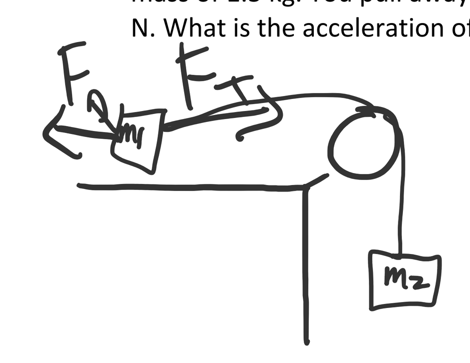
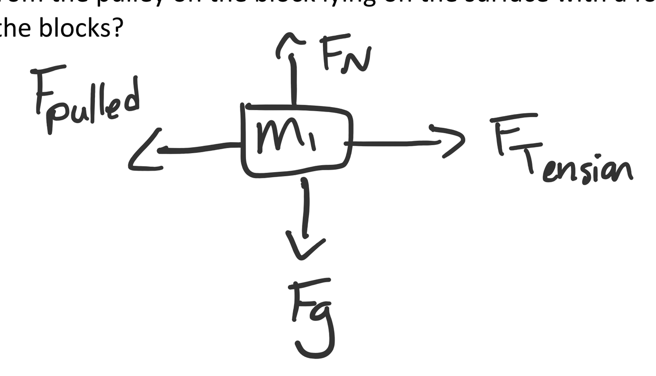
Exam 3 Review - Solutions

1. A block with a mass of 2 kg hangs from a rope that is attached to a pulley of mass 3 kg and radius .5 m. Attached to the other end of the rope is a block resting on a frictionless surface with a mass of 1.5 kg. You pull away from the pulley on the block lying on the surface with a force of 115 N. What is the acceleration of the blocks?



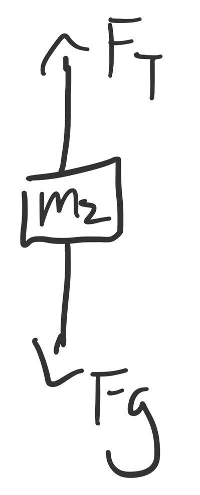


m_1:

	x	y
F_N	$\emptyset$	F_N
F_g	$\emptyset$	$-F_g$
F_{T_1}	F_{T_1}	$\emptyset$
F_P	$-115N$	$\emptyset$
ΣF	ma	$\emptyset$

$$\Sigma F_x = F_{T_1} - 115N = m_1 a$$

$$F_{T_1} = 115N + m_1 a$$

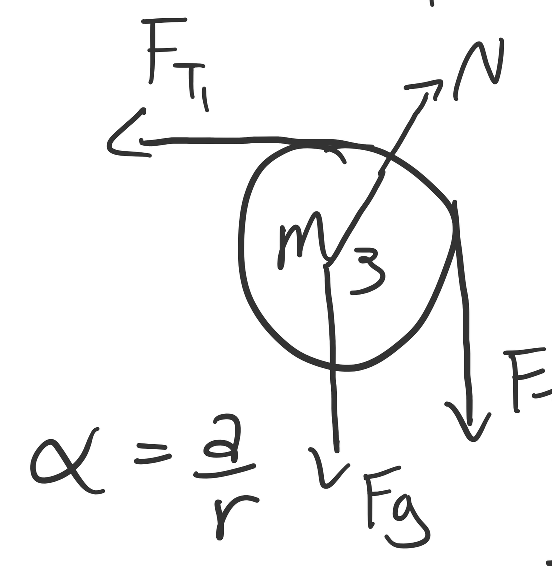


m_2:

	x	y
F_g	$\emptyset$	$-F_g$
F_{T_2}	$\emptyset$	F_{T_2}
ΣF	$\emptyset$	ma

$$\Sigma F_y = -F_g + F_{T_2} = m_2 a$$

$$F_{T_2} = m_2 a + F_g$$



$$\alpha = \frac{a}{r}$$

For pulley: $\Sigma \tau = I\alpha$

CW (-) CCW (+)

$$\tau_1 = F_{T_1} r \sin \cancel{\theta\, 90^\circ} \quad 1$$

$$\tau_1 = (115N + m_1 a) r$$

$$\tau_2 = -(m_2 a + F_g) r$$

$$\Sigma \tau = (115N + m_1 a) r - (m_2 a + F_g) r$$

$$I\alpha = (115N + m_1 a) r - (m_2 a + F_g) r$$

$$I \frac{a}{r} = (115N + m_1 a) r - (m_2 a + F_g) r$$

$$I \Rightarrow \text{pulley} = \frac{1}{2} m r^2$$

$$\frac{1}{2} m_3 r^{\cancel{2}} \frac{a}{\cancel{r}} = (115N + m_1 a)\cancel{r} - (m_2 a + m_2 g)\cancel{r}$$

