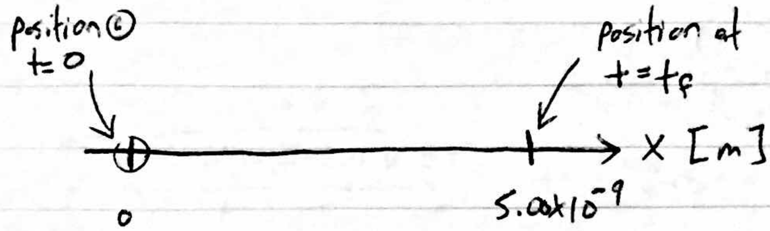
PHYS 1420 F19
Written HW#1
SOLs

P1



$V_0 = V(t=0) = 150\ m/s$

$V_1 = V(t=t_f) = 100\ m/s$

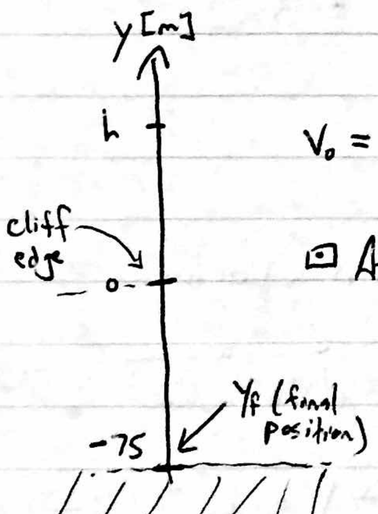
a) $\bar{V} = \frac{V_1+V_0}{2} = 125\ \frac{m}{s} = \frac{\Delta x}{\Delta t} = \frac{5.0\times10^{-9}}{t_f - 0}$

$\longrightarrow t_f = \frac{5.00\times10^{-9}}{125} \simeq \boxed{4.00\times10^{-11}\ s}$

b) Since the acceleration is constant (as stated), $a = \bar{a}$

$a = \bar{a} = \frac{\Delta V}{\Delta t} = \frac{V_1 - V_0}{t_f} = \frac{-50}{4.00\times10^{-11}} \boxed{= -1.25\times10^{12}\ m/s^2}$

P2 ▫ Treat as a 1-D problem (i.e. "straight up", "just misses"). But for simplicity, I'll use "2-D" notation here



$V_0 = 15\ m/s$ (positive because thrown upwards)

▫ At peak (i.e. $y=h$), $V=0$. Everywhere $a = -9.8\ m/s^2$

$V^2 = V_0^2 + 2a(h-0) = V_0^2 - 2(9.8)h$

$\longrightarrow h = \frac{V_0^2}{2(9.8)} = \frac{15^2}{19.6} = \boxed{11.5\ m}$

▫ Let t_f be the "total time of flight" and then we can write

$y_f = y_0 + V_0 t_f + \frac{1}{2}at^2 \longrightarrow -75 = 0 + 15t_f - \frac{9.8}{2}t_f^2$

cont. 1

P2 (cont)

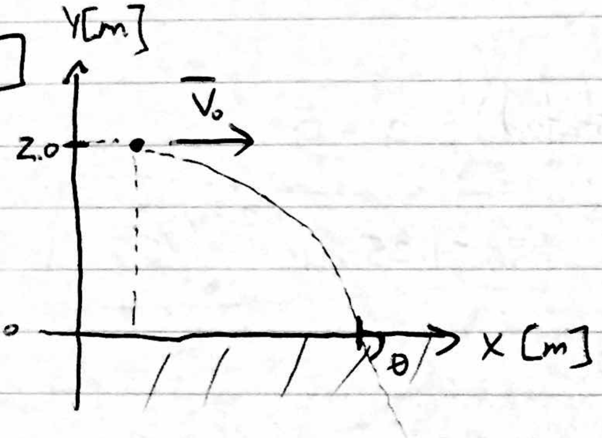
- This is just a quadratic eqn. for t_f:

$$4.9t_f^2 - 15t_f - 75 = 0 \rightsquigarrow t_f = \frac{15 \pm \sqrt{15^2 - 4(4.9)(-75)}}{2(4.9)}$$

$$\simeq \frac{15 \pm 41.2}{9.8} \Rightarrow \boxed{t_f \simeq 5.73\ s}$$

NOTE: Only the positive root matters here (i.e. the "negative time" is irrelevant)

