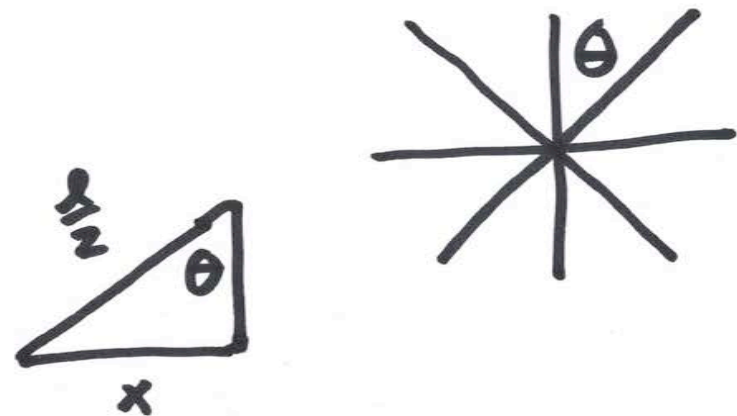
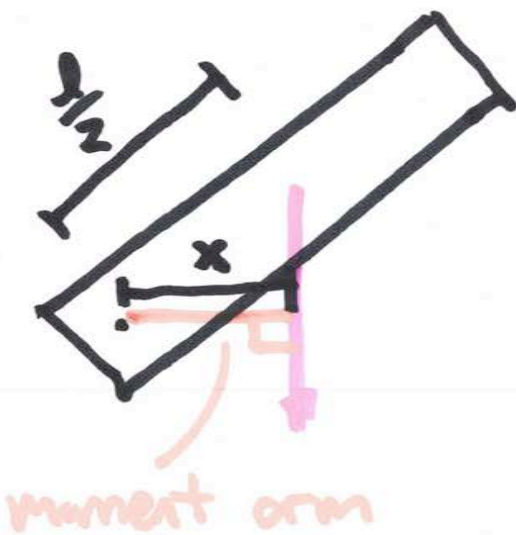
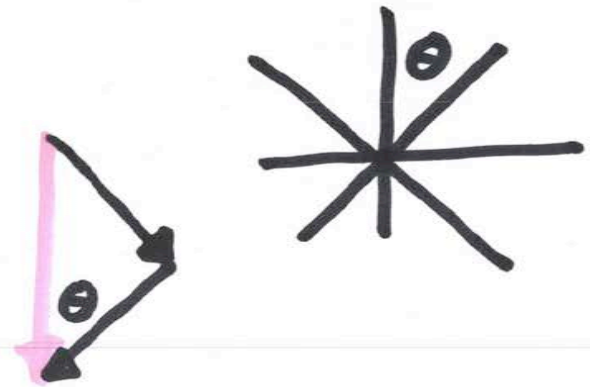
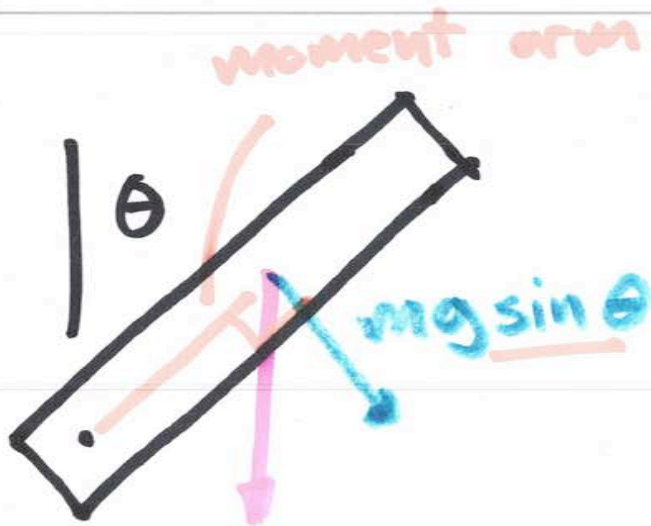
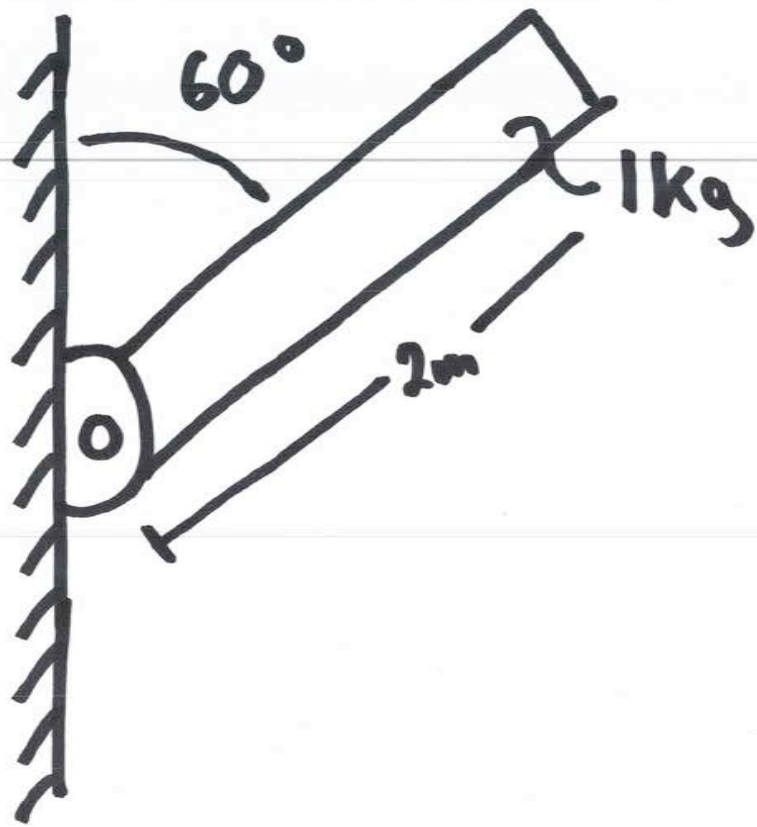


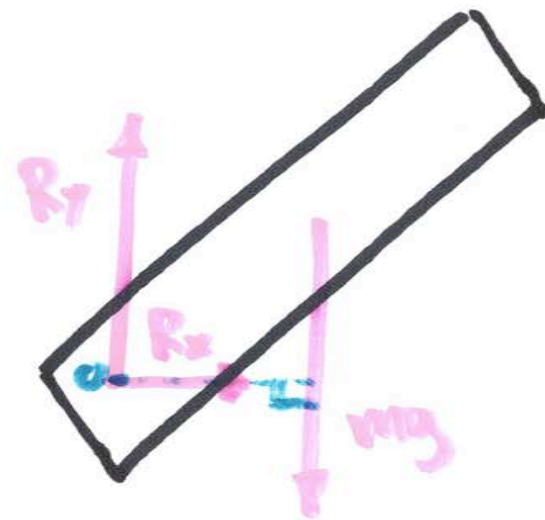
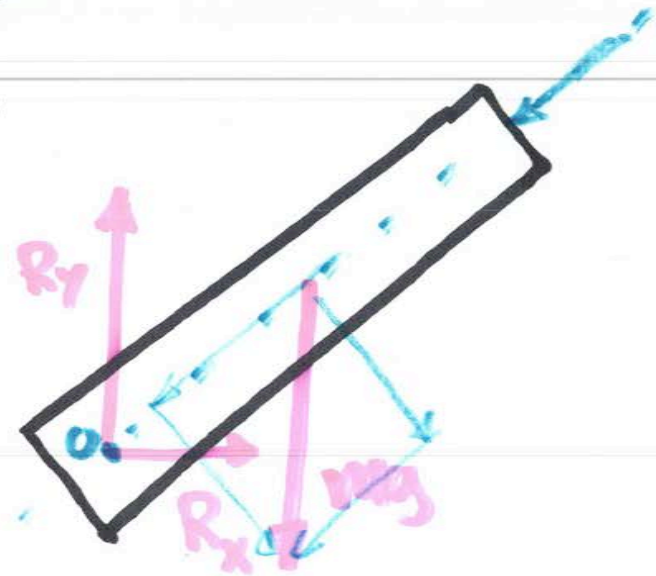
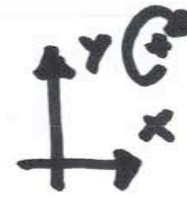
h Force to moment arm.



$$x = \frac{l}{2} \sin \theta$$



FBD:



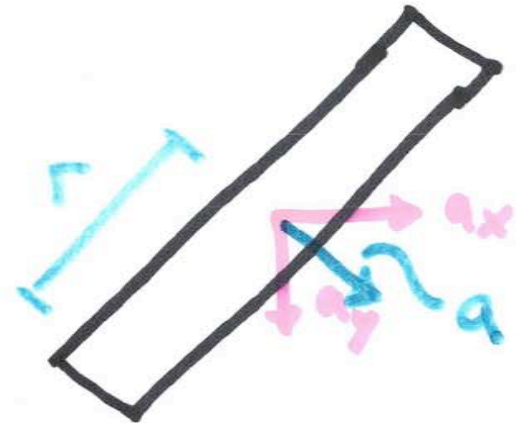
$$\Sigma F_x = ma_x = R_x$$

$$\Sigma F_y = ma_y = R_y - mg$$

$$\Sigma M_o = I_o \alpha_o = \frac{L}{2} mg \sin \theta$$

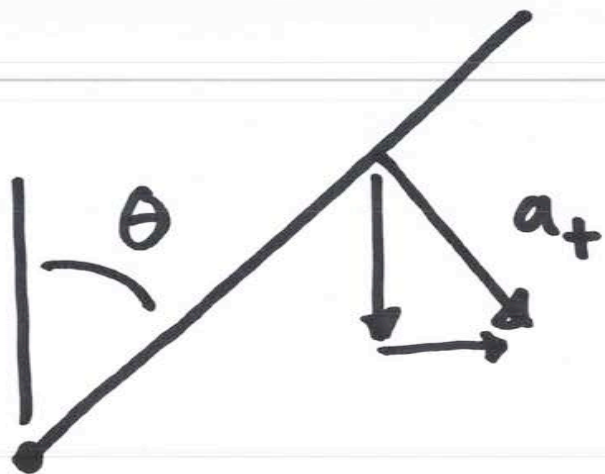
α to a_x and a_y .

