Name____

Physics 120 Quiz #2, January 17, 2020

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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Suppose that you reside on the third floor of a multi-story residence hall. One day you are looking out of your window and you notice water balloons falling past and that they strike the ground located $15m$ below $0.83s$ seconds after they pass you.

a. With what velocity were the water balloons going when they passed by your window?

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}a_y t^2$$
$$y_f = y_i + v_{iy}t - \tfrac{1}{2}gt^2$$
$$0m = 15m + v_{iy}\left(0.83s\right) - 4.9\tfrac{m}{s^2}\left(0.83s\right)^2$$
$$v_{iy} = -14\tfrac{m}{s}$$

b. With what velocity would the water balloons impact the sidewalk below?

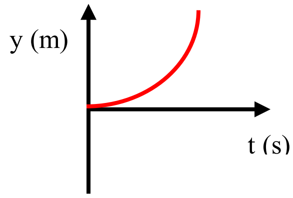
$$v_{fy} = v_{iy} + a_y t = -14\tfrac{m}{s} - 9.8\tfrac{m}{s^2}\left(0.83s\right) = -22.1\tfrac{m}{s}$$

c. If the water balloons were dropped from rest, from what floor were the balloons being dropped? Assume that each floor is $5m$ high.

$$v_{fy}^2 = v_{iy}^2 + 2a_y\Delta y = -2g\Delta y$$
$$\Delta y = -\frac{v_{fy}^2}{2g} = -\frac{\left(-22.1\tfrac{m}{s}\right)^2}{2\times 9.8\tfrac{m}{s^2}} = -24.9m$$
$$\Delta y = y_f - y_i = -y_i \sim -25m \times \frac{1\text{floor}}{5m} = 5^{th}\text{ floor}$$

d. Which of the following would give a possible trajectory for the water balloons as a function of time? Take up away from the ground as the positive y-axis.

1.



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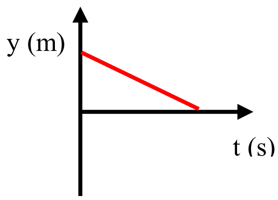

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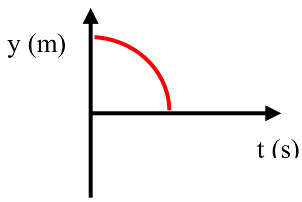

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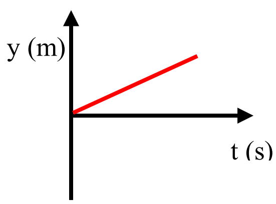

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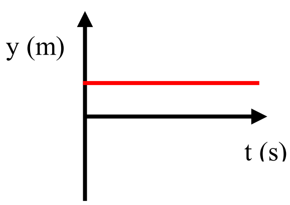

e. Suppose that for some unexplained reason that one of the water balloons didn't break when it hit the ground. You go pick it up and decide that it would be a good idea to throw it at a friend walking down the sidewalk at you. If you accelerate the balloon from rest over a distance of about $1.7m$ during your throw, with what speed will the water balloon leave your hand if $a = 2.6\frac{m}{s^2}$?

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

$$v_{fx} = \sqrt{2a_x\Delta x} = \sqrt{2 \times 2.6\frac{m}{s^2} \times 1.7m} = 2.97\frac{m}{s}$$

Physics 120 Formulas

Motion

$\Delta x = x_f - x_i$

$v_{avg} = \frac{\Delta x}{\Delta t}$

$a_{avg} = \frac{\Delta v}{\Delta t}$

Equations of Motion

displacement: $\begin{cases} x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2 \\ y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 \end{cases}$

velocity: $\begin{cases} v_{fx} = v_{ix} + a_x t \\ v_{fy} = v_{iy} + a_y t \end{cases}$

time-independent: $\begin{cases} v_{fx}^2 = v_{ix}^2 + 2a_x \Delta x \\ v_{fy}^2 = v_{iy}^2 + 2a_y \Delta y \end{cases}$

Uniform Circular Motion

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

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

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

Geometry /Algebra

Circles — $C = 2\pi r$, $A = \pi r^2$

Triangles — $A = \frac{1}{2}bh$

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

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

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

Vectors

magnitude of a vector: $v = |\vec{v}| = \sqrt{v_x{}^2 + v^2{}_y}$

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

Useful Constants

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

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

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

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

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

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

$U_g = mgh$

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

$W_T = FdCos\theta = \Delta E_T$

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

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

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

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

Rotational Motion

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

$\omega_f = \omega_i + \alpha t$

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

$\tau = I\alpha = rF$

$L = I\omega$

$L_f = L_i + \tau\Delta t$

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

$a_r = r\omega^2$

Simple Harmonic Motion/Waves

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

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

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

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

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

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

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

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

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

$I = 2\pi^2 f^2 \rho v A^2$