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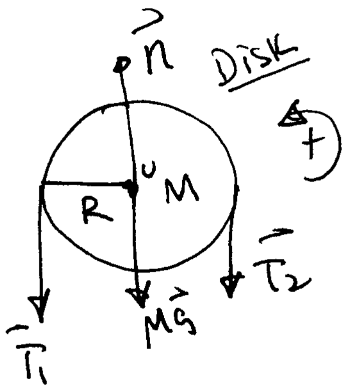
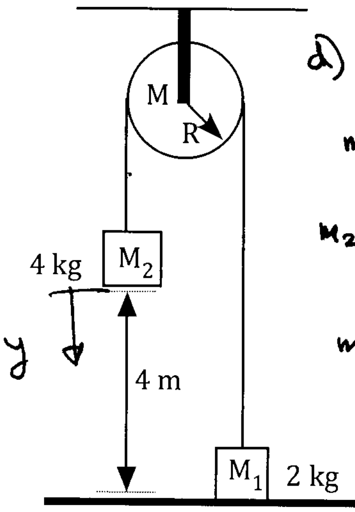
NAME: KEY

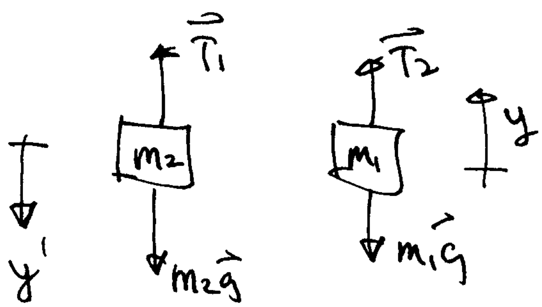
PHYSICS 4A
WINTER 2013
EXAM 3

PARTIAL CREDIT will be given so do what you can and make sure that you show all work for each problem. **No credit will be given if no work is shown**. The point value of each question is indicated. Express all answers in SI units.

1. The pulley (disk) has a radius of 16 cm and a mass of 0.75 kg. Assuming the blocks are released from rest calculate: (15 pts)
   a) The tension on the rope.
   b) The acceleration of the masses
   c) The speed of the 4 kg mass when it strikes the floor.
   d) Confirm your result in part (c) by using energy methods.







d) $\cancel{K_i}^{0} + U_i = K_f + \cancel{U_f}^{0} + m_1 g h$

$m_2 g h = \frac{1}{2}(m_1+m_2)v^2 + \frac{1}{2}I\omega^2 + m_1 g h$

$m_2 g h = \frac{1}{2}(m_1+m_2)v^2 + \frac{1}{2}\left(\frac{1}{2}M\cancel{R^2}\right)\frac{v^2}{\cancel{R^2}} + m_1 g h$

$m_2 g h = \left(\frac{1}{2}(m_1+m_2) + \frac{1}{4}M\right)v^2 + m_1 g h$

$v = \sqrt{\frac{(m_2-m_1)gh}{\frac{1}{2}(m_1+m_2+\frac{1}{4}M}}$

$v = 4.95\frac{m}{s}$ ✓

m_2: $\Sigma F_{y'} = m_2 g - \cancel{T_1} = m_2 a$

m_1: $\Sigma F_y = \cancel{T_2} - m_1 g = m_1 a$

$\cancel{T_1} - \cancel{T_2} = \frac{1}{2}Ma$

$(m_2 - m_1)g = \left(\frac{M}{2} + m_1 + m_2\right)a$

$\boxed{a = \frac{(m_2-m_1)g}{\frac{M}{2} + m_1 + m_2}} = \boxed{3.07\frac{m}{s^2}}$

$\boxed{T_1 = 26.9N \quad T_2 = 25.7N}$

Disk

$\Sigma\tau_0 = I\alpha$

$\boxed{v = R\omega \quad a = R\alpha}$

$T_1 R - T_2 R = \frac{1}{2}MR^2\alpha$

$(T_1 - T_2)\cancel{R} = \frac{1}{2}MR^{\cancel{2}}\left(\frac{a}{\cancel{R}}\right)$

