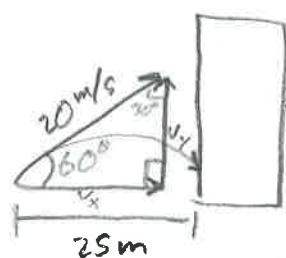


Big Exam #3, SUSTAIN, Schwartz Name

1) From 25 meters away from a building, I shoot a water balloon up at it with a speed of 20 m/s, at an angle of 60° above the horizon.

a) How high do I hit the building?

b) What is the velocity of the water balloon when it hits? (please give angle and magnitude).



*Kinematics focus: movement and height over time
Dynamics (a little): to show the sum of forces needed to make actual direction of force good Point.*

$$25\text{m} = (\cos 60 \cdot 20 \text{ m/s}) \cdot t$$

$$25\text{m} = 10\text{m/s} \cdot t$$

$$2.5\text{s} = t$$

$$@ y(t) = y_0 + V_y t + \frac{1}{2}(-g)t^2$$

$$\begin{aligned} y(2.5) &= 0\text{m} + (\sin 60 \cdot 20 \text{ m/s})(2.5\text{s}) + \frac{1}{2}(-10 \text{ m/s}^2)(2.5\text{s})^2 \\ &= (10\sqrt{3} \text{ m/s} \cdot 2.5\text{s}) - (5 \text{ m/s}^2 \cdot 7\text{s}^2) \end{aligned}$$

$$y \approx (40\text{m}) - (35\text{m})$$

$y \approx 5\text{m}$ up the building

(b)

$$V_y = V_{y_0} + at$$

$$\approx 17 \text{ m/s} + (-10 \text{ m/s}^2)(2.5\text{s})$$

$$V_y = -8 \text{ m/s}$$



$$\tan \theta = \frac{10}{-8} = -\frac{5}{4}$$

$$\theta = 50^\circ$$

$$\sin 50^\circ = \frac{10 \text{ m/s}}{X}$$

$$X = \frac{10 \text{ m/s}}{\sin 50^\circ} \approx \frac{10 \text{ m/s}}{\frac{\sqrt{2}}{2}} \approx 14 \text{ m/s}$$

$\theta = \tan^{-1} \left(\frac{-5}{4} \right)$ ← just under -1 ,
which $\tan^{-1}(-1) = 45^\circ$,
so 50°



'Simple & beautiful!'

- 2) A 2 kg object has a 0.2 coefficient of friction against a vertical wall in my apartment as I push it upward. If I push at an angle of 30° above the horizon on the box as shown with a force of 100 N, what is the box's acceleration? - please include direction and magnitude.

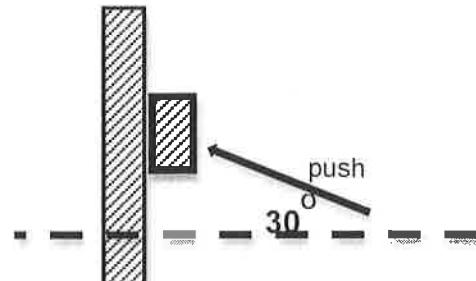
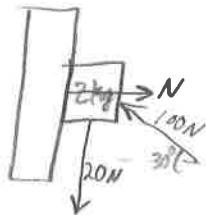
Dynamics, Forces involving acceleration

$$\mu = .2$$

$$F_f = \mu N$$

$$F_f = .2 \cdot 80N$$

$$F_f = 16N$$



$$F_x = \cos 30 \cdot 100N$$

$$F_x \approx 80N = N$$

$$F_y = \sin 30 \cdot 100N$$

$$F_y = 50N$$

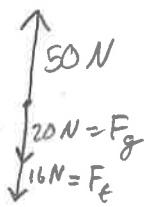
$$\sum \vec{F} = m\vec{a}$$

$$-F_g + F_f + F_p = m\vec{a}$$

$$-20N - 16N + 50N = (2kg) a$$

$$14N = 2kg a$$

$$[7m/s^2 = a] \text{ up the wall}$$



Big Exam #3, SUSTAIN, Schwartz Name

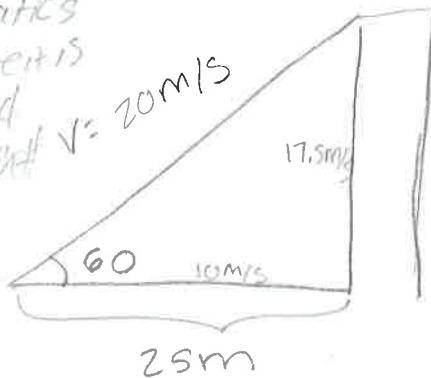
1) From 25 meters away from a building, I shoot a water balloon up at it with a speed of 20 m/s, at an angle of 60° above the horizon.

