Practice Exam 2b

1) a) $\vec{C} = \vec{A} + \vec{B} = (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j} + (A_z + B_z)\hat{k}$

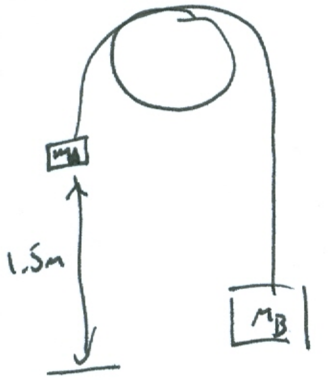
$= 2m\hat{i} - 1.5m\hat{j} - 2.2m\hat{k}$

b) $\|\vec{C}\| = \sqrt{C_x^2 + C_y^2 + C_z^2}$

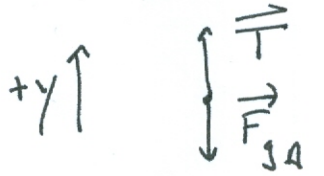
$= \sqrt{4m^2 + 2.25m^2 + 4.84m^2} = 3.3m$

$\|\vec{A}\| = \sqrt{4m^2 + 6.25m^2 + 3.24m^2} = 3.7m$

2)

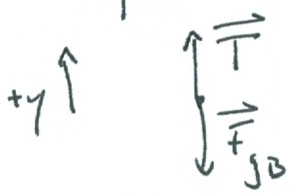


object = m_A



$a_{yA} = \frac{T - m_A g}{m_A}$

object m_B



$a_{yB} = \frac{T - m_B g}{m_B}$

$a_{yA} = -a_{yB} = a$

from object m_A: $m_A a = T - m_A g$

$T = m_A a + m_A g$

from object m_B:

$-a = \frac{T - m_B g}{m_B}$

$= \frac{m_A a + m_A g - m_B g}{m_B}$

$-m_B a = m_A a + (m_A - m_B) g$

$$-m_B a - m_A a = (m_A - m_B) g$$

$$-(m_A + m_B) a = (m_A - m_B) g$$

$$a = \frac{-(m_A - m_B)}{m_A + m_B} g = \left(\frac{m_B - m_A}{m_A + m_B} \right) g$$

$$= \frac{2kg - 5kg}{2kg + 5kg} 9.8 m/s^2$$

$$a = \frac{-3}{7} 9.8 m/s$$

$$\vec{a} = -4.2 m/s^2 \hat{j}$$

b) for constant acceleration

$V_y = v_{0y} + a_y t$ and $\Delta y = v_{0y} t + 1/2 a_y t^2$

since $V_{0y} = 0$

$V_y = a_y t$ and $\Delta y = 1/2 a_y t^2$

or

$t = \frac{v_y}{a_y}$

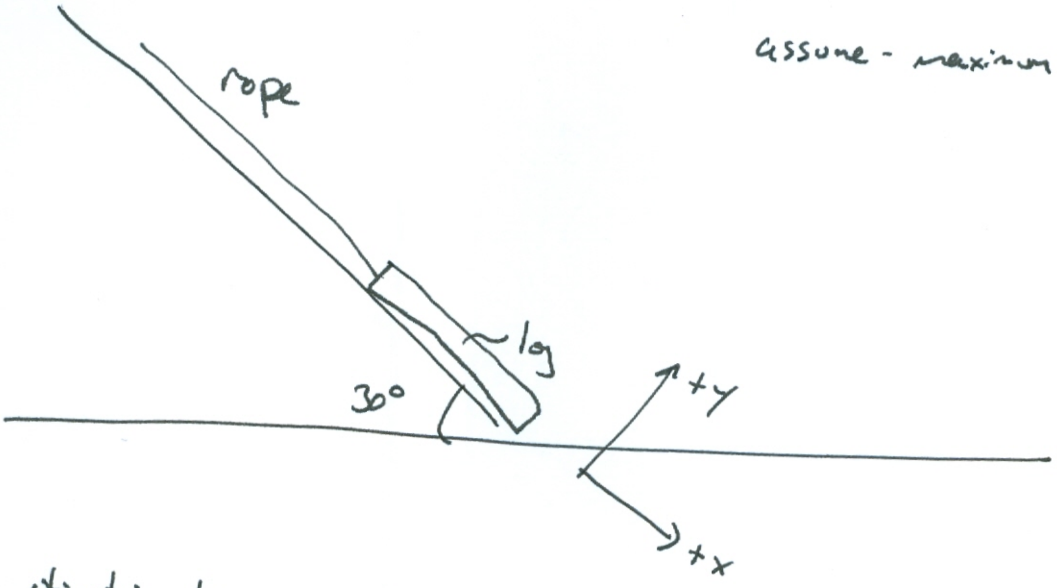
$$\Delta y = 1/2 a_y \left(\frac{V_y}{a_y} \right)^2$$

$$= 1/2 \frac{V_y^2}{a_y}$$

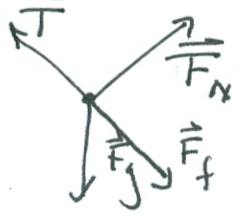
$$V_y^2 = 2 a_y \Delta y$$

$$V_y = \sqrt{2 a_y \Delta y} = 3.5 m/s$$

assume - maximum log mass



object: log



$$a_x = \frac{\sum F_x}{m}$$

$$a_x = \frac{F_{f_x} + T_x + \cancelto{0}{F_{N_x}} + F_{g_x}}{m}$$

$$a_x = \frac{\|\vec{F}_f\| - T + mg\sin 30°}{m}$$

since $\|\vec{F}_f\| = \mu_k \|\vec{F}_N\|$

$$m a_x = \mu_k \|\vec{F}_N\| - T + mg\sin 30°$$

$$a_y = \frac{\sum F_y}{m}$$

$$\cancelto{0}{a_y} = \frac{\cancelto{0}{F_{f_y}} + \cancelto{0}{T_y} + F_{N_y} + F_{g_y}}{m}$$

$$0 = \|\vec{F}_N\| - mg\cos 30°$$

$$\|\vec{F}_N\| = mg\cos 30°$$

from y-eq.

