Physics 200 Sample Exam 1

1.

a. You walk 345 meters at 22 degrees North of due West. How far West are you from where you started? How far North?
b. You walk 234 meters due East, then 321 meters due South. How far are you from where you started? At what angle must you walk to get back?
c. You walk 76 meters due South, then 98 meters at a 45 degree angle between North and West. Find the displacement vector from the origin to your final position.

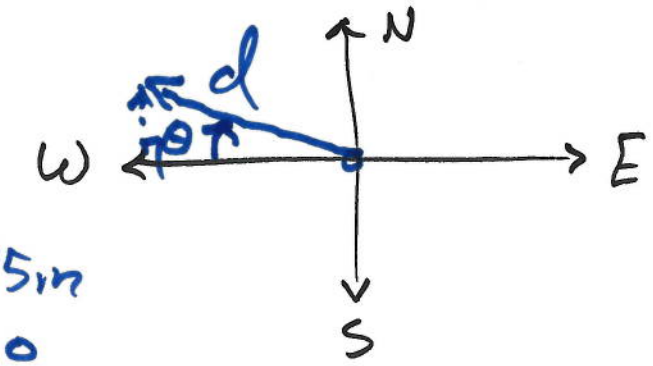
2. You slide your backpack across the floor, and its initial velocity is 4.32 m/s and it slows down at 0.76 m/s^2. Where does it stop? How long does it take to come to a stop?

3. If the ceiling in lab is 2.13 meters tall, and you launch your steel ball from 0.91 meters off the ground, directly upward, how fast can it be going and not quite reach the ceiling?

4. It is raining and a stream has formed on campus, 1.23 meters wide. If you stand on one side of the stream and jump at a 20 degree angle above the horizontal, what minimum speed do you need to cross the stream?

5. You can run at 5.55 m/s. Assume you jump, with this speed, at 20 degrees above the horizontal. How wide of a stream on campus can you jump across with your running start?

1. a.



SOH CAHTOA π P

$d = 345m$

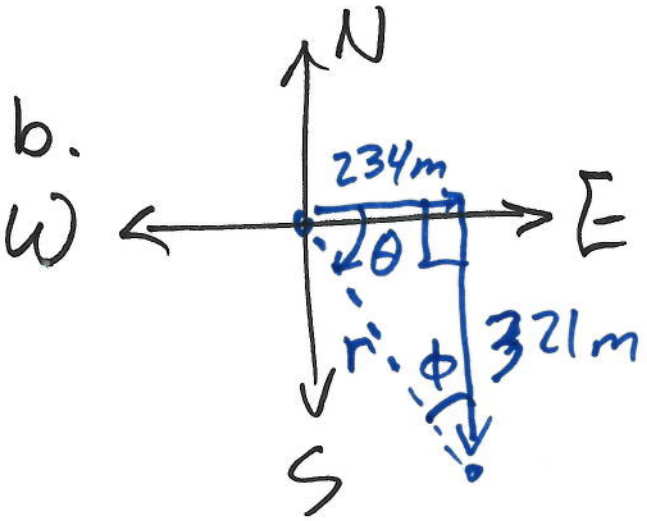
$\theta = 22°$

$\cos\theta = \frac{adj}{hyp} = \frac{west}{345m}$

west: $d \cos\theta = 320m$

North: $d \sin\theta = 129m$

b.