a) How high do I hit the building?

b) What is the velocity of the water balloon when it hits? (please give angle and magnitude).

A

This is a kinematics problem because it is based on time and the displacement (based on its time derivatives)



a)

$$V_x = \frac{10\text{ m}}{\text{s}} = \frac{25\text{ m}}{(\text{t})}$$

$$\text{t} = \frac{25}{10}$$

= 2.5 s hits building

$$V_x = 20 \cos(60^\circ) \\ = 10\text{ m/s}$$

$$V_y = 20 \sin(60^\circ) \\ = 10\sqrt{3} \\ \approx 17.3 \text{ m/s}$$

$$y(\text{position}) = V_0 + V_0 t - \frac{1}{2} g t^2$$

$$= 17.3(2.5) - \frac{1}{2}(10)(2.5)^2$$

$$= 12 \text{ m high}$$

please use units

b) $V_{y\text{final}} = V_0 + a t$

$$= 17.3 + -10(2.5)$$

$$= -7.68 \text{ m/s}$$

$$a_x = 0$$

$$V_{x0} = V_{x\text{final}} = 10\text{ m/s}$$

$$(7.68)^2 + (10)^2 = V^2$$

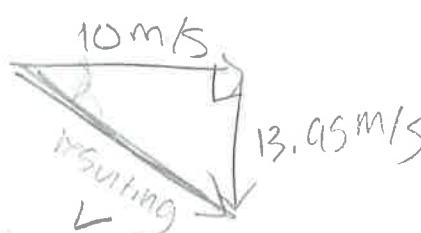
$$V = 12.6 \text{ m/s}$$

$$\tan \theta = \frac{12.6}{10}$$

$$\theta = \tan^{-1}\left(\frac{12.6}{10}\right)$$

$$\theta = 51.8^\circ \text{ below horizontal}$$

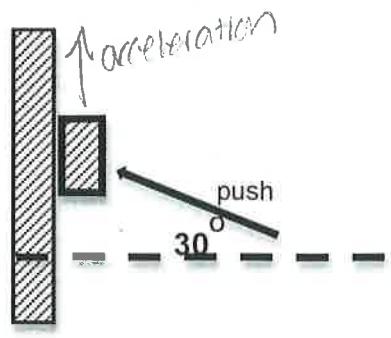
$$12.6 \text{ m/s}$$



great

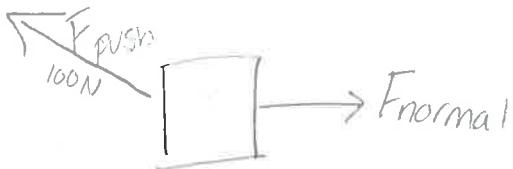
2) A 2 kg object has a 0.2 coefficient of friction against a vertical wall in my apartment as I push it upward. If I push at an angle of 30° above the horizon on the box as shown with a force of 100 N, what is the box's acceleration? - please include direction and magnitude.

Dynamics because it deals with acceleration due to the sum of vectors of force

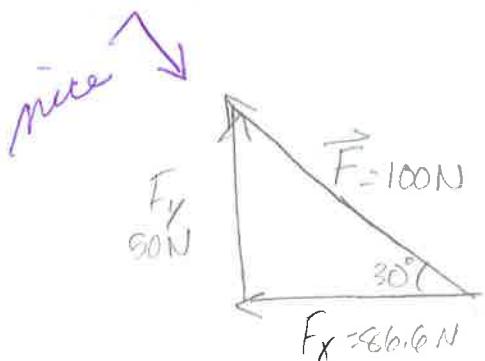


$$F_k = \mu_k N$$

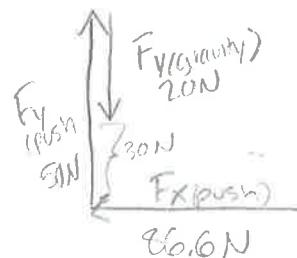
$$\mu_k = 0.2$$



$$\begin{aligned} F_g &= ma \\ &= (2\text{kg})(10\text{m/s}^2) \\ &= 20\text{N} \end{aligned}$$



