_R + W_T = \Delta E_R + \Delta E_T$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = 0$$

$$\Delta E_R + \Delta E_T + \Delta U_g + \Delta U_S = -\Delta E_{diss}$$

Heat

$$T_C = \tfrac{5}{9}[T_F - 32]$$

$$T_F = \tfrac{9}{5}T_C + 32$$

$$L_{new} = L_{old}(1 + \alpha\Delta T)$$

$$A_{new} = A_{old}(1 + 2\alpha\Delta T)$$

$$V_{new} = V_{old}(1 + \beta\Delta T):\ \beta = 3\alpha$$

$$PV = Nk_BT$$

$$\tfrac{3}{2}k_BT = \tfrac{1}{2}mv^2$$

$$\Delta Q = mc\Delta T$$

$$P_C = \frac{\Delta Q}{\Delta t} = \frac{kA}{L}\Delta T$$

$$P_R = \frac{\Delta Q}{\Delta T} = \varepsilon\sigma A\Delta T^4$$

$$\Delta U = \Delta Q - \Delta W$$

Rotational Motion

$$\theta_f = \theta_i + \omega_i t + \tfrac{1}{2}\alpha t^2$$

$$\omega_f = \omega_i + \alpha t$$

$$\omega^2{}_f = \omega^2{}_i + 2\alpha\Delta\theta$$

$$\tau = I\alpha = rF$$

$$L = I\omega$$

$$L_f = L_i + \tau\Delta t$$

$$\Delta s = r\Delta\theta:\ v = r\omega:\ a_t = r\alpha$$

$$a_r = r\omega^2$$

Fluids

$$\rho = \frac{M}{V}$$

$$P = \frac{F}{A}$$

$$P_d = P_0 + \rho gd$$

$$F_B = \rho gV$$

$$A_1v_1 = A_2v_2$$

$$\rho_1A_1v_1 = \rho_2A_2v_2$$

$$P_1 + \tfrac{1}{2}\rho v^2{}_1 + \rho gh_1 = P_2 + \tfrac{1}{2}\rho v^2{}_2 + \rho gh_2$$

Simple Harmonic Motion/Waves

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$T_S = 2\pi\sqrt{\frac{m}{k}}$$

$$T_P = 2\pi\sqrt{\frac{l}{g}}$$

$$v = \pm\sqrt{\frac{k}{m}}A\left(1 - \frac{x^2}{A^2}\right)^{\frac{1}{2}}$$

$$x(t) = A\sin\left(\tfrac{2\pi t}{T}\right)$$

$$v(t) = A\sqrt{\frac{k}{m}}\cos\left(\tfrac{2\pi t}{T}\right)$$

$$a(t) = -A\frac{k}{m}\sin\left(\tfrac{2\pi t}{T}\right)$$

$$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$$

$$f_n = nf_1 = n\frac{v}{2L}$$

$$I = 2\pi^2 f^2\rho vA^2$$

Sound

$$v = f\lambda = (331 + 0.6T)\,\tfrac{m}{s}$$

$$\beta = 10\log\frac{I}{I_0};\quad I_o = 1\times10^{-12}\,\tfrac{W}{m^2}$$

$$f_n = nf_1 = n\frac{v}{2L};\quad f_n = nf_1 = n\frac{v}{4L}$$