$r = \sqrt{234^2 + 321^2}\ m$

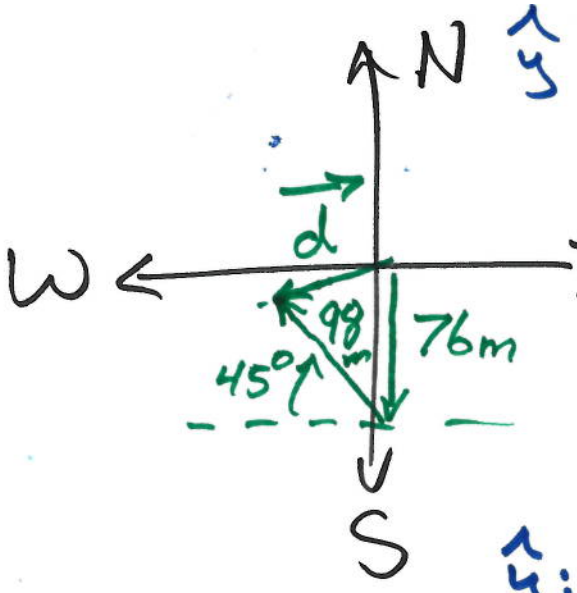
$= 397m$

$\tan\theta = \frac{opp}{adj} = \frac{321m}{234m}$ $\theta = 53.9°$

$\tan\phi = \frac{234m}{321m} \Rightarrow \phi = 36.1°$

Face North, turn 36.1° to the west. Then walk 397m and you get to origin.

1. c.



Find $\vec{d}$.

$\hat{y}$: $-76m + 98m \sin 45°$

$\hat{x}$: $0 - 98m \cos 45°$

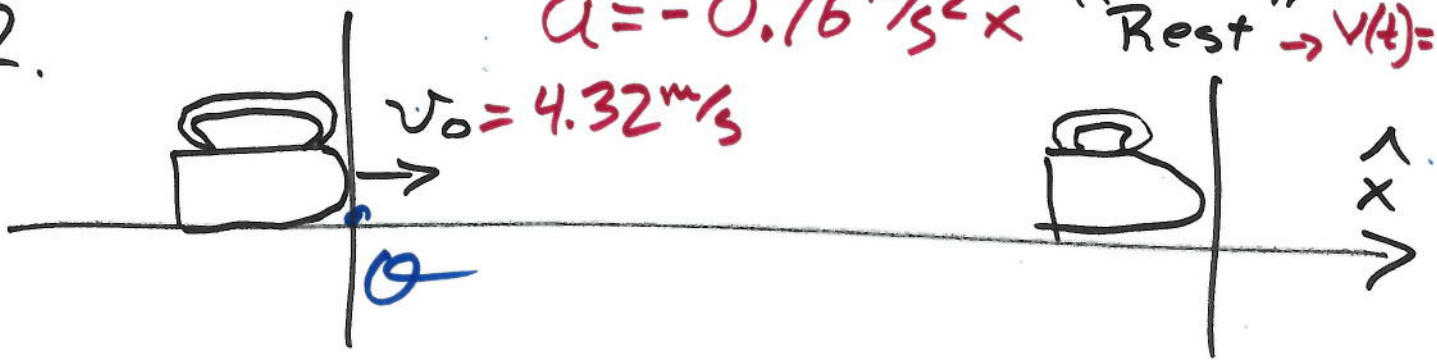
$\hat{y}$: $-6.7m$

$\hat{x}$: $-69.3m$

$\vec{d} = (-69.3, -6.7)m$

2.