$$\begin{aligned} F_x &= 100\cos(30^\circ) \\ &= 86.6\text{N} \end{aligned}$$



$$\begin{aligned} F_y &= 100\sin(30^\circ) \\ &= 50\text{N} \end{aligned}$$

$$\begin{aligned} F_y &= F_{y(\text{push})} + F_{y(\text{gravity})} \\ &= 50\text{N} - 20\text{N} \\ &= 30\text{N} \quad (\text{if frictionless}) \end{aligned}$$

$$N_{\text{Normal}} = 86.6\text{N}$$

frictionless

$$\begin{aligned} F_k &\approx 0.2(86.6) \\ &= 17.32\text{N} \end{aligned}$$



$$30 - 17.32 = 12.68\text{N} \uparrow$$

$$F = ma$$

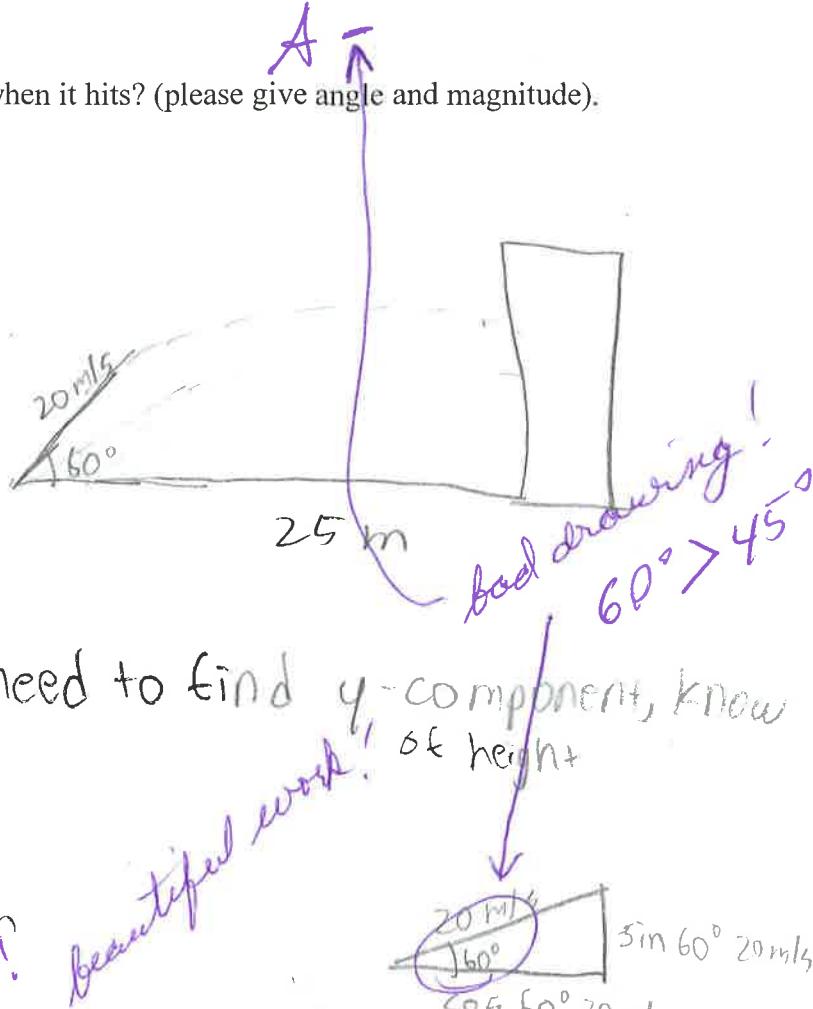
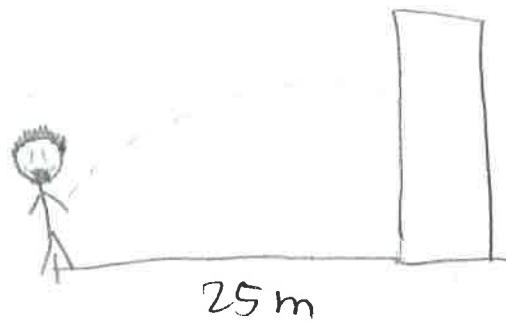
$$a = \frac{12.68\text{N}}{2\text{kg}} = 6.34\text{m/s}^2$$