→ study of kinematics.

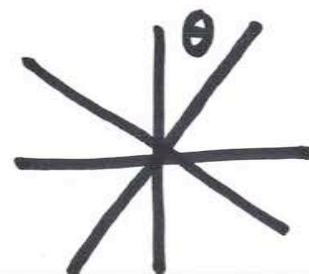
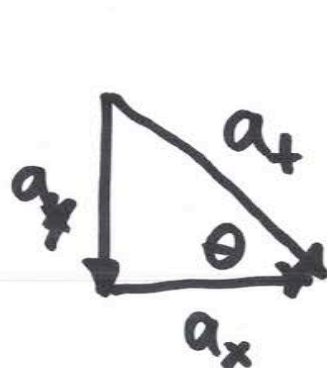


$$a = \alpha_o r$$

$$\sqrt{a_x^2 + a_y^2} = \alpha_o r$$



$$a_t = \alpha r$$



$$\begin{aligned} a_x &= a_t \cos \theta \\ &= \alpha r \cos \theta \end{aligned}$$

$$\begin{aligned} a_y &= a_t \sin \theta \\ &= \alpha r \sin \theta. \end{aligned}$$

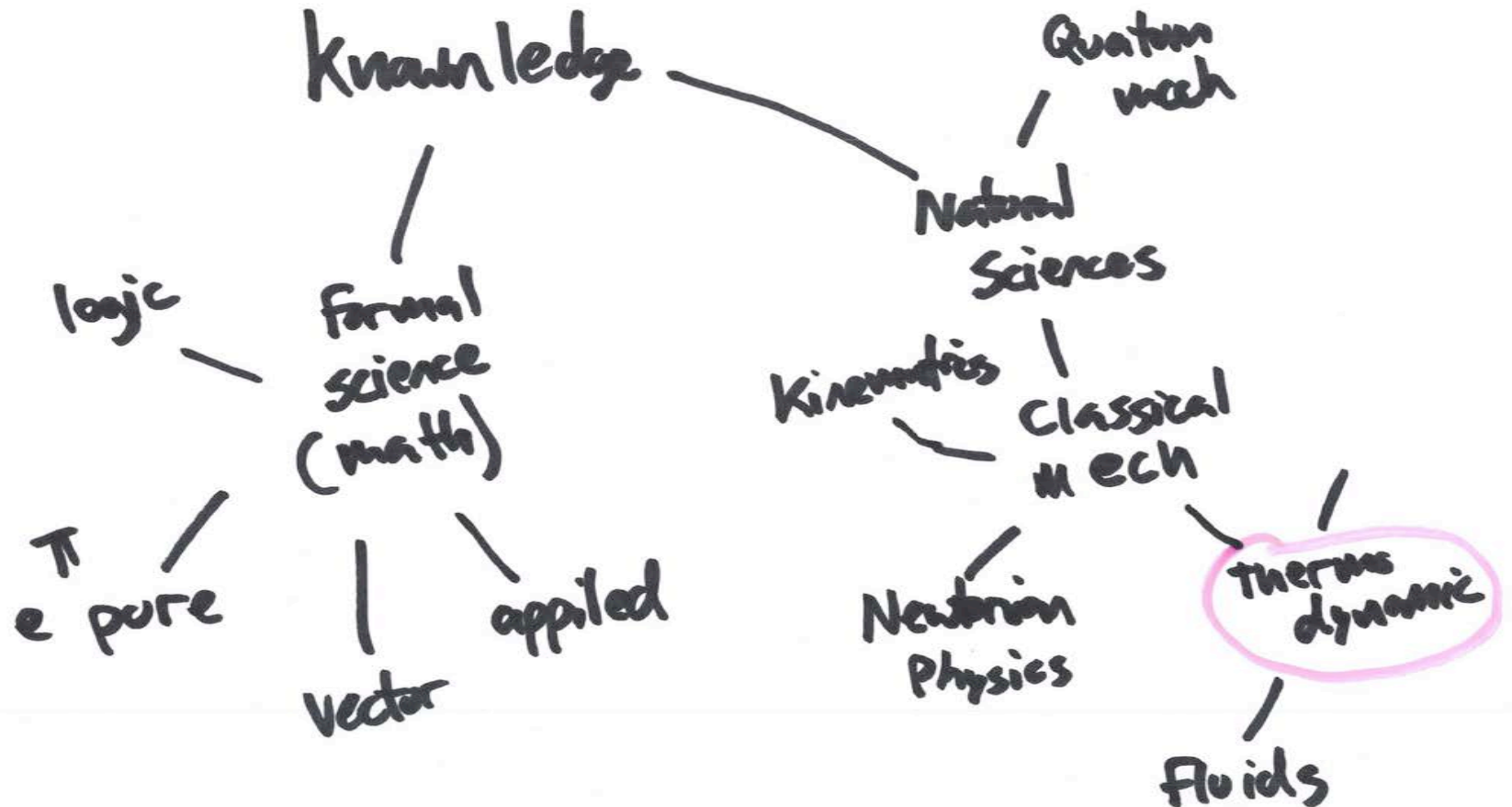
$$(1) \quad m \left[\alpha_0 \frac{l}{2} \cos \theta \right] = \underline{R_x}$$

$$(2) \quad m \left[-\alpha_0 \frac{l}{2} \sin \theta \right] = \underline{R_y} - mg$$

$$(3) \quad I_0 \alpha_0 = \frac{l}{2} mg \sin \theta$$

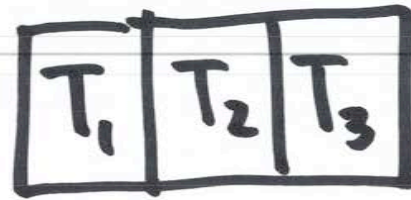
$$\alpha_0 = \frac{\frac{l}{2} mg \sin \theta}{I_0} = \frac{a_t}{\left(\frac{l}{2}\right)}$$

Why energy?



Thermodynamics

0th law:



if $T_1 = T_2$
 $T_2 = T_3$ then $T_1 = T_3$

1st law:

$$\Delta E = Q - W$$

energy is conserved

2nd law:

$$\Delta S > 0$$

always loss

3rd law:

$$T \rightarrow 0^\circ\text{K}$$

Type of Energy:

$$E_{PE} = mgh$$

$$E_{KE} = \frac{1}{2}mv^2$$

$$E_0 = mcT$$

$$E_R = \frac{1}{2}I_0\omega^2$$

$$E_E = IVt$$

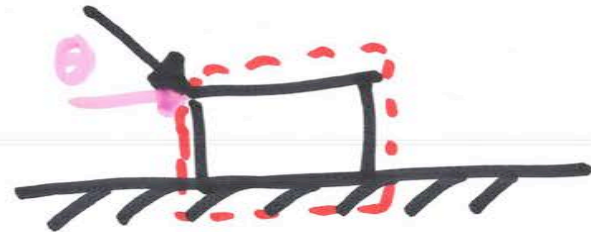
$$E_{\text{rel}} = mc^2$$

$$E = \text{see chem.}$$

$$E_{\text{rad}} = G\sigma(T^4 - T_s^4)A$$

Work:

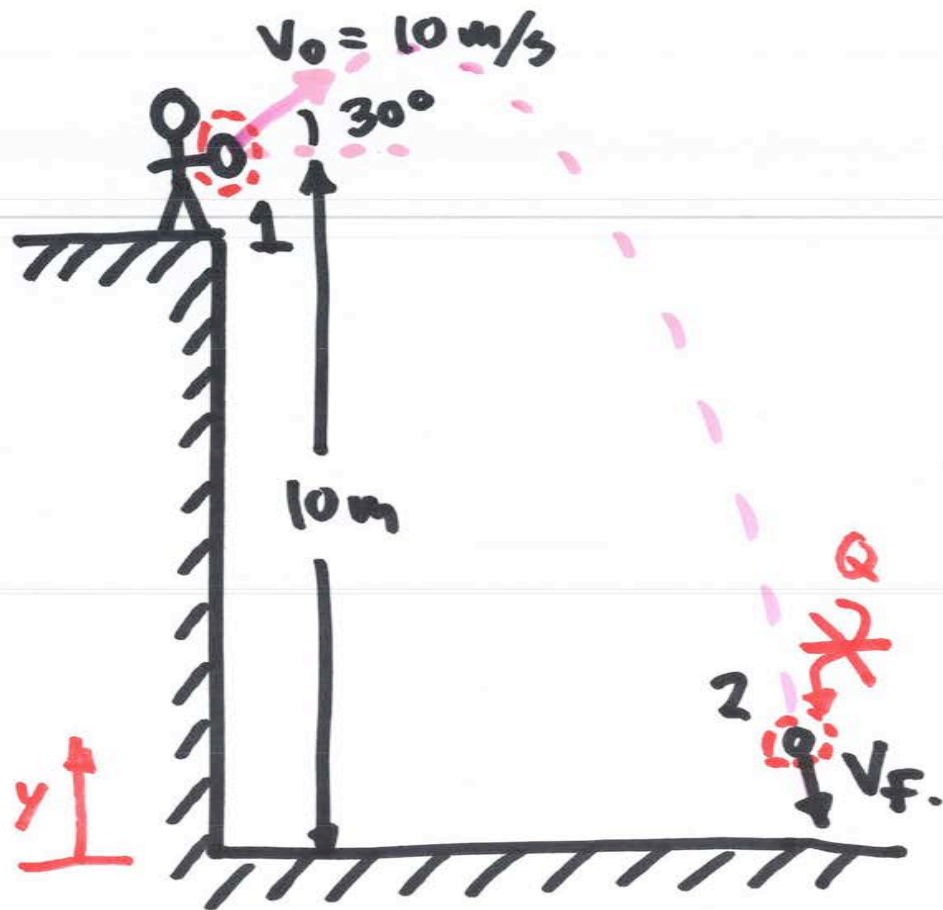
$$W = \vec{F} \cdot \Delta \vec{x}$$
$$= F \Delta x \cos \theta$$