$\vec{a} = -0.76\ m/s^2\ \hat{x}$ "Rest" $\rightarrow v(t)=0$



$x_0 = 0$

$t = 0$

$x(t) = \bigstar$

$t = \bigstar$

(I) $v(t) = v_0 + at$ $\bigstar$

$0 = 4.32\frac{m}{s} - 0.76\frac{m}{s^2}t$

$\frac{-4.32\ m/s}{-0.76\ m/s^2} = \boxed{t = 5.68\ s}$

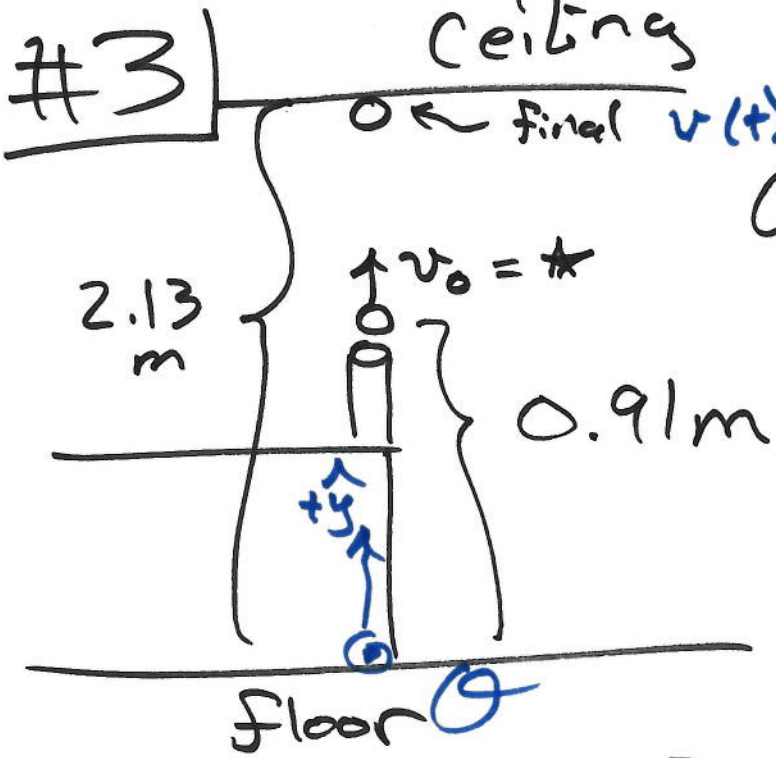
(II) $x(t) = \cancel{x_0}^{0} + v_0 t + \frac{1}{2} a t^2$

$x(t) = 0 + 4.32\frac{m}{s}(5.68s) + \frac{1}{2}\left(-.76\frac{m}{s^2}\right)(5.68s)^2$

$x(t) = 24.5m - 12.26m$

$\boxed{x(t) = 12.24m}$

#3



$a = -g = -9.8\frac{m}{s^2}$

$y_0 = 0.91m$

$y(t) = 2.13m$

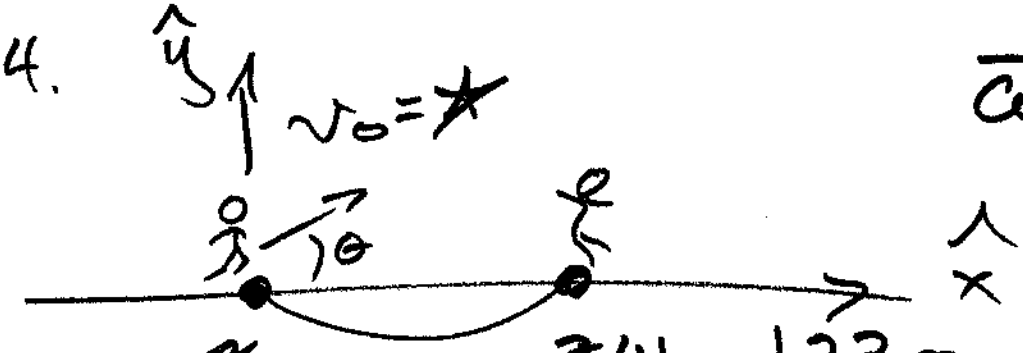
(III) $v^2(t) = v_0^2 + 2a(y(t) - y_0)$

$0 = v_0^2 - 2g(2.13m - 0.91m)$

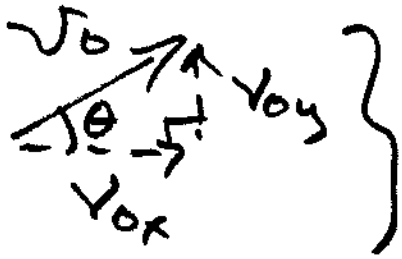
$0 = v_0^2 - 23.9\frac{m^2}{s^2}$

$\sqrt{23.9\frac{m}{s}} = \boxed{v_0 = 4.89\frac{m}{s}}$

4.