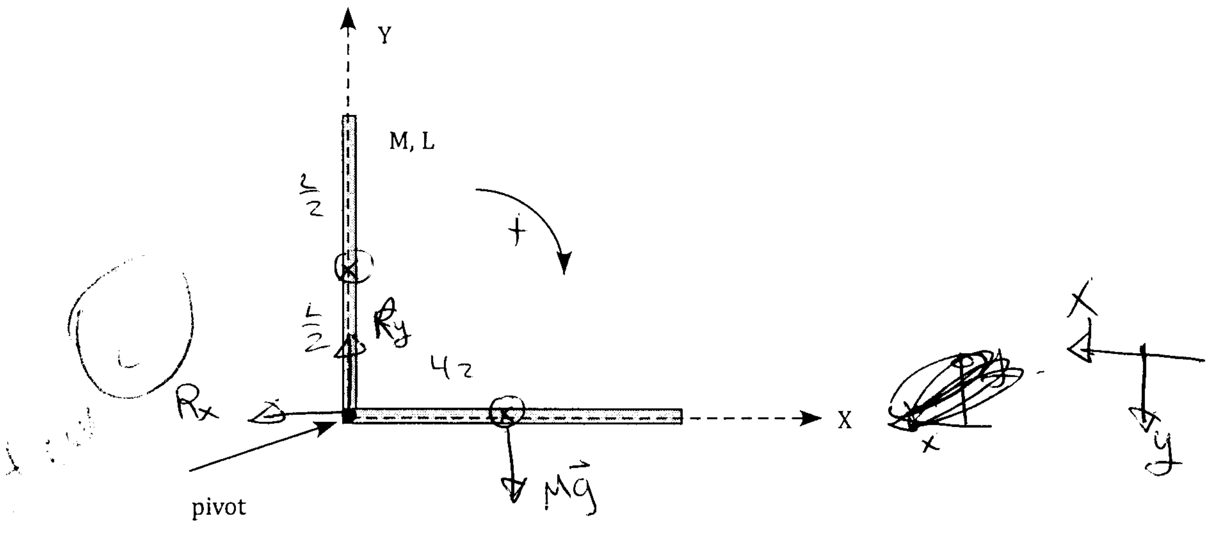
① $\boxed{T_1 - T_2 = \frac{1}{2}Ma}$

c) $v^2 = \cancel{v_0^2}^{0} + 2a\Delta y$

$\boxed{v = 4.95\, m/s}$

2. A uniform rod of length L and mass M is released from rest in the vertical position as shown below. It rotates about a frictionless pivot point. At the instant the rod reaches the horizontal position, find: (15 pts)

a) The angular speed.
b) The angular acceleration.
c) The horizontal and vertical components of the pivot force exerted on the rod.