Big Exam #3, SUSTAIN, Schwartz Name _____

1) From 25 meters away from a building, I shoot a water balloon up at it with a speed of 20 m/s, at an angle of 60° above the horizon.

a) How high do I hit the building?

b) What is the velocity of the water balloon when it hits? (please give angle and magnitude).



Kinematics - Given velocity, need to find y-component, know accelerations, of height

a)

$$x = 0m + (0 \text{ m/s} + \frac{1}{2} 0 \text{ m/s}^2)t^2 = 25 \text{ m}$$

$$t = 2.5 \text{ s}$$

nice units!

beautiful work!

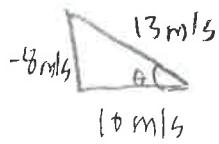
$$y = 0m + 17 \text{ m/s} + \frac{1}{2} (-10 \text{ m/s}^2)t^2 = 17 \text{ m/s} + -5 \text{ m/s}^2 t^2$$

$$\cos 60^\circ = \frac{x}{20 \text{ m/s}}$$

$$\Rightarrow 17 \text{ m/s}(2.5 \text{ s}) - 5 \text{ m/s}^2(2.5 \text{ s})^2 = 42.5 \text{ m} - 31.25 \text{ m} \approx 11 \text{ m}$$

The balloon hits the building in 2.5 s at a height of 11 m.

b)



$$V_x = 10 \text{ m/s} + (0 \text{ m/s}^2)t = 10 \text{ m/s}$$

$$V_y = 17 \text{ m/s} + (-10 \text{ m/s}^2)(2.5 \text{ s}) = -8 \text{ m/s}$$

$$\sqrt{(-8 \text{ m/s})^2 + (10 \text{ m/s})^2} = V$$

$$\tan \theta = \frac{8}{10}$$

$$V = \sqrt{64 \text{ m/s}^2 + 100 \text{ m/s}^2} = \sqrt{164 \text{ m/s}^2} \approx 13 \text{ m/s}$$

$$\theta = \tan^{-1} \frac{4}{5}$$

$$\theta = 39^\circ$$

The balloon hits the building at 13 m/s at a 39° angle.

- 2) A 2 kg object has a 0.2 coefficient of friction against a vertical wall in my apartment as I push it upward. If I push at an angle of 30° above the horizon on the box as shown with a force of 100 N, what is the box's acceleration? - please include direction and magnitude.

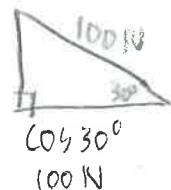
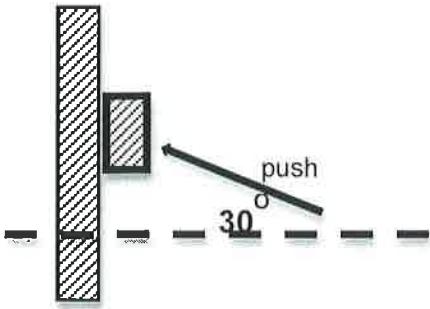
Dynamics - Regards forces, have to find acceleration given mass.

$$\sum F_y = \sin 30^\circ 100\text{N} - (10\text{m/s}^2)(2\text{kg}) - \cos 30^\circ 100\text{N}(0.2)$$