$\vec{a} = (0, -g)$, with a_x and a_y



$$v_{0x} = v_0 \cos 20°$$
$$v_{0y} = v_0 \sin 20°$$

(II) $x(t) = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$ ($a_x = 0$: NOT GRAVITY, DAMNIT)

$$1.23\,m = 0\,m + v_0 \cos 20° \, t$$

(III) $v_x^2(t) = v_{0x}^2 + 2a_x(x(t) - x_0)$ ($a_x = 0$)

$\Rightarrow v_x(t) = v_{0x}$ ... yay?

(II)$_y$ $y(t) = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$ ($a_y = -g$)

$$0 = 0 + v_0 \sin\theta \, t - \frac{1}{2}gt^2$$

$$0 = \left(v_0 \sin\theta - \frac{1}{2}gt\right) t$$

$\left(v_0 \sin\theta - \frac{1}{2}gt\right) = 0$ or: $t = 0$

$1.23m = v_0 \cos 20° \, t$

$v_0 \sin\theta = \frac{1}{2} g t$

$v_0 = \frac{gt}{2\sin\theta}$ ×

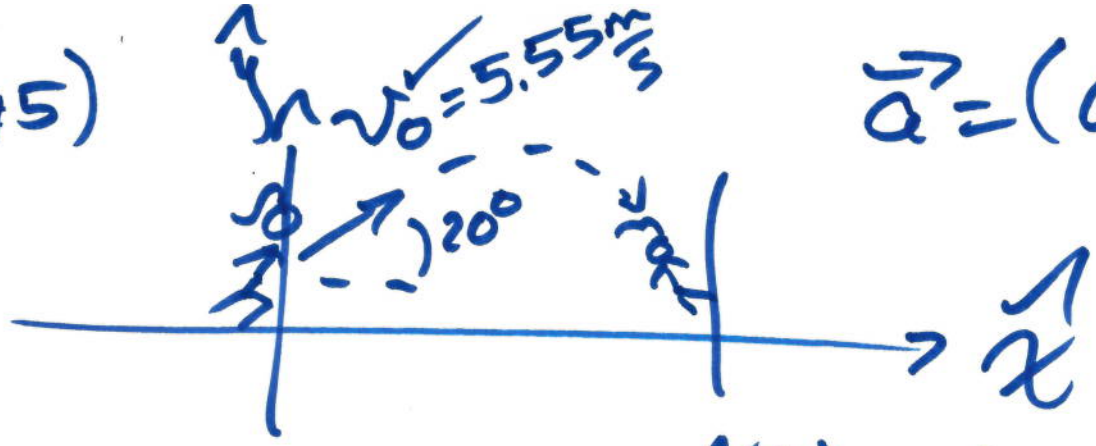
$t = \frac{2 v_0 \sin\theta}{g}$

t

$1.23m = v_0 \cos 20° \left[\frac{2 v_0 \sin 20°}{9.8 \frac{m}{s^2}} \right]$

$\sqrt{\frac{1.23m \times 9.8 \frac{m}{s^2}}{2 \sin 20° \cos 20°}} = \sqrt{v_0^2} = 4.33 \frac{m}{s}$

#5)



$\vec{a} = (0, -g)$

$x_0 = 0$

$y_0 = 0$

$x(t) = *$

$y(t) = 0$

$v_{0y} = 5.55\frac{m}{s} \sin 20° = 1.9\frac{m}{s}$

$v_{0x} = 5.55\frac{m}{s} \cos 20° = 5.21\frac{m}{s}$

$(II)_x \quad x(t) = x_0 + v_{0x} t$

$x(t)$: $*$; x_0: 0 ; v_{0x}: $5.21\frac{m}{s}$; t: ?

