Practice Exam - A bit too easy!

(1) The max human accel ~ 10g:

$$v_{max} \simeq 10g \cdot 1s \sim 100\,m/s$$

So

$$\Delta x \sim \frac{1}{2}at^2 \sim \frac{1}{2} 10g\, 1s^2 \sim 50m$$

We start and stop so the approximate minimum distance is

$$\Delta x \sim 100m$$

(2) The velocity is

(2.1) $$V_f - V_i = \int_0^{5s} a(t)\,dt = (1m/s^2)(3s) + (-1m/s^2)(2s)$$

$$V_f = 1m/s + V_i$$

$$V_f = 1m/s - 1.5m/s = \boxed{-0.5m/s = V_f}$$

2.2) To find how far it travelled we break it up

Since acceleration is constant in the first period

$x = \cancel{x_0}^{0} + v_0 t + \frac{1}{2} a t^2$ $\quad v = v_0 + at$

$x = (-1.5 m/s)(3s) + \frac{1}{2}(1 m/s^2)(3s)^2$ $\quad v = -1.5 m/s + (1 m/s^2) 3s$

$x = 0$ $\quad v = 1.5 m/s$

amusing accident

For the second period

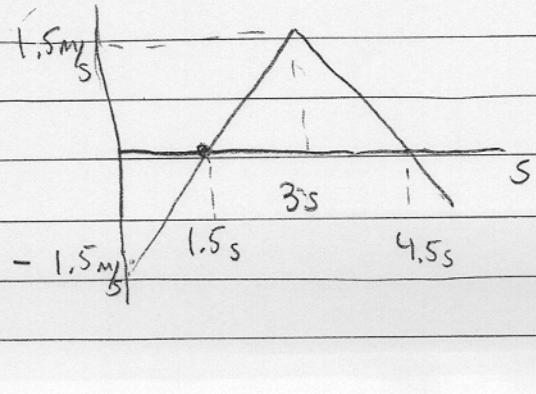
$x = \cancel{x_0}^{0} + v_0 t + \frac{1}{2} a t^2$ $\quad v = v_0 + at$

$x = 0 + (1.5 m/s)(2s) + \frac{1}{2}(-1 m/s^2)(2s^2)$ $\quad v = 1.5 m/s + (-1 m/s)(2$

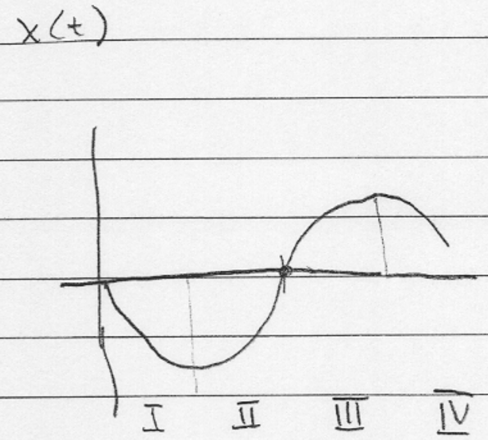
$\boxed{x = 1m}$ $\quad v = -0.5 m/s$

So the final position is 1m to right

2.3 v(t)



Then



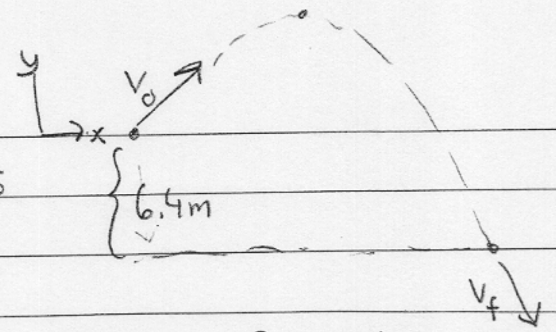
Looking x vs. time we have IV periods of time

I: moving Left and slowing down

II: moving right and speeding up

III: moving right and slowing down

IV: moving left and speeding up



First resolve $\vec{v}_0$ into components

$V = 8.1 m/s$

$$\vec{v}_0 = V\cos 43^\circ \hat{i} + V\sin 43^\circ \hat{j}$$

$$\vec{v}_0 = 8.92 \, m/s \, \hat{i} + 5.52 \, m/s \, \hat{j}$$

Then to find the maximum, we set $V_{oy} = 0$

$$V_y = V_{oy} - gt = 0$$

B. $$t_{max} = \frac{V_{oy}}{g} = \frac{5.92 m/s}{9.8 m/s^2} = 0.604s$$ ⇐ Part B

A. To find how high it goes we use

$$y(t) = \cancel{y_0}^{0} + v_{oy} t - \frac{1}{2} g t^2$$

And substitute the time t_{max} into this equation

$$y(t) = (5.52 m/s)(0.604s) - \frac{1}{2}(9.8 m/s^2)(0.604s)^2$$

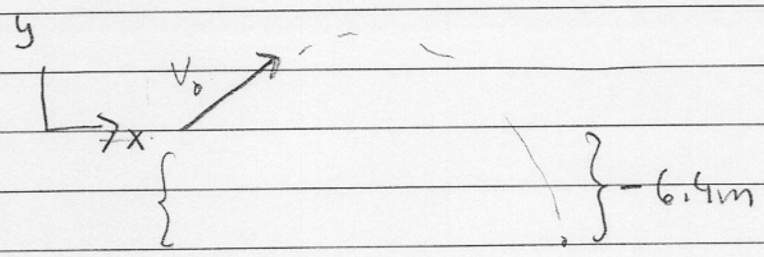
$$y = 1.55m$$

C.