P3



$\bar{V}_o = 4.00\hat{x}$ (i.e. $V_{ox} = 4.00$, $V_{oy} = 0$)

- Note that $a_x = 0$ such that $V_{fx} = 4.00$ (i.e. no change in horizontal component), so we only need to deal w/ a_y ($=g$) so to find V_{fy}

$$V_{fy}^2 = V_{oy}^2 + 2a_y(y - y_o) = 0 + 2(-9.8)(0-2) = 39.2 \ \left(\frac{m^2}{s^2}\right)$$

$$\rightarrow V_{fy} = \sqrt{39.2} = 6.26\ m/s$$

- Keep in mind that we are asked for the velocity, which is a vector!

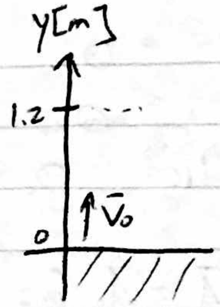
$$\bar{V}_f = V_{fx}\hat{x} + V_{fy}\hat{y}$$

$$\rightsquigarrow |\bar{V}_f| = \sqrt{V_{fx}^2 + V_{fy}^2} = \sqrt{4.00^2 + 6.26^2} \simeq 7.43\ \frac{m}{s}$$

$$\rightsquigarrow \angle \bar{V}_f \equiv \theta = \tan^{-1}\left(\frac{V_{fy}}{V_{fx}}\right) = \tan^{-1}\left(\frac{6.26}{4.00}\right) \simeq -57.4°$$

$$\Rightarrow \boxed{\bar{V}_f = 4.00\hat{x} - 6.26\hat{y} \rightsquigarrow \text{speed is } 7.43\ \tfrac{m}{s} \text{ and angle } \theta = -57.4 \text{ re the ground}}$$

P4



$\bar{V}_0 = ?$, $y_0 = 0$, $y_f = 1.2\ m$, $a_y = -9.8\ m/s^2$

$$0 = V_0^2 - 2(9.8)(1.2-0) \rightarrow \boxed{V_0 = \sqrt{23.5} \simeq 4.85\ m/s}$$

<u>NOTE</u>: As a velocity: $\bar{V} = 4.85\hat{y}\ \frac{m}{s}$

P5 [very similar to last problem!]

a) $V_f = 0$, $V_0 = 7.00\ m/s$, $a_y = -9.8\ m/s^2$, $y_0 = 0$

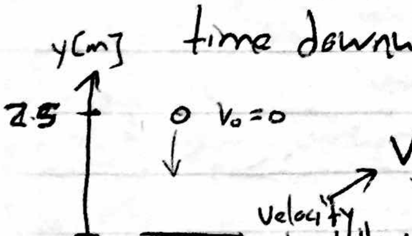
$$0 = 7^2 - 2(9.8)(y_f - 0) \rightsquigarrow \boxed{y_f = \frac{49}{19.6} \simeq 2.50\ m}$$

b) $y_f = y_0 + V_0 t + \frac{1}{2}at^2 = 0 + 7.00t - \frac{9.8}{2}t^2 = 2.50$

$\rightsquigarrow 4.9t^2 - 7.00t - 2.50 = 0$ (quadratic eqn. for t) $\longrightarrow \boxed{t = \frac{7.00 \pm \sqrt{49 - 4(4.9)(2.5)}}{19.6} = 0.714\,s}$

Note # of sig. figs!

c) Good idea to explicitly do the calculation, but logically it would be twice the answer in part b (i.e. 1.43 s). Let's verify. Let t_1 be the answer to part b (i.e. time of flight upwards) and t_2 be time downwards. Thus total flight time is $t_T = t_1 + t_2$. For t_2:



$$V_g^2 = V_0^2 + 2a(y - y_0) = 0 - 2(9.8)(0 - 2.5)$$

$$\rightsquigarrow V_g = \sqrt{2.5(19.6)} = \sqrt{49} = 7.00\ m/s$$ (<u>Note</u>: Same as question a V_0!)