$(II)_y \quad y(t) = y_0 + v_{0y} t - \frac{1}{2} g t^2$

$0 = 0 + 1.9\frac{m}{s} t - 4.9\frac{m}{s^2} t^2$

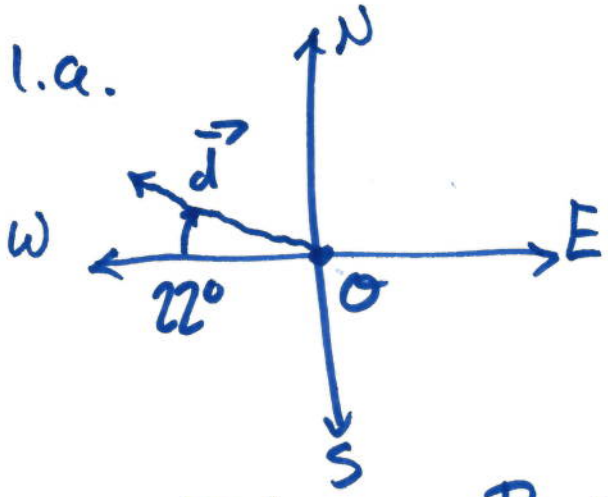
$0 = 1.9\frac{m}{s} - 4.9\frac{m}{s^2} t$

$t = \frac{1.9\,m/s}{4.9\,m/s^2} = 0.39\,s$

$x(t) = 0 + 5.21\frac{m}{s}(0.39\,s)$

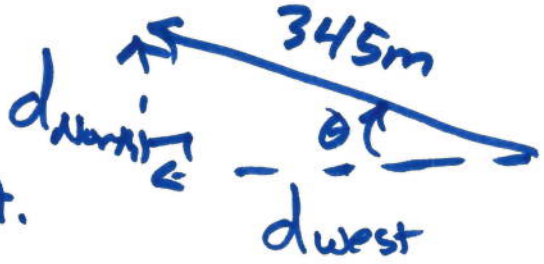
$= 2.03\,m \pm 0.01\,m$

1.a.



$d = 345m$.

how far west?
North?

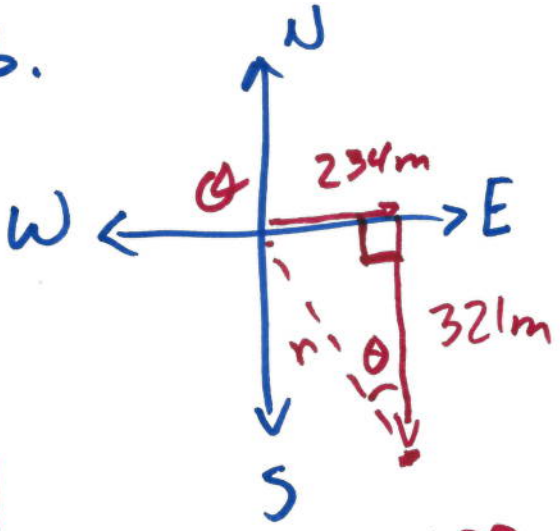


Polar → Rect.

$d_{North} = 345m \cdot \underline{\sin} \; 22° = 129m$

$d_{west} = 345m \cdot \underline{\cos} \; 22° = 320m$

1.b.