$$T = \mu_k mg\cos 30° - m a_x + mg\sin 30°$$

$$= m\left(\mu_k g\cos 30° + g\sin 30° - a_x\right)$$

$m = 200\ \text{kg}$

$g = 98\ \text{m/s}^2$

$\mu_k = 0.9$

$a_x = -0.8\ \text{m/s}^2$

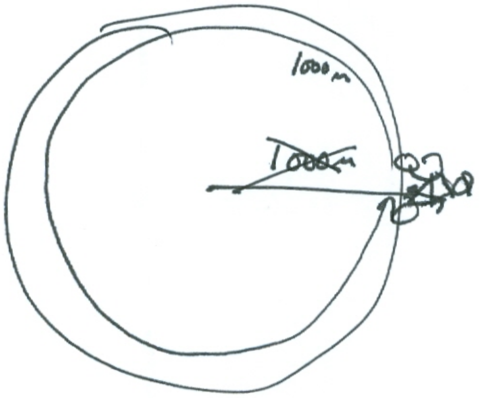
so

$T = 200\,\text{kg}\,(0.9 \cdot 9.8$

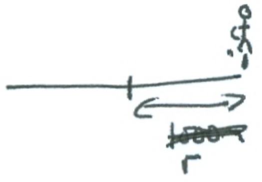
T: 2667 N

The rope should accomodate a force of 2667 N.

4)



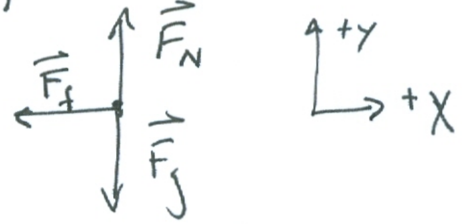
or



$2\pi r = 1000\,m$

$r = \frac{1000\,m}{2\pi} = \frac{500\,m}{\pi}$

object - rider + bike



$a_x = \frac{\sum F_x}{m}$

$a_y = \frac{\sum F_y}{m}$

$a_y = 0$

$0 = \frac{\sum F_y}{m} = F_N - mg$

$F_N = mg$

$a_x =$ centripital accel

$= \frac{-v^2}{r}$

$\frac{-v^2}{r} = \frac{F_f}{m} \leq \frac{-\mu_s \|\vec{F}_N\|}{m}$

This relationship will hold if the wheel doesn't slip

$\frac{mv^2}{r} \leq \mu_s \|\vec{F}_N\|$

$\frac{\cancel{m}v^2}{r} \leq \mu_s \cancel{m}g$

$\frac{v^2}{r} \leq \mu_s g$

$\frac{25\,m/s^2}{\frac{500\,m}{\pi}} \leq 0.29 \times 9.8\,m/s$

so

$3.9 \leq 2.8$

NO

she will slip

She needs a bigger track to go 25 m/s

the very smallest track would be

$$\frac{(25\,m/s)^2}{r} = 0.29 \times 9.8\,m/s^2$$

or

$$r = \frac{(25\,m/s)^2}{0.29 \times 9.8\,m/s^2} = 220\,m$$

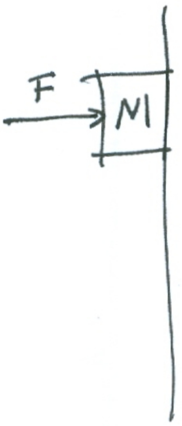
the circumference of such a track is

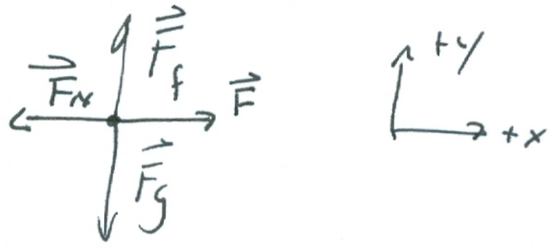
$$C = 2\pi r = 1382\,m$$

5

object: block

Free Body Diagram





$$a_x = 0 = \frac{\sum F_x}{m} = \frac{F - F_N}{m}$$

$$F_N = F$$

$$a_y = \frac{\sum F_y}{m} = \frac{F_f - mg}{m} = \frac{\mu_k F_N - mg}{m}$$

~~$= \frac{\mu_k mg + mg}{m} = g(\mu_k - 1)$~~

~~since $\mu_k < 1$ typically it is better to write~~

~~$\vec{a} = -g(1-\mu_k)\hat{j}$~~

$$a_y = \frac{\mu_k F - mg}{m}$$

$$\vec{a} = \frac{\mu_k F - mg}{m}\hat{j}$$