<u>NOTE</u>: Be careful!! Because of the squaring, one can lose track that V_g is actually $-7.00\ m/s$!

$y_f = y_0 + V_0 t_2 + \frac{1}{2}at_2^2 \Rightarrow 0 = 2.50 + (0)t_2 - \frac{1}{2}(9.8)t_2^2 \rightsquigarrow t_2 = \sqrt{\frac{2.5}{4.9}} \simeq 0.714$

$$\Longrightarrow \boxed{t_T = 2(0.714) \simeq 1.43\,s}$$

d) Already did this re part c: $\boxed{V_g = 7.00\ m/s}$

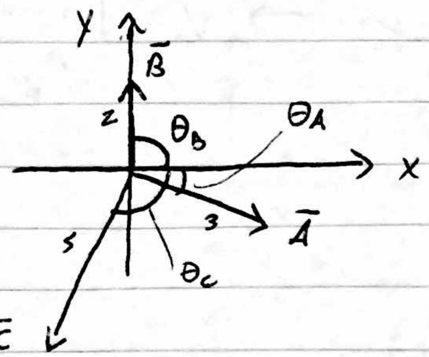
P6 Rewrite vectors in polar form: $|\bar{A}| = 3.0$, $\angle\bar{A} = -20^\circ = \theta_A$

NOTE: Units are in meters and angles re +x-axis

$|\bar{B}| = 2.0$, $\angle\bar{B} = 90^\circ = \theta_B$

$|\bar{C}| = 5.0$, $\angle\bar{C} = -110^\circ = \theta_C$

a)



b) In component form: $\bar{A} = A_x\hat{x} + A_y\hat{y}$ (and similarly for others)

$$A_x = 3.0\cos(-20^\circ) \simeq 2.8 \text{ m}$$
$$A_y = 3.0\sin(-20^\circ) \simeq -1.0 \text{ m}$$

similarly:

$$B_x = 2.0\cos(90) = 0$$
$$B_y = 2.0\sin(90) = 2.0$$
$$C_x = 5.0\cos(-110) \simeq -1.7$$
$$C_y = 5.0\sin(-110) \simeq -4.7$$

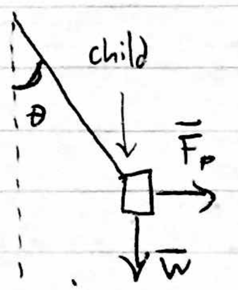
$$\Rightarrow \boxed{\bar{A} = (2.8\hat{x} - 1.0\hat{y})\text{m},\ \bar{B} = (2.0\hat{y})\text{m},\ \bar{C} = (-1.7\hat{x} - 4.7\hat{y})\text{m}}$$

c) $\bar{D} = \bar{A} + \bar{B} + \bar{C} = \hat{x}(2.8 + 0 - 1.7) + \hat{y}(-1.0 + 2.0 - 4.7)$

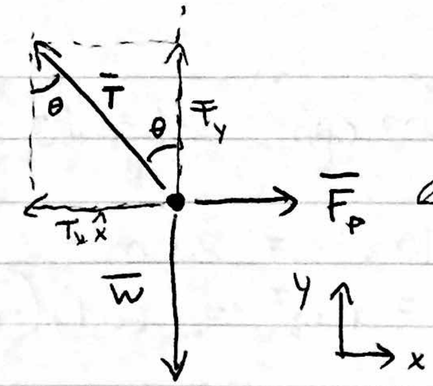
$$\boxed{= (1.1\hat{x} - 3.7\hat{y})\text{m} = \bar{D}}$$

$$\boxed{\begin{aligned} |\bar{D}| &= \sqrt{1.1^2 - 3.7^2} \simeq 3.9 \text{ m} \\ \angle\bar{D} &= \theta_D = \tan^{-1}\left(\frac{-3.7}{1.1}\right) \simeq -73^\circ \end{aligned}}$$