find r, direction to walk back

$r^2 = (234m)^2 + (321m)^2$

$\boxed{r = 397m}$

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CAH
TOA

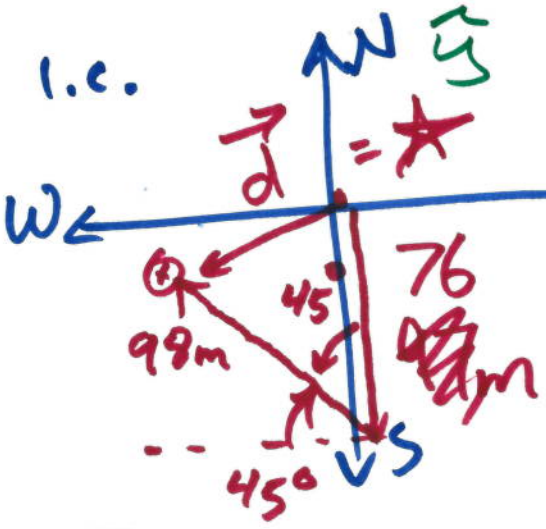
$\tan\theta = \frac{opp}{adj} = \frac{234m}{321m}$ $\quad \theta = Tan^{-1}\left(\frac{234}{321}\right)$

$\boxed{= 36.1°}$

$\theta = Tan^{-1}(\tan\theta) = Tan^{-1}\left(\frac{234}{321}\right)$

Face North. Turn 36.1° toward West.
Walk 397m. You will be at O.

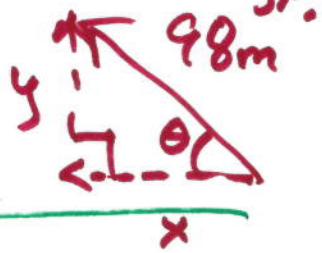
1.c.



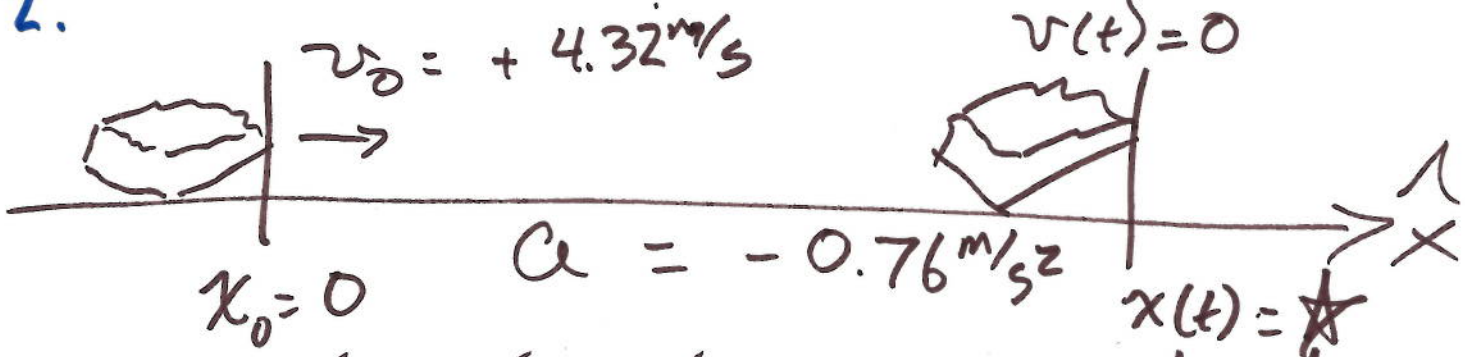
find $\vec{d}$.

$\vec{d} = -76\text{m}\,\hat{y} + -98\text{m}\cos 45^\circ\,\hat{x} + 98\text{m}\sin 45^\circ\,\hat{y}$

$\vec{d} = -69.3\text{m}\,\hat{x} - 6.7\text{m}\,\hat{y}$



2.