$$\frac{1}{2} m_3 a = 115N + m_1 a - m_2 a - m_2 g$$

$$\frac{1}{2} m_3 a - m_1 a + m_2 a = 115N - m_2 g$$

$$a\left(\frac{1}{2} m_3 - m_1 + m_2\right) = 115N - m_2 g$$

$$a = \frac{115N - m_2 g}{\left(\frac{1}{2} m_3 - m_1 + m_2\right)} = \frac{115N - (2kg \cdot 9.8\frac{m}{s^2})}{\left(\frac{1}{2}(3kg) - 1.5kg + 2kg\right)}$$

$$a = \frac{95.4N}{2} = 47.7\, m/s^2$$

2. A block with a mass of 2 kg is attached to a spring and stretched 60 cm from equilibrium. The spring has a constant k = 200 N/m. At t=0 s, the block is released from rest.
   a. What is the max speed?
   b. At what time t does max speed occur? 1st occur
   c. If the block is 30 cm from equilibrium, what is its speed?

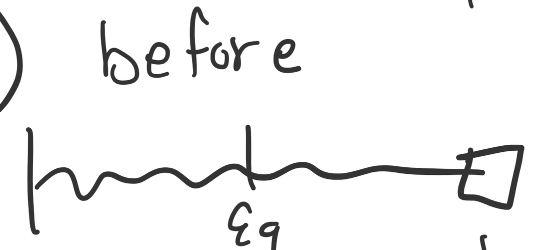
a) $\frac{1}{2} KA^2 = \frac{1}{2} m v^2$

$$\sqrt{\frac{200\frac{N}{m}(.6m)^2}{2kg}} = V = 6\frac{m}{s}$$

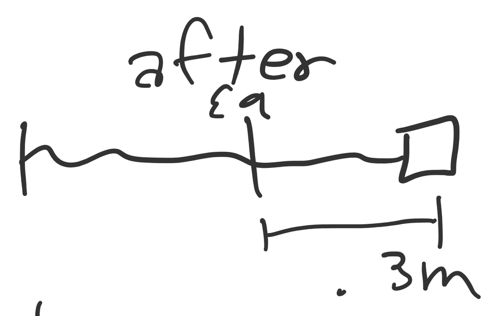
b) $T = 2\pi\sqrt{\frac{m}{K}} = 2\pi\sqrt{\frac{2kg}{200\frac{N}{m}}} = .63s$

Max speed $\rightarrow \frac{1}{4}T \rightarrow \frac{1}{4}(.63s) = .1575s$

c) before



after



$$\frac{1}{2}KA^2 = \frac{1}{2}Kx^2 + \frac{1}{2}mv^2$$

$$\sqrt{\frac{KA^2 - Kx^2}{m}} = V = 5.2\frac{m}{s}$$

3. In a thermally insulated container, .5 kg of ice at -20 C is combined with .8 kg of water at an unknown temperature.
   a. If all of the ice melts, leaving the container to be filled only with water at 10 C, then what is the initial temperature of the.8 kg of water?
   b. What is the entropy change of the ice-water system?

a) ice @ -20C $\xrightarrow{Q_1}$ ice as water @ 0°C $\xrightarrow{Q_2}$ ice as water @ 10°C   water @ 10°C $\xleftarrow{Q_3}$ water @ ?°C < 72.4°C

m	m_i	m_i	m_w
type	SH	LH	SH
#	C_i	L_f	C_w
+/-	+	+	−

a) $\Delta Q = \emptyset = Q_1 + Q_2 + Q_3$

$$m_i C_i \Delta t + L_f m_i - m_w C_w \Delta t = \emptyset$$

$$(.5kg)(2.10)(20) + (334)(.5kg) - .8kg(4.186)(\Delta t) = \emptyset$$

$$|\Delta t| = 62.4°C$$

So initial temp water is

$$\Delta t + 10°C = 72.4°C$$

b) $\Delta S_{LH} = \frac{mL}{T}$ $\Delta S_{SH} = mc \ln\left(\frac{T_{Hot}}{T_{cold}}\right)$

$$\Delta S_{system} = \underbrace{M_{ice}(C_{ice})\ln\left(\frac{273K}{253K}\right)}_{Q_1} + \underbrace{\frac{L_f M_{ice}}{273K}}_{Q_2} + \underbrace{M_{ice} C_w \ln\left(\frac{283K}{273K}\right)}_{Q_3} - \underbrace{m_w C_w \ln\left(\frac{345.4K}{283K}\right)}_{Q_4}$$

$$= .0799 + .612 + .075 - .667$$

$$\Delta S_{system} \sim .1\frac{KJ}{K}$$