How to use:

apply system boundary

apply 1st law to the system.



we are not talking
about components of
velocity, just magnitude.

$$\Delta E = E_2 - E_1$$

$$\Delta E = E_2 - E_1$$

$$E_1 = mgh_1 + \frac{1}{2}mv_0^2$$

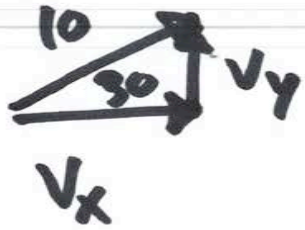
$$E_2 = \frac{1}{2}mv_F^2 + mgh_2$$

$$\left[\frac{1}{2}mv_F^2 \right] - \left[mgh + \frac{1}{2}mv_0^2 \right] = 0$$

$$v_F = \sqrt{2\left(gh + \frac{1}{2}v_0^2\right)}$$

$$v_F = 17.2 \text{ m/s}$$

Check in kinematics



$$v_{x0} = 10 \cos 30 = 8.66$$

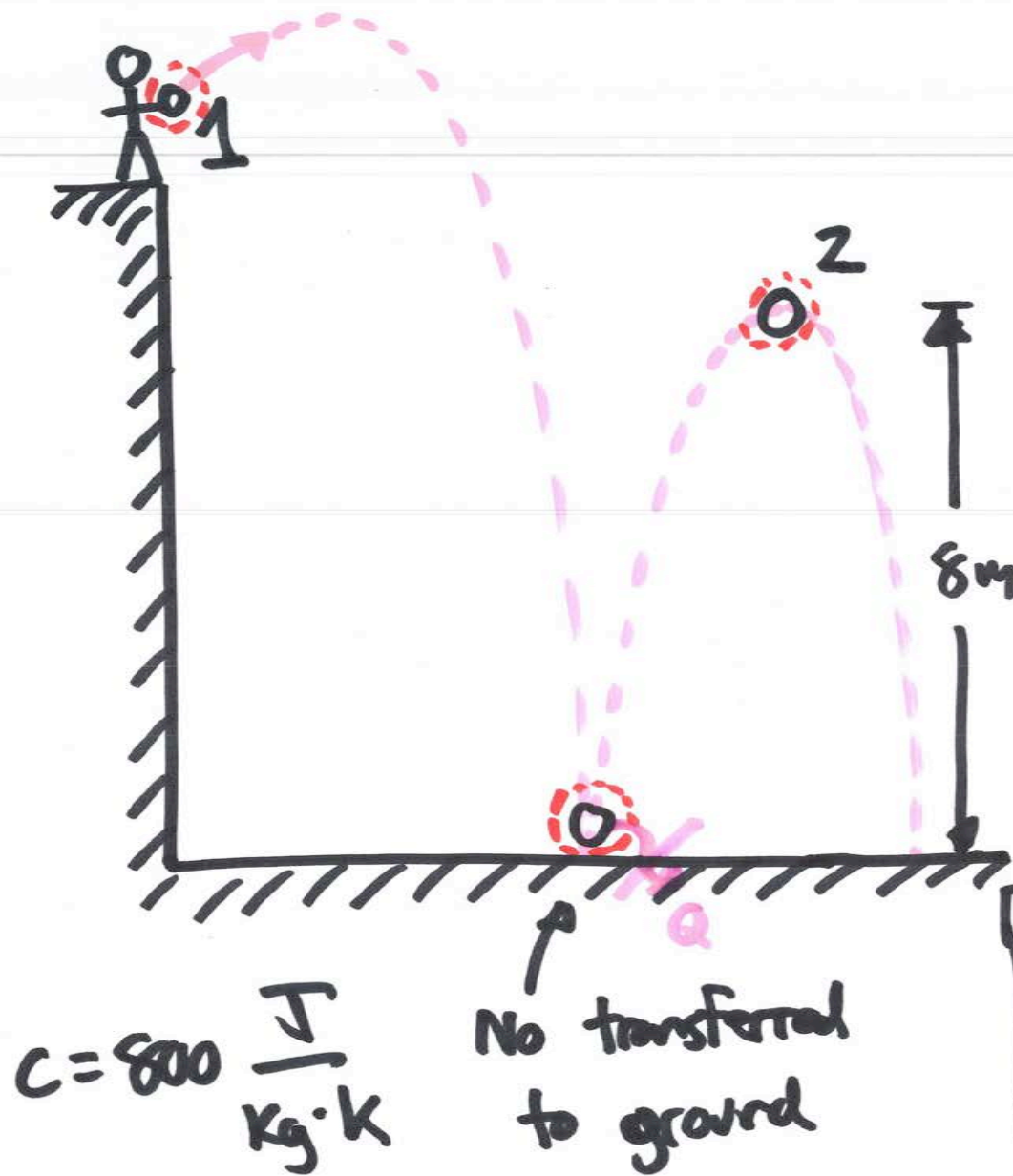
$$v_{y0} = 10 \sin 30 = 5$$

$$v_{fy}^2 = v_{oy}^2 + 2a_y \Delta y$$

$$v_{fy} = 14.87 \text{ m/s}$$

$$v_{fx} = v_{x0} = 8.66$$

$$v_f = \sqrt{v_{fy}^2 + v_{fx}^2} = 17.2 \text{ m/s}$$



$$E_1 = mgh_1 + \frac{1}{2}mv_0^2 + mcT_1$$

$$E_2 = mgh_2 + mcT_2$$

$$\Delta E = \cancel{Q} - \cancel{W}$$

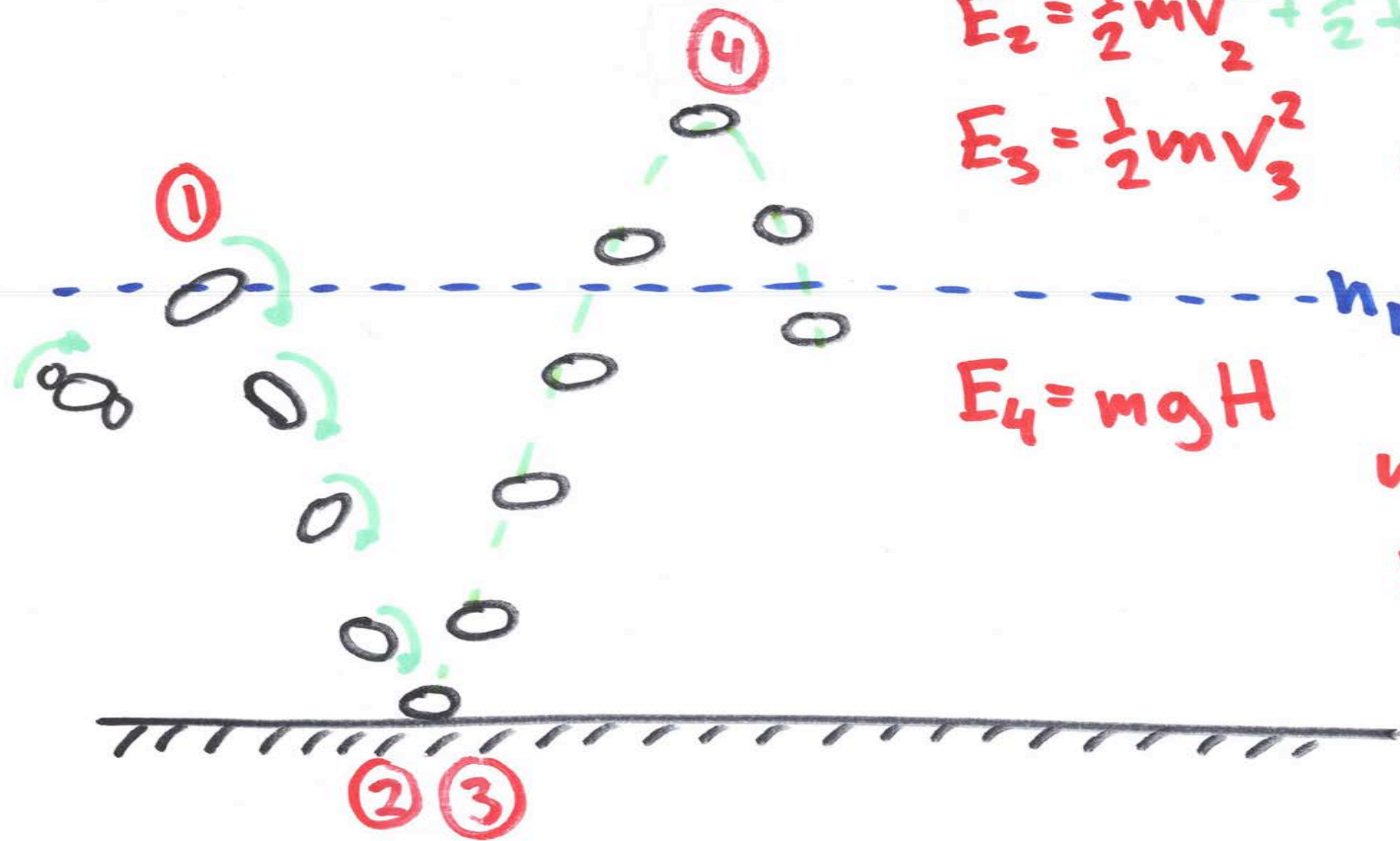
$$= [mgh_2 + mcT_2] -$$

$$[mgh_1 + \frac{1}{2}mv_0^2 + mcT_1]$$