(I)$_x$ $v(t) = v_0 + at$ ★

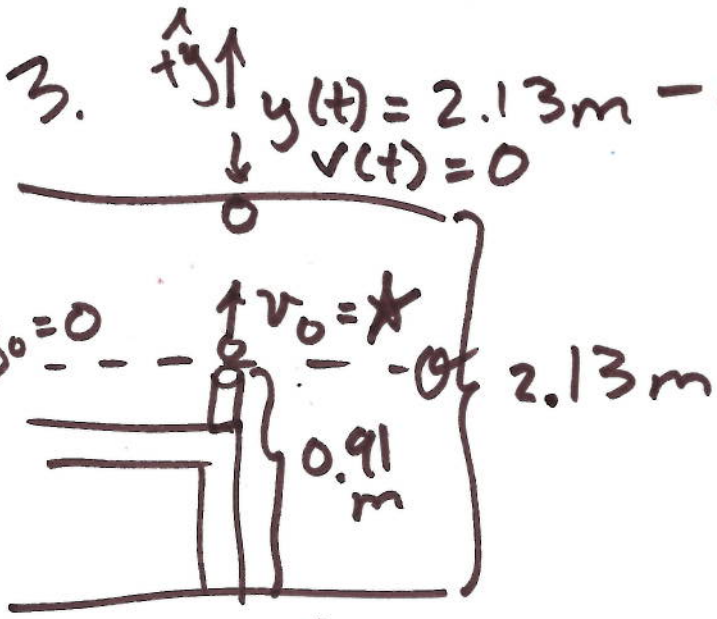
$0 = 4.32\text{m/s} - 0.76\text{m/s}^2\, t$

$\frac{-4.32\text{m/s}}{-0.76\text{m/s}^2} = t = 5.68\text{ s}$

(III)$_x$ $v^2(t) = v_{0x}^2 + 2a_x(x(t) - x_0)$ ★

$0 = (4.32\text{m/s})^2 + 2(-0.76\text{m/s}^2)\,x(t)$

$\frac{-(4.32\text{m/s})^2}{2(-0.76\text{m/s}^2)} = x(t) = 12.3\text{m}$

3. 

$a = -g = -9.8\,m/s^2$ ↑ down.

want v_0

know: $v(t)$ y_0 $y(t)$ a

(II) $v^2(t) = v_0^2 + 2a(y(t) - y_0)$

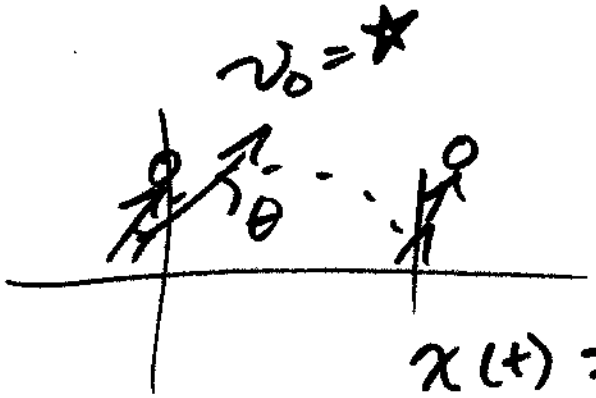
$0 = v_0^2 - 2(9.8\,m/s^2)(1.22m - 0)$

$\pm\sqrt{23.9\,\frac{m^2}{s^2}} = \sqrt{v_0^2}$

$+ 4.89\,\frac{m}{s} = v_0$

Choose ⊕.

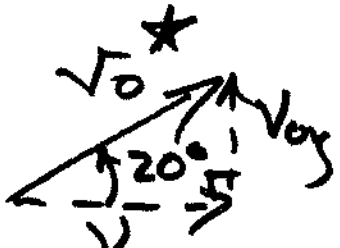
#4)



$\theta = 20°$

$a_x = 0$

$a_y = -g$



$\cos 20° = \frac{adj}{hyp} = \frac{v_{ox}}{v_0}$

$x(t) = 1.23\,m$

$y(t) = 0$

(II)$_x$ $x(t) = \cancel{x_0}^{0} + \underbrace{v_{ox}}_{v_0\cos 20°} t + \frac{1}{2}\cancel{a_x}^{0} t^2$