P7



Make a FBD



this is what we need to determine (actually, $|\bar{F}_p|$)

$\bar{W} = 200\ N$

- Since child would be at rest at the moment, $\sum \bar{F}_n = 0$

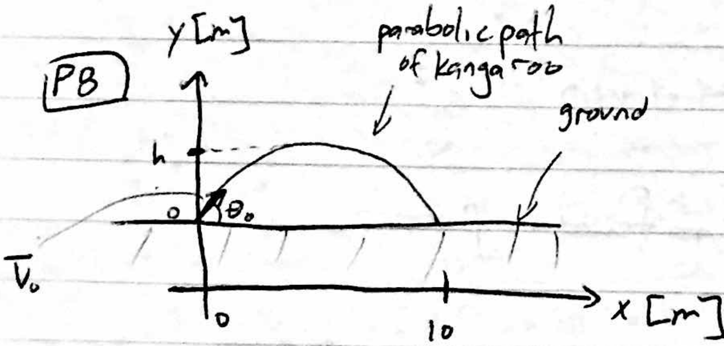
$$\sum F_x = 0 \longrightarrow F_p - T\sin\theta = 0$$
$$\sum F_y = 0 \longrightarrow T\cos\theta - W = 0$$

two eqns. two unknowns

$$T = \frac{W}{\cos(\theta)} = \frac{200}{\cos(30)} \simeq 231\ N$$

$$F_p = T\sin\theta = 231\sin(30°) \simeq 116\ N \Rightarrow \boxed{|\bar{F}_p| \simeq 116\ N}$$

P8



- Need to determine $|\bar{V}_0|$ and h. We are given X_f (i.e. the "range") and angle of the jump (i.e. $\angle \bar{V}_0 = 20° \equiv \theta_0$)

- We know a "projectile" range is $X_f = \frac{2V_0}{g}\sin\theta\cos\theta$

$$\rightsquigarrow V_0 = \frac{X_f\, g}{2\sin\theta_0\cos\theta_0} = \frac{(10)(9.8)}{2\sin(20)\cos(20)} \simeq 12.3$$

$$\Rightarrow \boxed{|\bar{V}_0| = 12.3\ \tfrac{m}{s}}$$

- We know projectile max height is given by

$$h = \frac{V_0^2\sin^2\theta}{2g} = \frac{(12.3)\sin^2(20)}{19.6} \simeq \boxed{0.90\ m = h}$$

P9 $\omega = 4000 \text{ rpm} = 4000 \frac{rev}{min} = 4000 \frac{rev}{min} \cdot \frac{1 \, min}{60 \, s} \cdot \frac{2\pi \, rads}{1 \, rev} \simeq 419 \frac{rads}{s}$

a) Here $r = 10 \text{ cm} = 0.1 \text{ m}$

$\rightsquigarrow a_r = r\omega^2 = (0.1)(419)^2 \simeq \boxed{1.75 \times 10^4 \, m/s^2 = a_r}$

b) ok, first we need to calc. the speed of somthing haven fallen (from rest) from a height of 1 m:

$$V_f^2 = V_0^2 + 2a(y_f - y_0) = 0 - 2(9.8)(0-1) \rightsquigarrow V_f \simeq -4.43 \, m/s$$

(Note: It is neg.!)

Now we assume the object undergoes a const. acceleration such that it goes from $V_0 = 4.43 \, m/s$ to $V_f = 0$ over $t = 1 \times 10^{-3} s$

$$V_f = V_i + a(\Delta t) \rightsquigarrow 0 = -4.43 + a(0.001)$$

$$\Longrightarrow \boxed{a \simeq 4.4 \times 10^3 \, m/s^2}$$

$\rightsquigarrow$ This value is only $\sim \frac{1}{4}$ of that found in part a.