$$\Delta T = \frac{g(h_1 - h_2) + \frac{1}{2}v_0^2}{c}$$

$$\Delta T = 0.09^\circ\text{C}$$

Physics Girl Youtube. Tic-Tac's

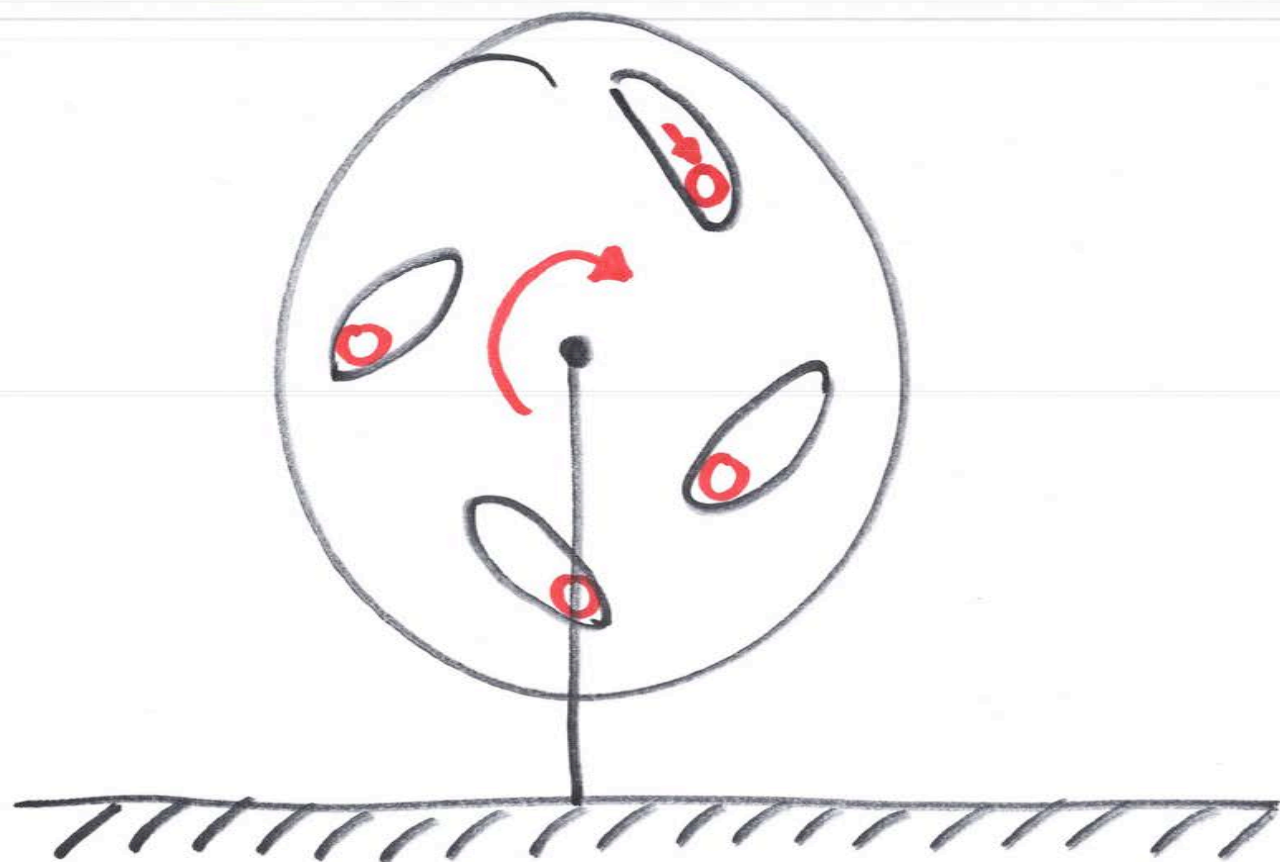


$$E_1 = mgh_1 + \frac{1}{2}I_0\omega^2$$

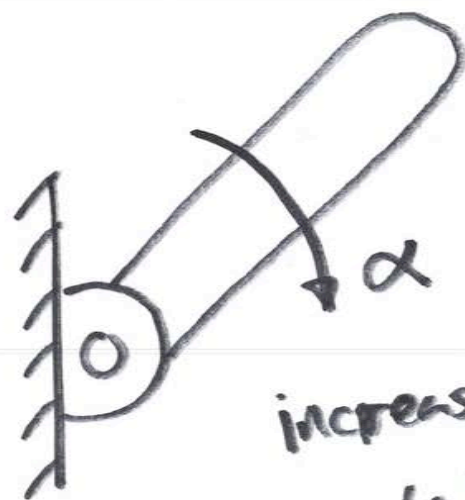
$$E_2 = \frac{1}{2}mv_2^2 + \frac{1}{2}I\omega^2$$

$$E_3 = \frac{1}{2}mv_3^2 \quad \text{where} \quad v_3 > v_2$$

$$E_4 = mgh \quad \text{where} \quad H > h_1$$



perpetual motion
doesn't work.



increase
 ω .

$\frac{1}{2} I \omega^2$
would
increase

Conservation of energy:

$$\Delta E = Q - W$$

↖ work done by system.
↖ heat added to system

$$E_g = mgh$$

$$E_k = \frac{1}{2}mv^2$$

$$E_v = mcT$$

$$E_m = mc^2$$

$$E_{chem} = \text{see shem. chem}$$

$$E_v = VI +$$

$$E_R = \frac{1}{2}I\omega^2$$

gravitational

kinetic

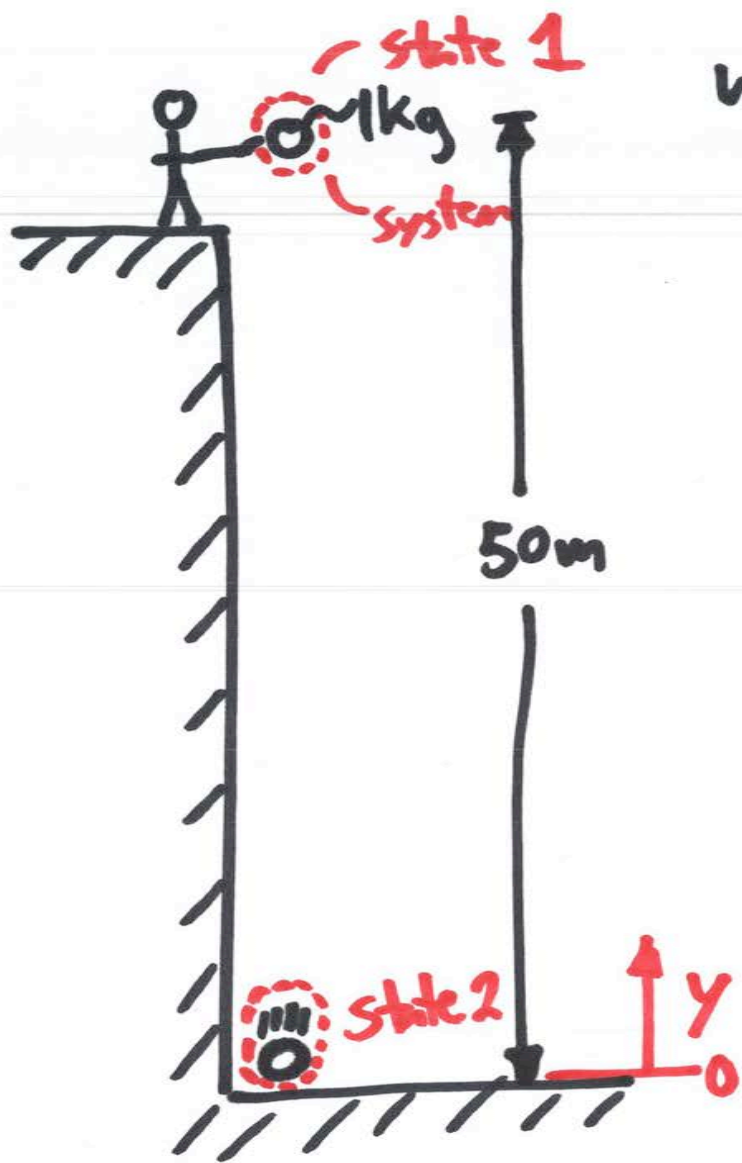
internal

mass

chem

rotational

$$W = \vec{F} \cdot \Delta \vec{x}$$
$$= F \cdot \Delta x \cdot \cos\theta$$



$$Q \& W = 0$$

What's the final speed.