C. To find when you hit the ground use

$$y(t) = y_0 + v_{0y} t_* - \frac{1}{2} g t_*^2 = -6.4m$$

The gound



$$-6.4m = 0 + 5.52m/s\ t_* - \frac{1}{2}(9.8m/s^2)\, t_*^2$$

So $t_* = -0.71s$ and $\underline{t_* = 1.83s}$ ← physical solution

D. To find the velocity

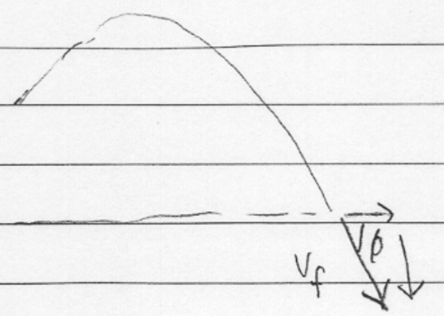
$$\vec{V} = \vec{V}_0 + \vec{a}t$$

$$\vec{V} = \begin{pmatrix} 5.92m/s \\ 5.52m/s \end{pmatrix} + \begin{pmatrix} 0 \\ -9.8m/s^2 \end{pmatrix} 1.837s$$

$$\vec{V}_f = \begin{pmatrix} 5.92m/s \\ -12.08m/s \end{pmatrix} \qquad V = \sqrt{V_x^2 + V_y^2} = 13.45m/s$$

See

E. The angle



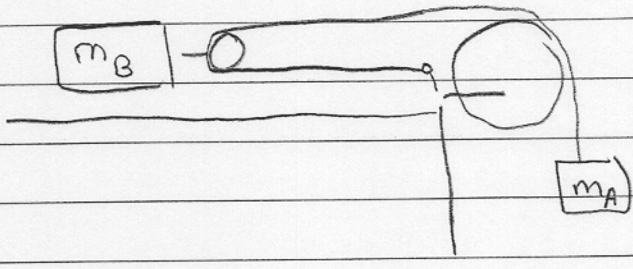
$\phi = \tan^{-1}\frac{V_y}{V_x} = \tan^{-1}\left(\frac{-12.08\,m/s}{5.92\,m/s}\right) = -63.9^{\circ}$

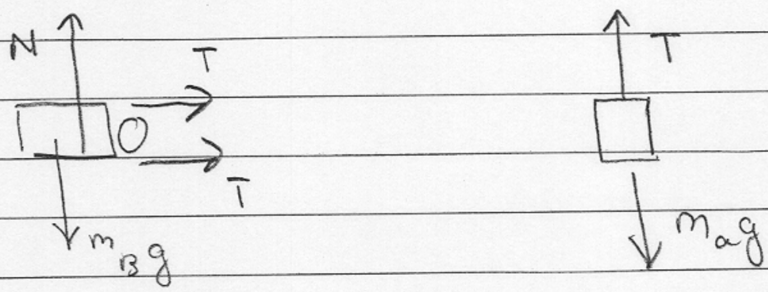
F. Range : Since the x velocity is const

$\Delta x = V_{ox}\, t$

$\Delta x = (5.92\,m/s)(1.837\,s) = 10.875\,m$

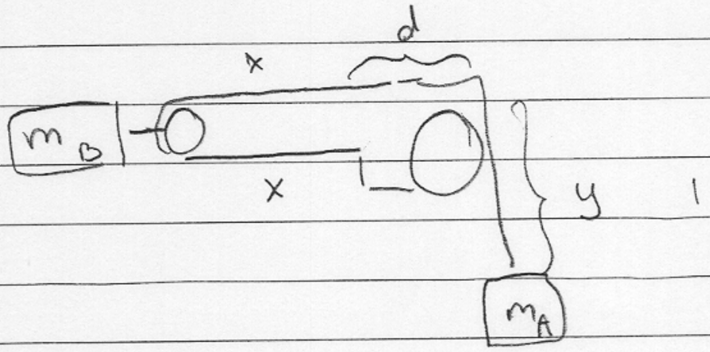
Problem:





① $2T = m_B a_B$ $\qquad$ $T - m_a g = m_a a_a$

② To determine the acceleration of B relative to a we no



$$2x + \overset{\text{const}}{d} + y = \overset{\text{const}}{L}$$

Length of rope

$$2\ddot{x} + \ddot{y} = 0$$

second deriv. w.r.t. time

$$2a_B + a_A = 0$$

$$a_A = -2a_B$$

$$2T = m_B a_B \qquad T - m_a g = -2m_a a_B$$

$$2(m_a g - 2m_a a_B) = m_B a_B \qquad T = m_a g - 2m_a a_B$$

$$2m_a g = (4m_a + m_B) a_B$$

$$\frac{2m_a g}{4m_a + m_B} = a_B \quad \checkmark \qquad a_B = 2.54 m/s^2$$

The tension

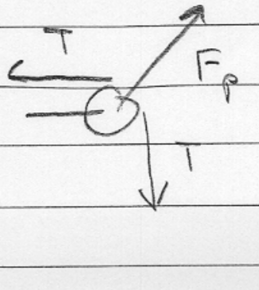
$$T = m_a g - 2m_A a_B$$

$$T = m_a g - \frac{4m_a^2 g}{4m_a + m_B}$$

$$T = \frac{m_B m_a g}{4m_a + m_B} = 25.4N$$

The Wheel

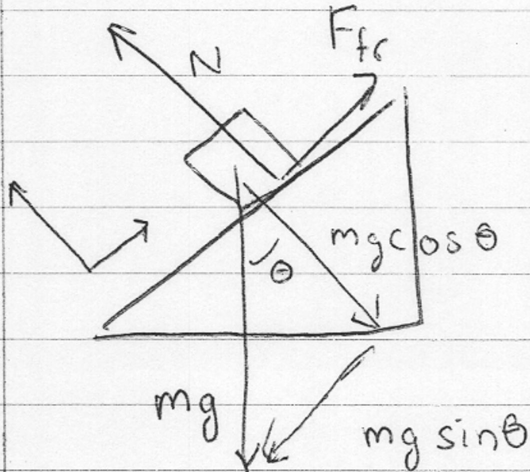
Wheel is stationary



$$\vec{F}_p - T\hat{j} - T\hat{i} = m\cancel{\vec{a}}^{\,0}$$

$$\vec{F}_p = T\hat{i} + T\hat{j}$$

$$|\vec{F}_p| = \sqrt{T^2 + T^2} = \sqrt{2}T = 36N$$



To find the acceleration

$$N - mg\cos\theta = m\cancel{a_y}^{\,0} \qquad +\mu_k N - mg\sin\theta = ma_x$$

not jumping off plane

$$\mu_k \cancel{m}g\cos\theta - \cancel{m}g\sin\theta = \cancel{m}a$$

$$g(\mu_k\cos\theta - \sin\theta) = a$$

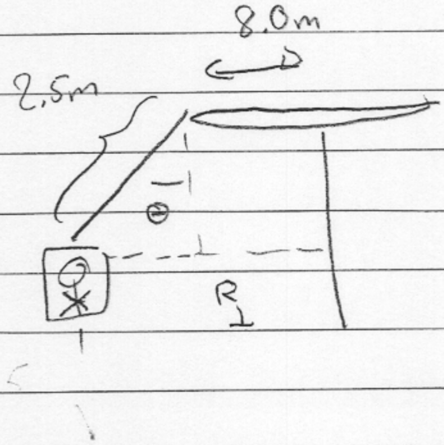
The distance travelled is

$$\cancel{v_f^2}^{\,0} = v_0^2 + 2a\Delta x$$

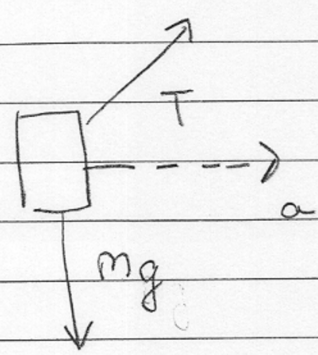
means down the slope

$$\frac{-v_0^2}{2a} = \Delta x \Rightarrow \Delta x = \frac{v_0^2}{2g(\sin\theta - \mu_k\cos\theta)} = -\frac{v_0^2}{2g(\mu_k\cos\theta - \sin\theta)}$$

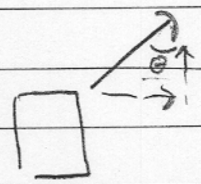
assume $\mu_k \cos > \sin$



The FBD



So Newtons Laws



$$-T\sin\theta = m\,a_x \qquad T\cos\theta - mg = m\cancel{a_y}^{\,0}$$

$$-\frac{\cancel{m}g}{\cos\theta}\sin\theta = -\cancel{m}\,\frac{v^2}{R_\perp} \qquad T = mg/\cos\theta$$

$$+gR\tan\theta = v^2$$

$$\sqrt{gR_\perp\tan\theta} = v \qquad R_\perp = 8.0\text{m} + 2.5\text{m}\sin 28^\circ$$

$$\sqrt{(9.8\text{m/s})(9.74\text{m})(\tan 28^\circ)} = v \qquad R_\perp = 9.74\text{m}$$

$$\boxed{v = 7.12\text{m/s}}$$ ✓