Force - Gravity - Friction

$$\Rightarrow 50\text{N} - 20\text{N} - 17\text{N} = 13\text{N}$$

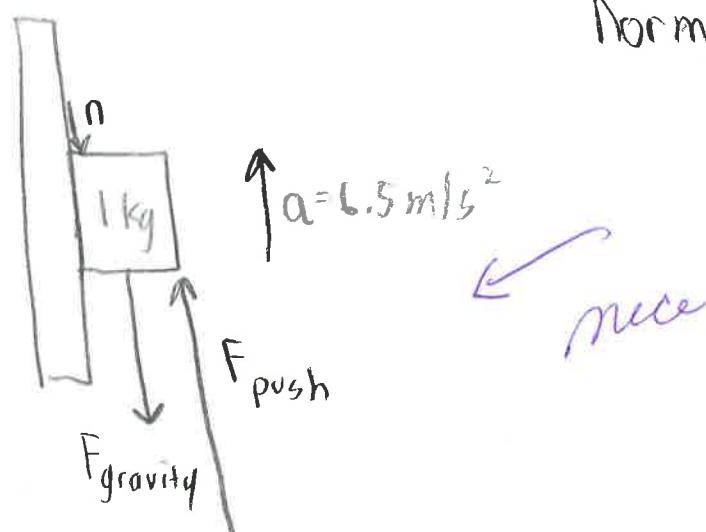
$$\sum F_x = \cos 30^\circ 100\text{N} - \cos 30^\circ 100\text{N} = 0$$



$$\sum F_y = 13\text{N} = (2\text{kg})(a) \Rightarrow a = \frac{13\text{N}}{2\text{kg}} = 6.5 \text{ m/s}^2$$

$$\sum F_x = 0$$

The object accelerates at 6.5 m/s^2 in an upwards direction. There is no acceleration/movement in the horizontal direction.



$$\text{Normal force} = \cos 30^\circ 100\text{N} \approx 87 \text{ N}$$

mece

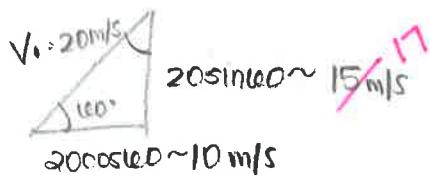
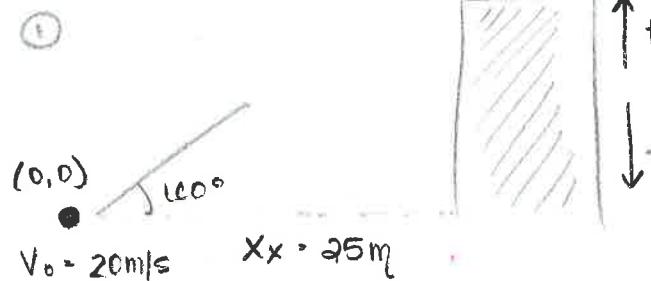
(A)

- 1) From 25 meters away from a building, I shoot a water balloon up at it with a speed of 20 m/s, at an angle of 60° above the horizon.

a) How high do I hit the building?

b) What is the velocity of the water balloon when it hits? (please give angle and magnitude). *nicely!*

This is a two dimensional kinematics problem. We know this because there is an angle involved. Acceleration in the x direction is zero and in the y direction is -9.8 m/s^2 or $\sim 10 \text{ m/s}^2$



$$\begin{aligned} X_x(t) &= X_{0x} + V_{0x}t + \frac{1}{2}at_x^2 \\ &= V_{0x}t \end{aligned}$$

$$\begin{aligned} X_y(t) &= X_{0y} + V_{0y}t + \frac{1}{2}at_y^2 \\ &= V_{0y}t - \frac{1}{2}gt^2 \end{aligned}$$

$$V_{0x}t = (10 \text{ m/s})(t) = 25 \text{ m}$$

$$t = 2.5 \text{ s}$$

$$\begin{aligned} V_{0y}t - \frac{1}{2}gt^2 &= \frac{17}{42.5} (15 \text{ m/s})(2.5) - \frac{1}{2}(10 \text{ m/s})(2.5)^2 \\ &= \frac{37.5}{42.5} \text{ m} - 5(7.25) \\ &= 37.5 - 36.25 \text{ m} = \cancel{1.25 \text{ m}} \end{aligned}$$

$$\begin{array}{r} 30 + \frac{E}{2} = 37.5 \\ 1 \\ 2 \\ 2.5 \\ \times 2.5 \\ \hline 125 \\ 500 \\ \hline 7.25 \end{array}$$