→ could solve with kinematics.

→ let's try with energy:

$$\Delta E = Q - W$$

$$\Delta E = E_2 - E_1 = 0$$

$$E_1 = mgh_1 + \frac{1}{2}mv_1^2$$

$$E_2 = mgh_2 + \frac{1}{2}mv_2^2$$

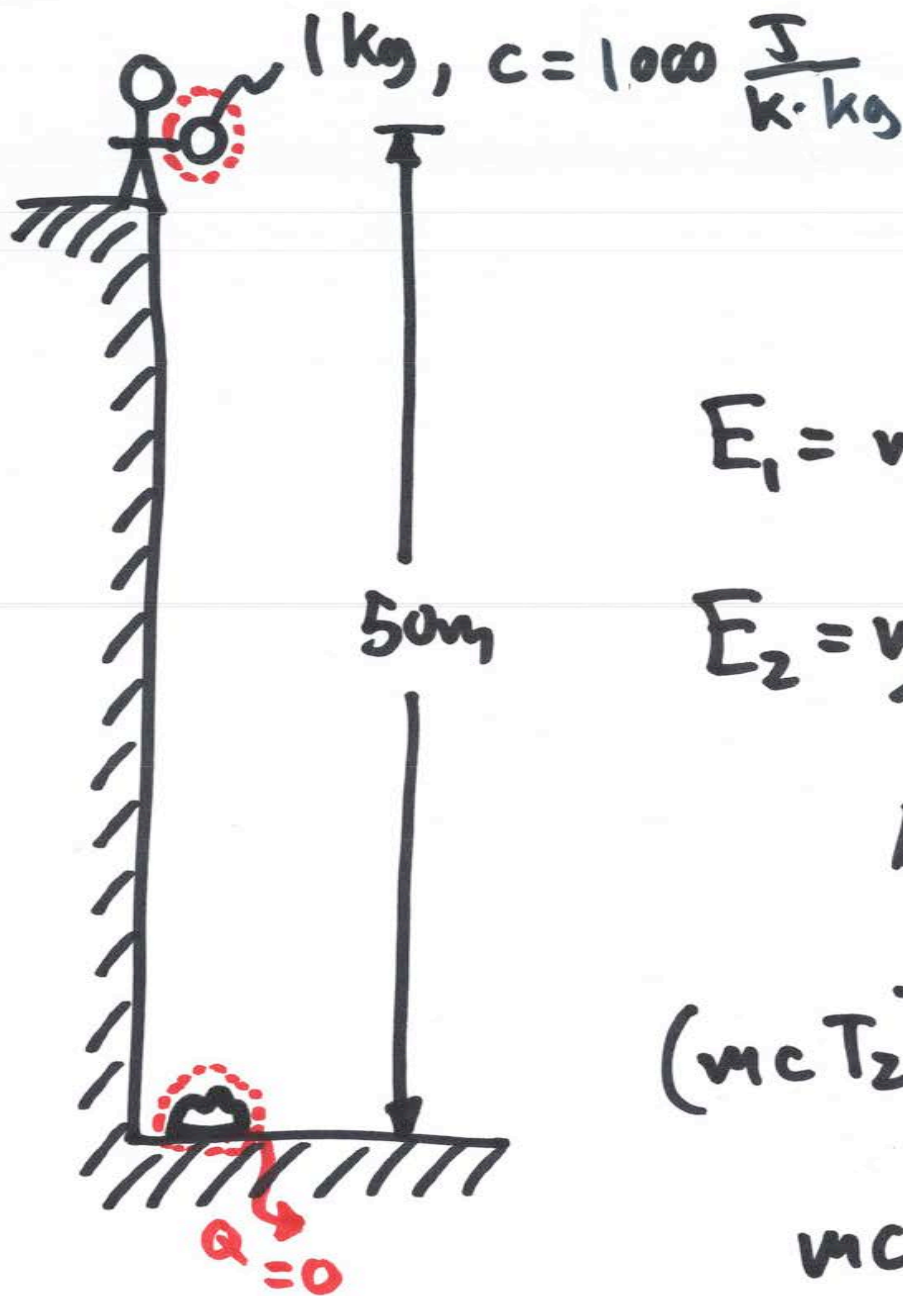
$$E_2 - E_1 = 0$$

$$\left(mgh_2 + \frac{1}{2}mv_2^2\right) - \left(mgh_1 + \frac{1}{2}mv_1^2\right) = 0$$

$$\left[(1)(9.81)(0) + \frac{1}{2}(1)(v_2^2) \right] - \left[(1)(9.81)(50) + \frac{1}{2}(1)(0)^2 \right] = 0$$

$$\frac{1}{2}v_2^2 = (9.81)(50)$$

$$v_2 = 31.3 \text{ m/s}$$



$$\Delta E = Q - W$$

$$E_1 = mgh_1 + \cancel{\frac{1}{2}mv_1^2} + mcT_1$$

$$E_2 = \cancel{mgh_2} + \cancel{\frac{1}{2}mv_2^2} + mcT_2$$

$$\Delta E = E_2 - E_1 = 0$$

$$(mcT_2) - (mgh_1 + mcT_1) = 0$$

$$mc(T_2 - T_1) = mgh$$

$$\Delta T = \frac{gh}{c} = \frac{(9.81)(50)}{1000}$$

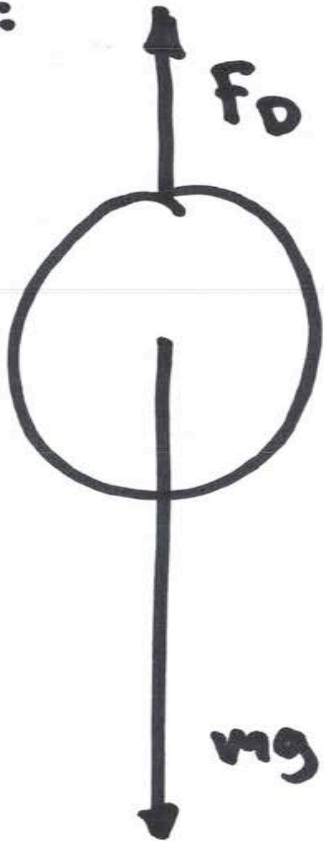
$$\Delta T = 0.5^\circ\text{C}$$

assume

$$Q \& W = 0$$

Terminal velocity:

FBD:



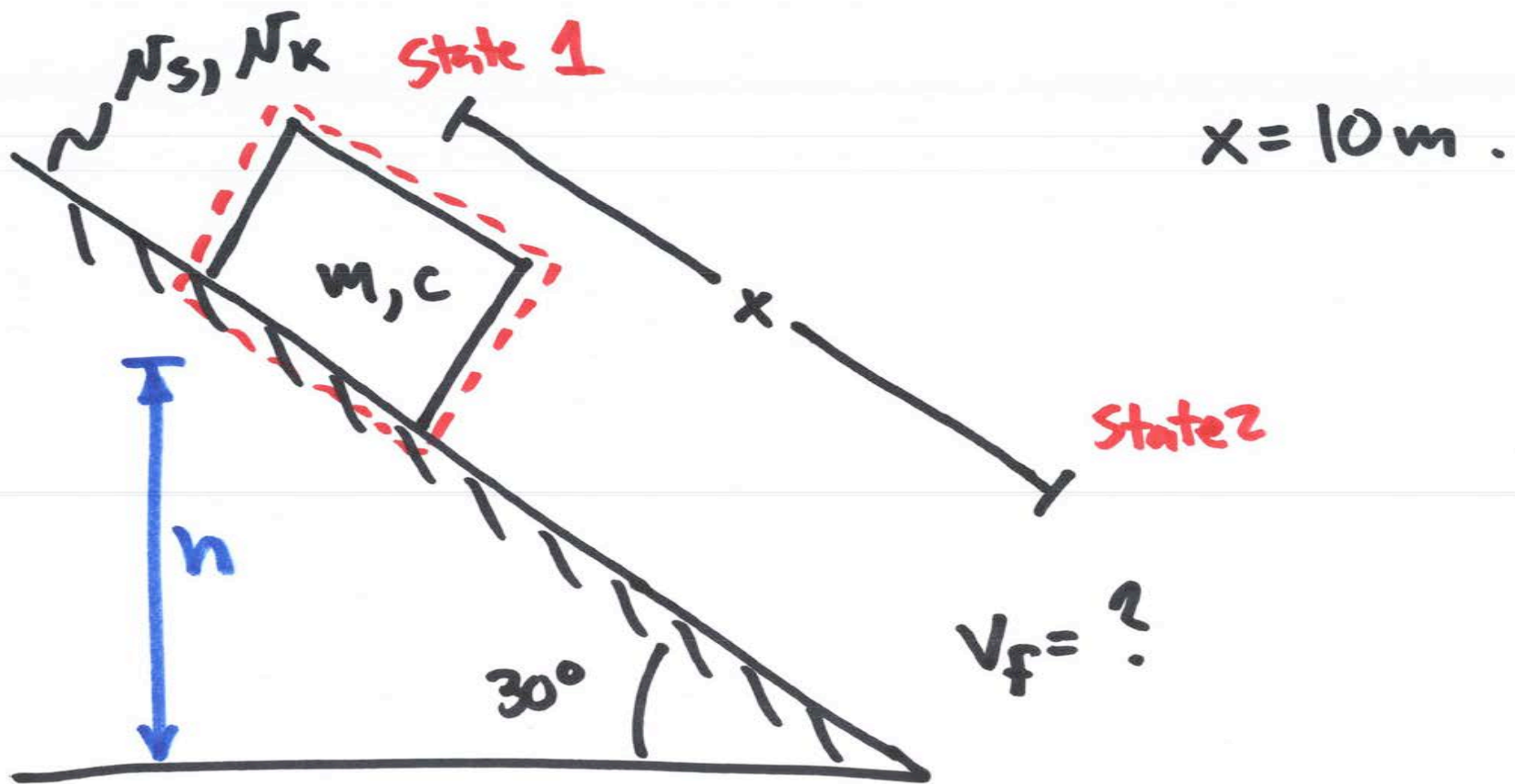
$$F_D = \frac{1}{2} \rho u^2 C_D$$

density of fluid
drag coefficient
velocity

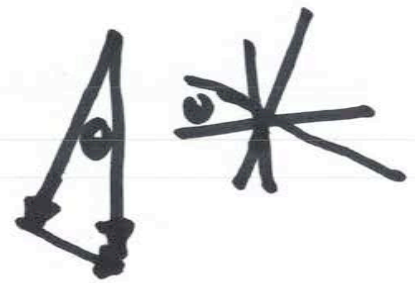
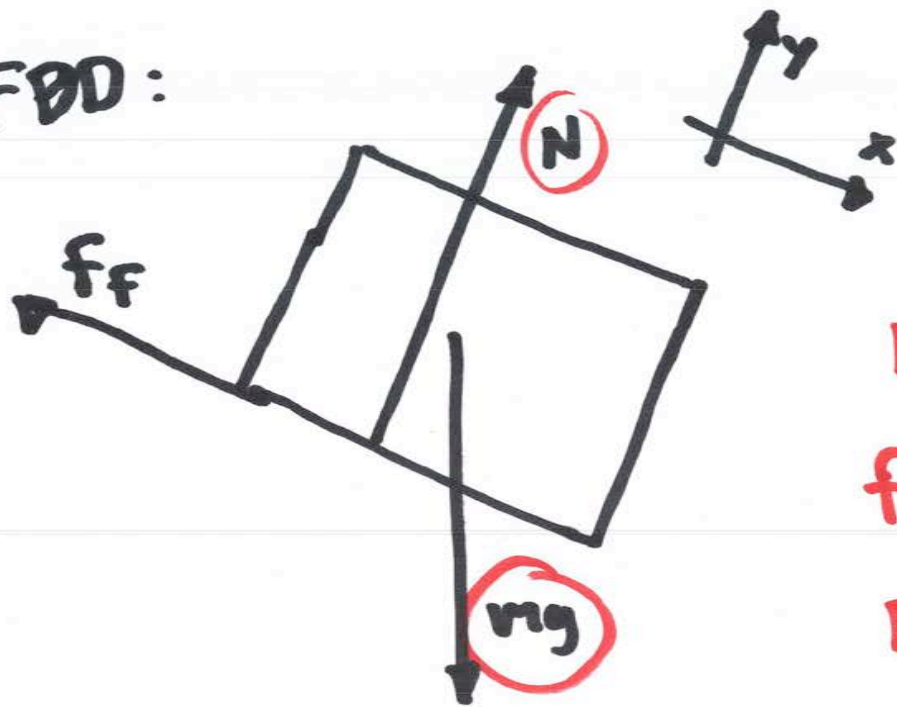


terminal velocity:

$$\sum \vec{F}_y = m \vec{a}_y = \frac{1}{2} \rho v^2 C_D - mg$$



FBD:



$N \perp \Delta x$

$f_f \parallel \Delta x \rightarrow$ produce work.

E_g

Newton's 2nd Law:

$$\sum F_x = ma_x = mg \sin \theta - f_f$$

$$\sum F_y = \cancel{ma_y^0} = N - mg \cos \theta$$

$$\Rightarrow \boxed{N = mg \cos \theta}$$

does it move?

$$a_x = g \sin \theta - \frac{\mu_s [mg \cos \theta]}{m}$$

$$a_x = 2.36 \text{ m/s}^2 !!$$

$$m = 1 \text{ kg}$$

$$\mu_s = 0.3$$

$$\mu_k = 0.2$$

$$\theta = 30^\circ$$

$$F_f = \mu_k N = \mu_k mg \cos \theta$$

$$F_f = 1.7 \text{ N}$$

Energy:

$$\Delta E = Q - W$$

$$E_1 = mgh_1 + \cancel{\frac{1}{2}mv_1^2}$$

$$h_1 = x \sin 30 \\ = 5 \text{ m}$$

$$E_2 = mgh_2 + \frac{1}{2}mv_2^2$$

$$W = \vec{F} \cdot \vec{\Delta x}$$

$$= F_f \cdot \Delta x = (1.7)(10) = 17 \text{ J}$$

$$\left[\frac{1}{2}mv_2^2 \right] - [mgh_1] = -[17]$$

$$v_2 = \sqrt{\frac{2}{m}(mgh_1 - 17)} = 8 \text{ m/s}$$

check with kinematics:

$$a_x = g \sin \theta - \mu_k g \cos \theta = 3.2 \text{ m/s}^2$$

kinematics:

$$v^2 = v_0^2 + 2a\Delta x$$

$$v_f = \sqrt{2a\Delta x} = 8 \text{ m/s}$$

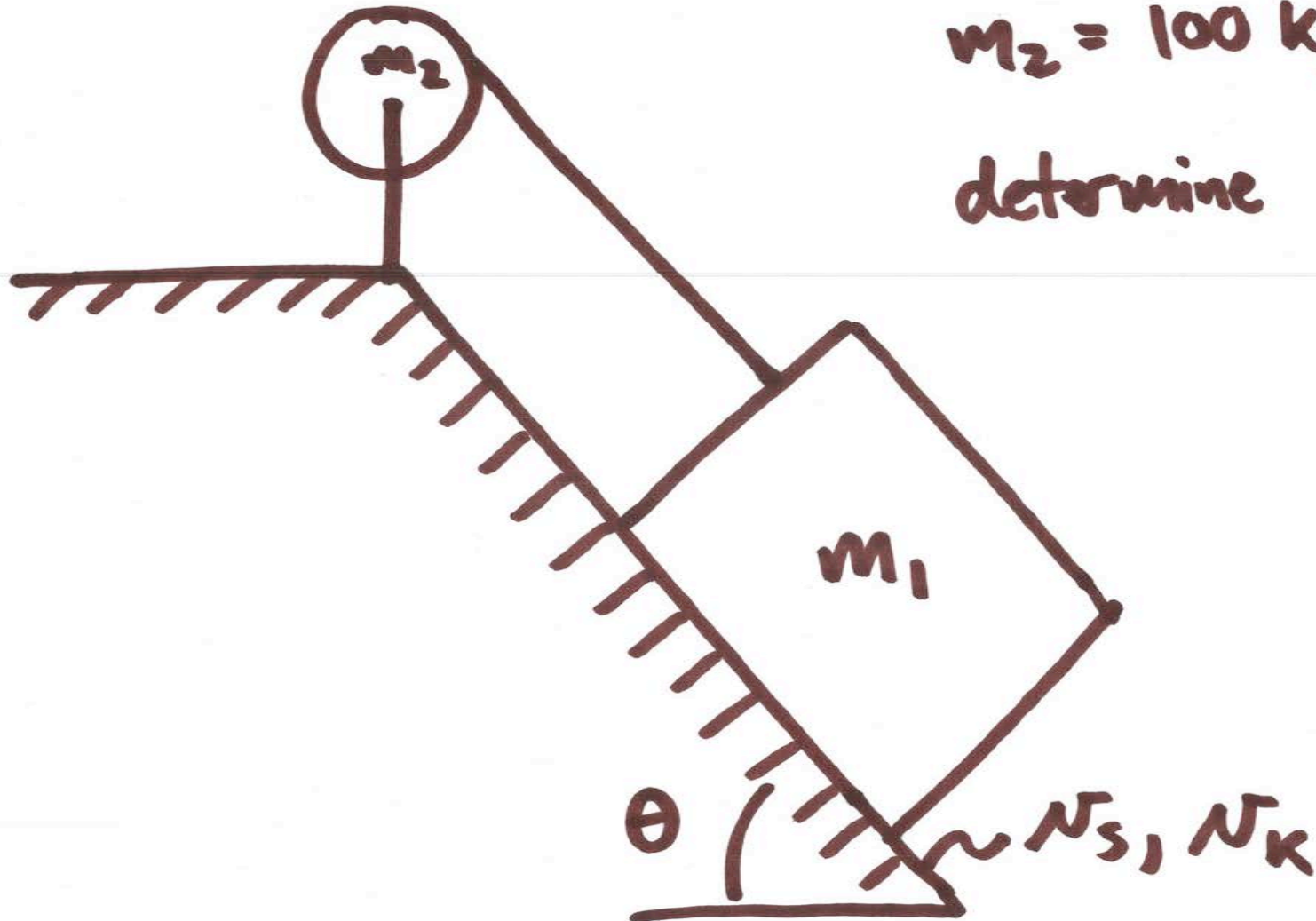
$$r = 0.5 \text{ m}$$

$$\theta = 40^\circ$$

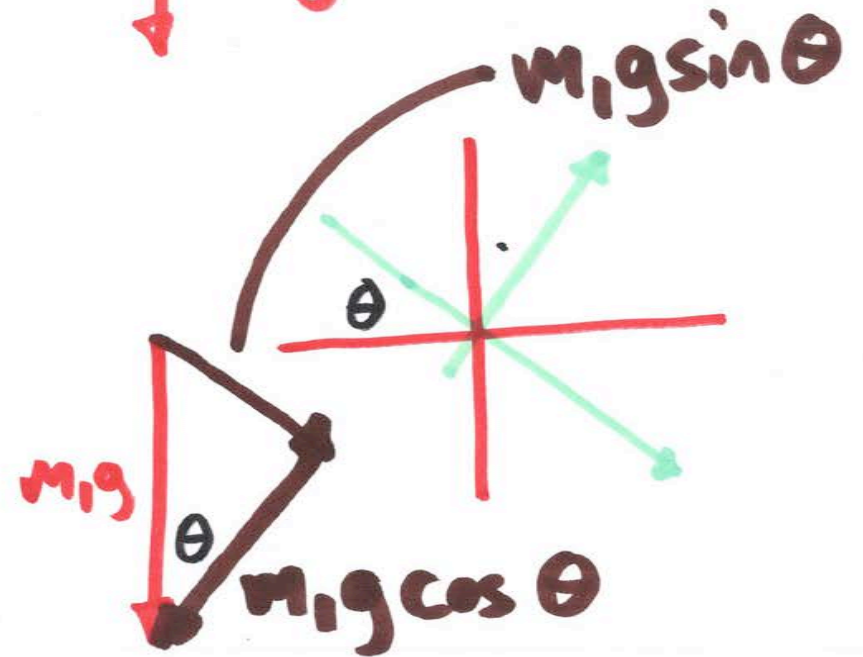
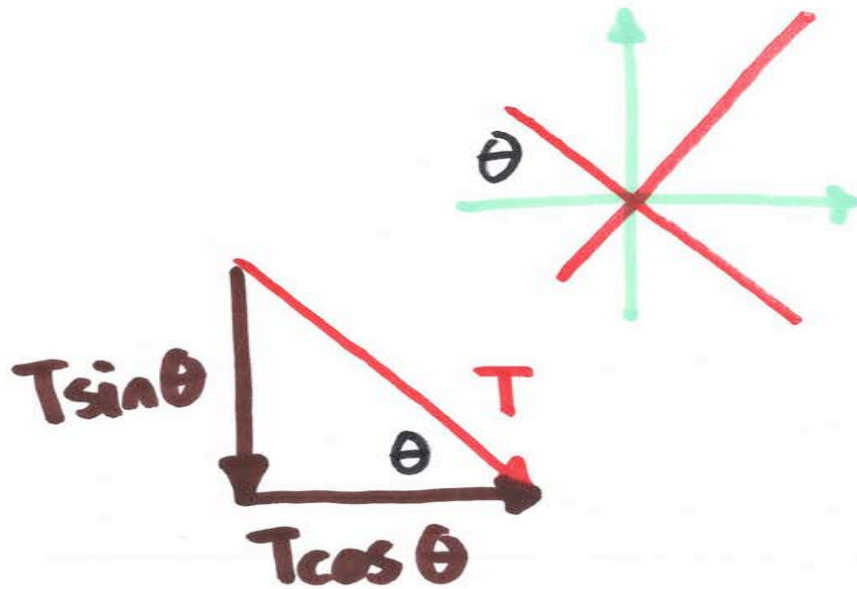
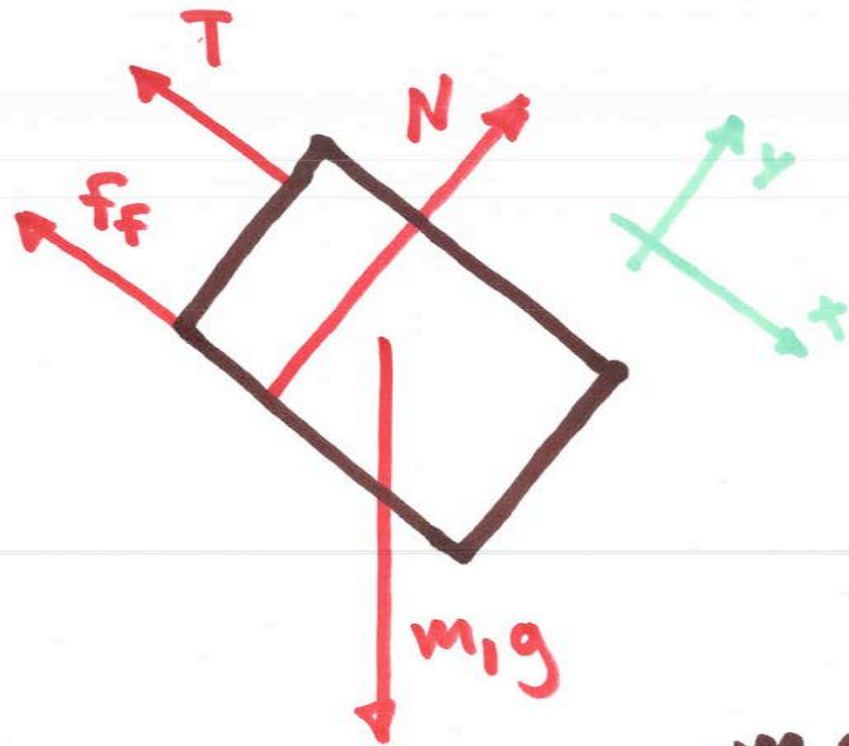
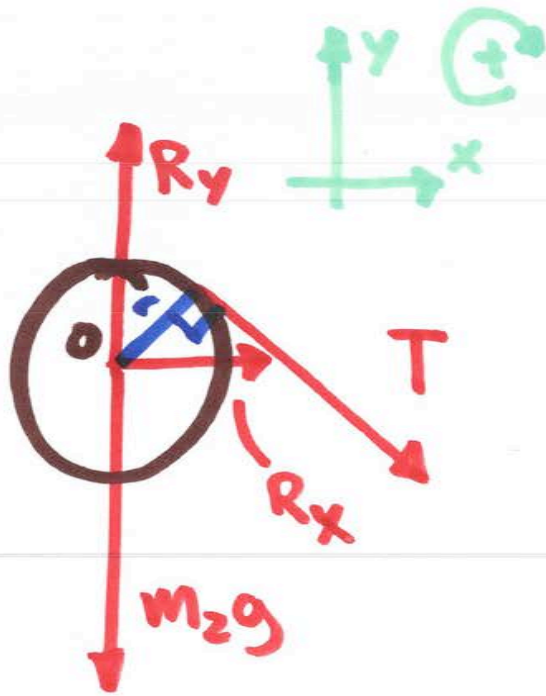
$$m_1 = 10 \text{ kg}$$

$$m_2 = 100 \text{ kg}$$

determine a_x ?



FBD:



$$\circ \quad \Sigma F_x = m_2 \cancel{a_{x_2}} = \underline{T} \cos \theta + \underline{R_x} \quad (1)$$

$$\Sigma F_y = m_2 \cancel{a_{y_2}} = \underline{R_y} - \underline{T} \sin \theta - m_2 g \quad (2)$$

$$\Sigma M_o = I_o \underline{\alpha_o} = \underline{T} r \quad (3)$$

$$\square \quad \Sigma F_x = m_1 \cancel{a_{x_1}} = m_1 g \sin \theta - \underline{T} - \underline{f_f} \quad (4)$$

$$\Sigma F_y = m_1 \cancel{a_{y_1}} = \underline{N} - m_1 g \cos \theta \quad (5)$$

massless, stretchless rope

$$a_{x_1} = \alpha_o r \quad (6)$$

sub (6) into (3)

$$I_o \left[\frac{a_x}{r} \right] = T r \quad (3a)$$

sub (3a) into (4)

$$m \underline{a_x} = m_1 g \sin \theta - \left[\frac{I_o \underline{a_x}}{r^2} \right] - \underline{f_f}$$

does this move?