$$x(t) = v_0 \cos\theta\, t$$

(II)$_y$ $y(t) = y_0 + v_{oy} t + \frac{1}{2} a_y t^2$

$0 = 0 + v_0 \sin 20° t - \frac{1}{2} g t^2$

$0 = t\left(v_0 \sin 20° - \frac{1}{2} g t\right)$

$= 0$

$$v_0 \sin 20° = \frac{1}{2} g t$$

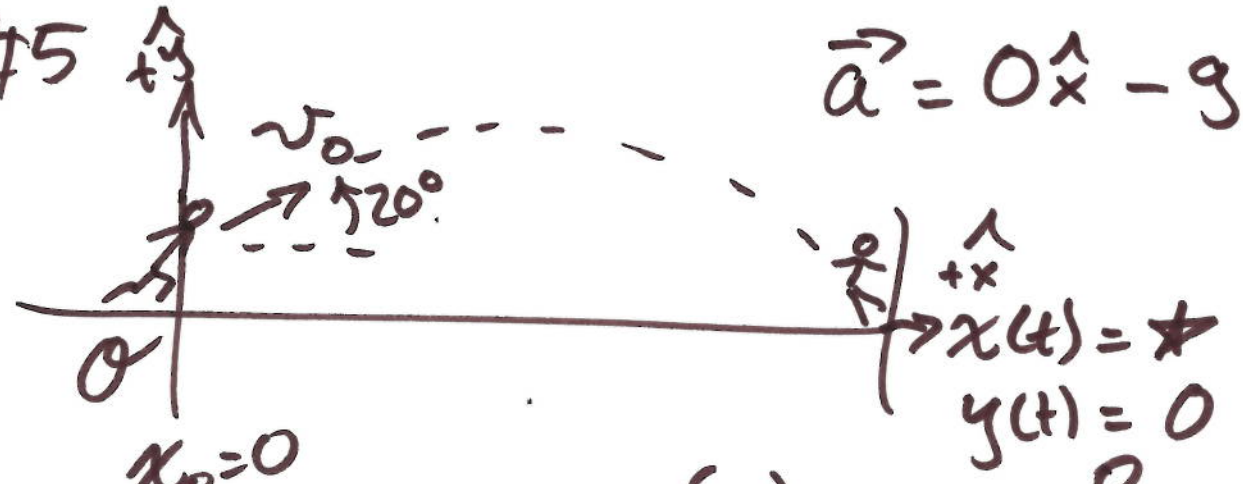
$$\frac{2 v_0 \sin 20°}{g} = t \overset{\text{set}}{=} \frac{x(t)}{v_0 \cos\theta} = t$$

$$v_0^2 = \frac{g \cdot x(t)}{2 \sin 20° \cos 20°} = \frac{9.8\,\frac{m}{s^2}\,(1.23\,m)}{2 \sin 20° \cos 20°}$$

$$\sqrt{v_0^2} = \sqrt{18.75 \frac{m^2}{s^2}}$$

$$v_0 = \pm 4.33 \text{ m/s} \quad \text{choose } \oplus.$$

#5



$v_0 = 5.55\,m/s$

$v_{oy} = v_0 \sin\theta$

θ

$v_{ox} = v_0 \cos\theta$

(II)$_x$ $x(t) = x_0 + v_{ox}t + \frac{1}{2}a_x t^2$ ($x_0 = 0$, $a_x = 0$)

$x(t) = \star = v_{ox}t$

(II)$_y$ $y(t) = y_0 + v_{oy}t + \frac{1}{2}a_y t^2$

$0 = 0 + v_0 \sin\theta\, t - \frac{1}{2}gt^2$

$0 = t\left(v_0 \sin\theta - \frac{1}{2}gt\right)$

$t = 0$: toss

$v_0 \sin\theta - \frac{1}{2}gt = 0$

$v_0 \sin\theta = \frac{1}{2}gt$

$\frac{2v_0 \sin\theta}{g} = t$

$x(t) = v_0 \cos\theta \frac{2v_0 \sin\theta}{g}$

$x(t) = 2\left(5.55\,m/s\right)^2 \cdot \cos 20° \cdot \sin 20° / 9.8\,m/s^2 = 2.02\,m$