a) $\cancel{K_i} + U_i = K_f + \cancel{U_f}$

$Mg\frac{L}{2} = \frac{1}{2}\left(\frac{1}{3}ML^2\right)\omega^2$

$\boxed{\omega = \sqrt{\frac{3g}{L}}}$ 3

b) $\sum \tau_p = I_p\alpha$

$Mg\frac{L}{2} = \left(\frac{1}{3}ML^2\right)\alpha$

$\boxed{\alpha = \frac{3}{2}\frac{g}{L}}$ 4

c) $\sum F_y = Mg - R_y = Ma_{t(cm)}$

$Mg - R_y = M\frac{3}{4}g$

$\boxed{R_y = \frac{1}{4}Mg}$

$\sum F_x = R_x = Ma_{r(cm)}$

$R_x = M\left(\frac{3}{2}g\right)$

$\boxed{R_x = \frac{3}{2}Mg}$

$a_{t(cm)} = \left(\frac{L}{2}\right)\alpha$

$a_{t(cm)} = \frac{L}{2}\left(\frac{3}{2}\frac{g}{L}\right)$

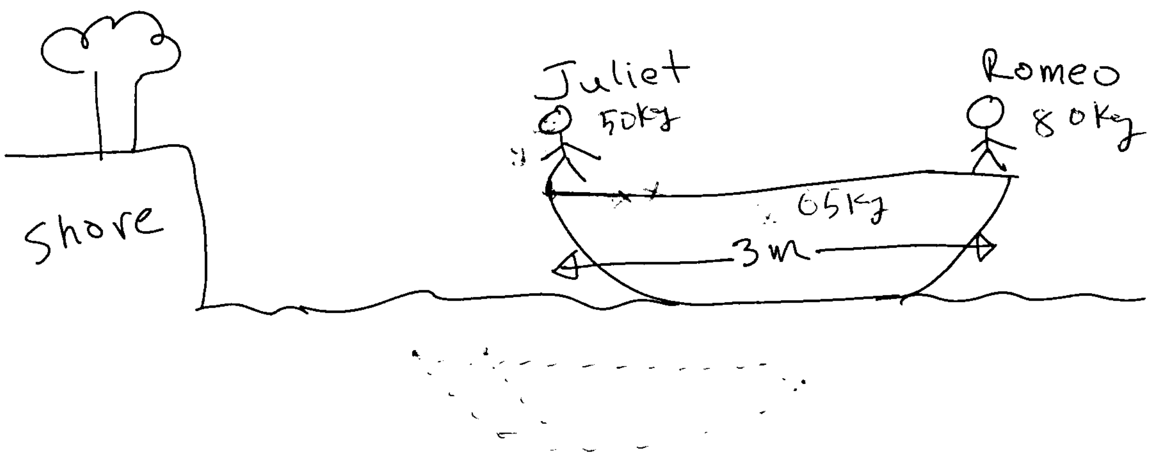
$= \frac{3}{4}g$

$a_{r(cm)} = \left(\frac{L}{2}\right)\omega^2$

$= \frac{L}{2}\frac{3g}{L}$

$= \frac{3}{2}g$

3. Romeo (80 kg) entertains Juliet (50 kg) by playing his guitar from the rear of their boat at rest in still water. Romeo is 3.0 m away from Juliet, who is in front of boat. After the serenade, Juliet, initially holding a 5 kg gift, carefully moves to the rear of the boat (**away from the shore**) to give Romeo the gift. (20 pts)



a) For the Romeo, Juliet, gift, and boat system is the momentum conserved? Explain!

b) What can you conclude about the motion of the center of mass of the system? Explain!

c) Calculate how far the 65 kg boat moved from the shore when Juliet delivers the gift to Romeo.

d) After receiving the ~~gift from Juliet,~~ they begin to argue and Juliet takes back the gift and walks back to the other end, stops, and then throws the gift toward the shore with a speed of 15 m/s (she's very mad!) relative to the boat. Calculate the total kinetic energy of the system (relative to the earth's reference frame) immediately after Juliet throws the gift.

e) What is the source of energy for the kinetic energy that the system acquires after the gift is thrown? Explain!

f) Describe and explain the motion of the center of mass of the system before and after Juliet throws the gift.

a) $\sum \vec{F}_{ext} = \frac{d\vec{P}_{sys}}{dt} = 0$ (Isolated System)

$\vec{P}_{sys} = M\vec{V}_{cm} = const \Rightarrow$ (conserved)

b) $\vec{V}_{cm} = const. = \frac{d\vec{r}_{cm}}{dt} = 0$

$\vec{r}_{cm} = const.$ (Never moves!)

$\vec{r}_{i,cm} = \vec{r}_{f,cm}$

c) $x_{i,cm} = x_{f,cm}$

$$\frac{\cancel{m_j x_{ij}} + m_r x_{ir} + \cancel{m_g x_{ig}} + m_b x_{ib}}{\cancel{m_j + m_r + m_g + m_b}} = \frac{m_j x_{fj} + m_r x_{fr} + m_g x_{fg} + m_b x_{fb}}{\cancel{\sum m_i}}$$

$$(80)(3) + (65)(1.5) = 55(0-x) + 65(1.5-x) + 80(3-x)$$

$$\boxed{x = 0.825\,m}$$

d) $K_T = \frac{1}{2}(m_b + m_r + m_j) v_{bE}^2 + \frac{1}{2} m_g v_{gE}^2$

$$p_{ix} = p_{fx}$$

$$0 = (m_b + m_r + m_j) v_{bE} + m_g v_{gE}$$

$$0 = 195\, v_{bE} + 5 v_{gE}$$

$$v_{gE} = -39\, v_{bE}$$

$$v_{gb} = -15\,\frac{m}{s}$$

$$v_{gE} = v_{gb} + v_{bE}$$

$$-39\, v_{bE} = -15 + v_{bE}$$

$$\boxed{\begin{aligned} v_{bE} &= +0.375\,m/s \\ v_{gE} &= -14.6\,m/s \end{aligned}}$$

$$\boxed{K_T = 547\,J}$$