set $f_f = \mu_s N$ (maximum possible friction)

$$r^2 m_1 a_x = m_1 r^2 g \sin \theta - I_o a_x - \mu_s N r^2 \quad (4a)$$

sub (5) into (4a)

$$a_x (I_0 + m_1 r^2) = m_1 r^2 g \sin \theta - \mu_s [m_1 g \cos \theta] r^2$$

$$I_0 = \frac{1}{2} m_2 r^2$$

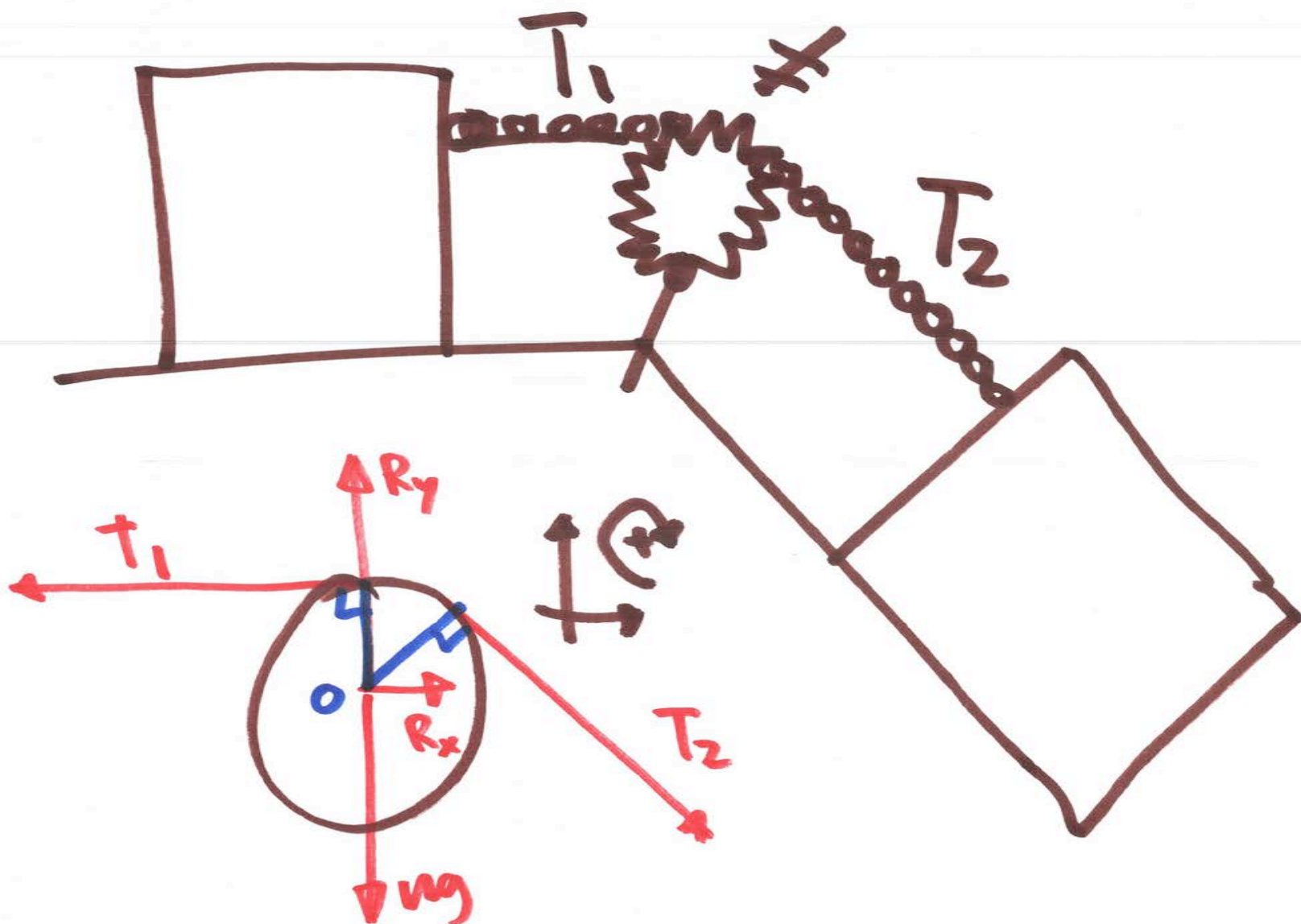
$$a_x = \frac{m_1 r^2 g (\sin \theta - \mu_s \cos \theta)}{I_0 + m_1 r^2}$$

$$\mu_s = 0.3$$

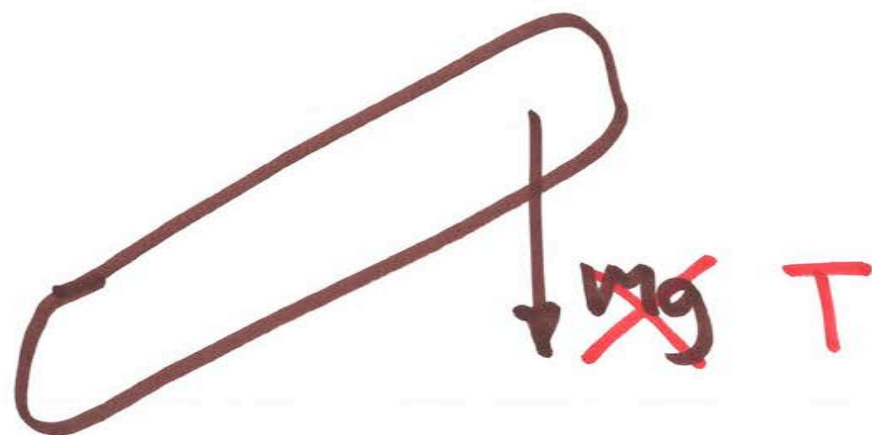
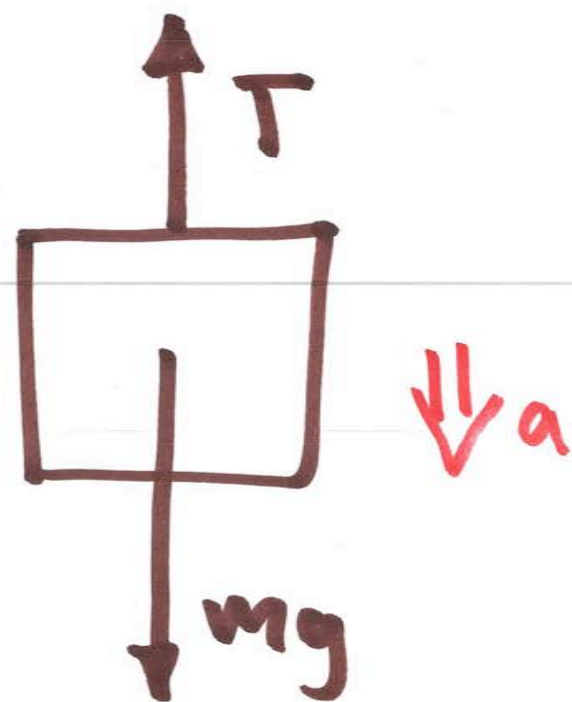
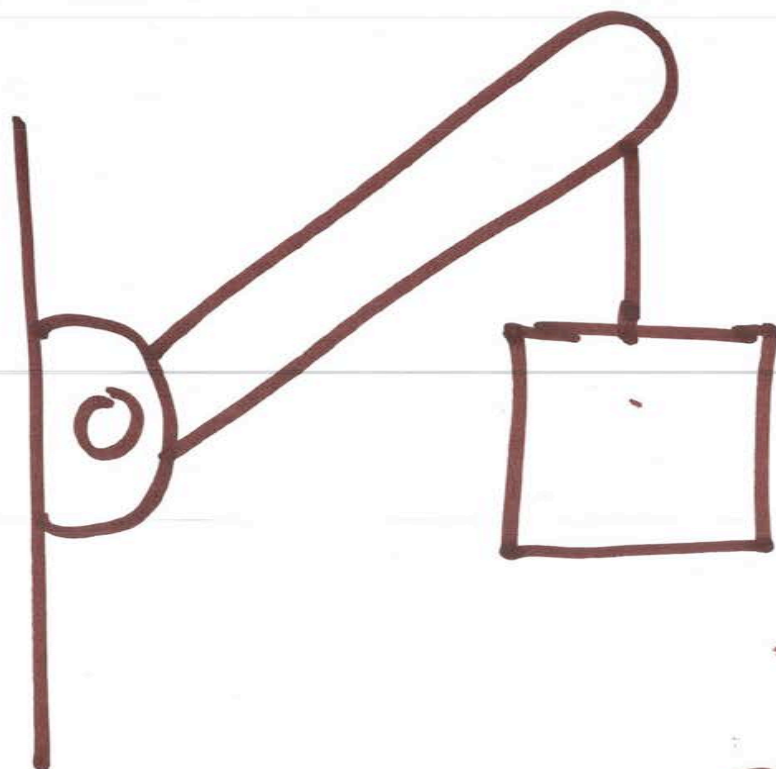
$$a_x = 0.67 \text{ m/s}^2 \text{ +ive }$$

$$\mu_k = 0.2$$

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



$$\Sigma M_o = I_o \alpha_o = T_2 r - T_1 r$$



Civl 11

- kinematics

- dva graphs

- equations



- Dynamics

- FBD

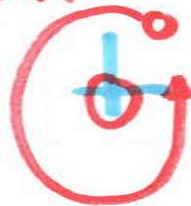


- Newton's Laws

$$\sum F = ma =$$

- Circular motion

- equation



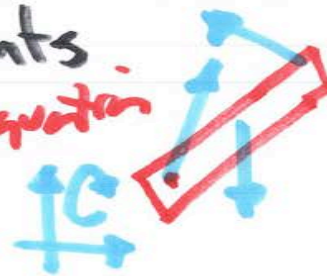
test 1

est 2

Final

Moments

- equation



te

Energy



Newton's Laws

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

$$\int F dr = \int m a dr$$

$$\int F dt = \int m \vec{a} dt$$

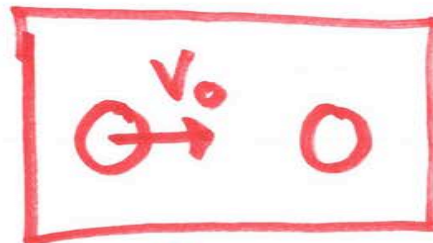
$$\sum M_o = I_o \alpha_o$$

Moments.

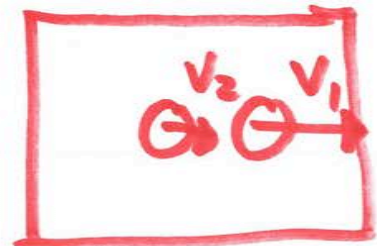
$$\int F dt = m \vec{v} = P$$

impulse

Momentum



t_0



t_1