$$\frac{17}{42.5}$$

$$= 31.25 \text{ m}$$

$$= 42.5 - 31.25 \text{ m}$$

~~velocity~~

$$= 11.25 \text{ m}$$

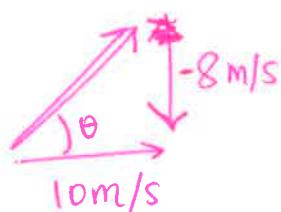
} using calculator

$$2(-10 \text{ m/s})(11.25 \text{ m}) = V_f^2 - (17 \text{ m/s})^2$$

$$\begin{array}{r} -225 = V_f^2 - 289 \\ +289 \quad +289 \end{array}$$

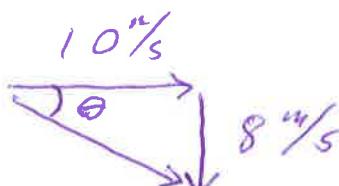
$$(V_f^2 = 64) \sqrt[1]{2}$$

$$\boxed{V_{f,y} = -8 \text{ m/s}}$$



oops!

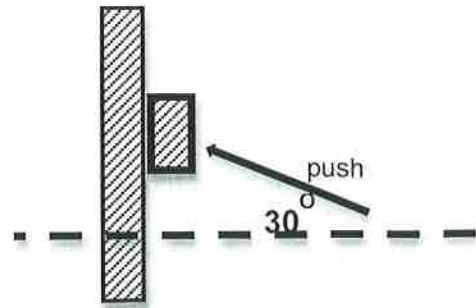
$$\tan^{-1}(\frac{8}{10}) = 38.6598^\circ$$



it "goes" up for $\sim 1.74 \text{ s}$
then \downarrow Velocity Vertical is \downarrow

$$\Delta t = \frac{\Delta v}{a} = \frac{10 \text{ m/s}}{10 \text{ m/s}^2} = \frac{17.4 \text{ m/s}}{10 \text{ m/s}^2}$$

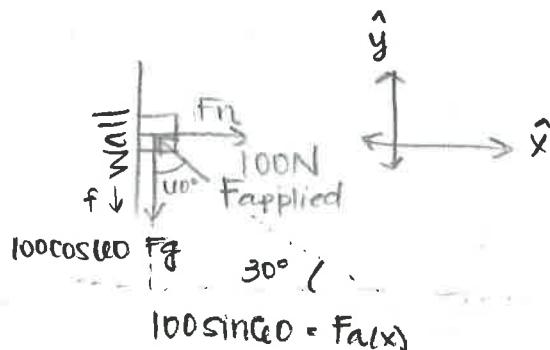
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① Forces/Dynamics: There is a force of friction ($f = \mu f_n$) involved. From Newton's Second Law, we can determine the acceleration of the block.

② $\sum \vec{F} = m\vec{a}$

③ FBD



$$\begin{aligned}\sum F_x &= m\vec{a}_x \\ f_n - F_{\text{ax}} &= m\vec{a}_x \\ f_n &= F_{\text{ax}} \\ f_n &= 100\sin 60^\circ\end{aligned}$$

$$\begin{aligned}\sum F_y &= m\vec{a}_y \\ -f_g + F_{\text{ay}} - f &= m\vec{a}_y \\ -mg + 100\cos 60^\circ - \mu f_n &= m\vec{a}_y \\ -mg + 100\cos 60^\circ - \mu 100\sin 60^\circ &= m\vec{a}_y\end{aligned}$$

$$\vec{a} = \frac{mg - (2\text{kg})(10\text{m/s}^2) + 100\cos 60^\circ - (0.2)(100\sin 60^\circ)}{2\text{kg}}$$

$$\begin{aligned}\vec{a} &= -20\text{N} + \frac{50\text{N}}{2\text{kg}} - \frac{17\text{N}}{2\text{kg}} \\ 13\text{N} &= \frac{45\text{N}}{2\text{kg}} = \boxed{22.5\text{m/s}^2}\end{aligned}$$

$$= \frac{13\text{N}}{2} = \boxed{6.5\text{m/s}^2}$$