Assignment 9:

**UNIVERSITY OF OTTAWA**
**Principles of Physics**
**PHY1321/1331 FALL 2018**
***Dr. A. Czajkowski***

STUDENT #: ________________

NAME: ______________________

WORK, ENERGY
Assigned: Nov 9
Due: Monday Nov 19 5:30 PM

1 A coin placed 30.0 cm from the center of a rotating, horizontal turntable slips when its speed is 50.0 cm/s.
(a) What force causes the centripetal acceleration when the coin is stationary relative to the turntable?
(b) What is the coefficient of static friction between coin and turntable?

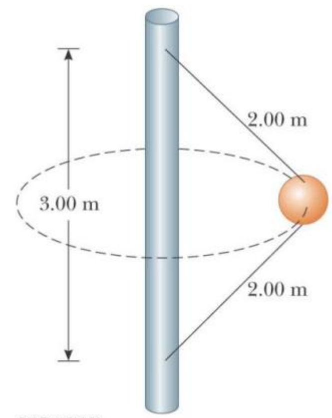
(a) static friction

(b) $m a\hat{\mathbf{i}} = f\hat{\mathbf{i}} + n\hat{\mathbf{j}} + mg(-\hat{\mathbf{j}})$ $\sum F_y = 0 = n - mg$

thus $n = mg$ and $\sum F_r = m\frac{v^2}{r} = f = \mu n = \mu mg$.

Then $\mu = \frac{v^2}{rg} = \frac{(50.0 \text{ cm/s})^2}{(30.0 \text{ cm})(980 \text{ cm/s}^2)} = \boxed{0.0850}$.

2 A 4.00-kg object is attached to a vertical rod by two strings, as in Figure The object rotates in a horizontal circle at constant speed 6.00 m/s. Find the tension in (a) the upper string and (b) the lower string.




Solution:

$F_g = mg = (4 \text{ kg})(9.8 \text{ m/s}^2) = 39.2 \text{ N}$

$\sin\theta = \frac{1.5 \text{ m}}{2 \text{ m}}$

$\theta = 48.6°$

$r = (2 \text{ m})\cos 48.6° = 1.32 \text{ m}$

$\sum F_x = ma_x = \frac{mv^2}{r}$

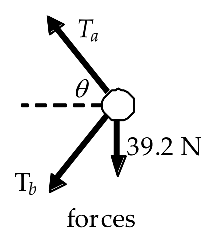
$T_a \cos 48.6° + T_b \cos 48.6° = \frac{(4 \text{ kg})(6 \text{ m/s})^2}{1.32 \text{ m}}$

$T_a + T_b = \frac{109 \text{ N}}{\cos 48.6°} = 165 \text{ N}$

$\sum F_y = ma_y$

$+T_a \sin 48.6° - T_b \sin 48.6° - 39.2 \text{ N} = 0$

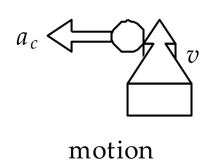
$T_a - T_b = \frac{39.2 \text{ N}}{\sin 48.6°} = 52.3 \text{ N}$




To solve simultaneously, we add the equations in $T_a$ and $T_b$:

$T_a + T_b + T_a - T_b = 165 \text{ N} + 52.3 \text{ N}$

$T_a = \frac{217 \text{ N}}{2} = \boxed{108 \text{ N}}$ $T_b = 165 \text{ N} - T_a = 165 \text{ N} - 108 \text{ N} = \boxed{56.2 \text{ N}}$



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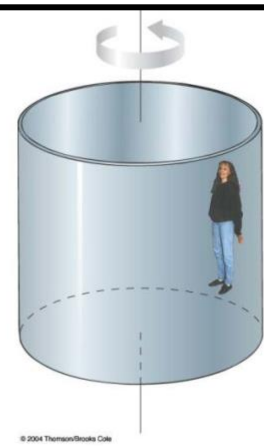
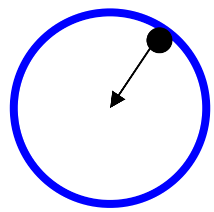
3 A rid in an amusement park consists of a large vertical cylinder that spins about its axis fast enough that any person inside is held up against the wall when the floor drops away . The coefficient of static friction between person and wall is $\mu_s$, and the radius of the cylinder is $R$. (a) Show that the maximum period of revolution necessary to keep the person from falling is $T = (4\pi^2 R\mu_s/g)^{1/2}$. (b) Obtain a numerical value for $T$ if $R$ = 4.00 m and $\mu_s$ = 0.400. How many revolutions per minute does the cylinder make?



(a) $n = \dfrac{mv^2}{R}$ $\qquad f - mg = 0$



$f = \mu_s n$ $\qquad v = \dfrac{2\pi R}{T}$ $\qquad T = \boxed{\sqrt{\dfrac{4\pi^2 R\mu_s}{g}}}$

4 A skier of mass 70.0 kg is pulled up a slope by a motor-driven cable. (a) How much work is required to pull him a distance of 60.0 m up a 30.0° slope (assumed frictionless) at a constant speed of 2.00 m/s? (b) A motor of what power is required to perform this task?

(a) $\sum W = \Delta K$, but $\Delta K = 0$ because he moves at constant speed. The skier rises a vertical distance of $(60.0\ \text{m})\sin 30.0° = 30.0\ \text{m}$ . Thus,

$$W_{\text{in}} = -W_g = (70.0\ \text{kg})(9.8\ \text{m/s}^2)(30.0\ \text{m}) = \boxed{2.06\times 10^4\ \text{J}} = \boxed{20.6\ \text{kJ}}.$$

(b) The time to travel 60.0 m at a constant speed of 2.00 m/s is 30.0 s. Thus,

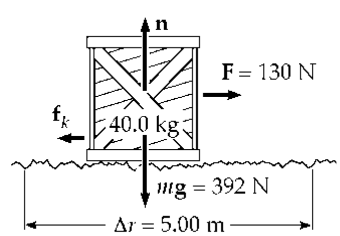
$$P_{\text{input}} = \frac{W}{\Delta t} = \frac{2.06\times 10^4\ \text{J}}{30.0\ \text{s}} = \boxed{686\ \text{W}} = 0.919\ \text{hp}.$$

2. A 40.0-kg box initially at rest is pushed 5.00 m along a rough, horizontal floor with a constant applied horizontal force of 130 N. If the coefficient of friction between box and floor is 0.300, find (a) the work done by the applied force, (b) the increase in internal energy in the box-floor system due to friction, (c) the work done by the normal force, (d) the work done by the gravitational force, (e) the change in kinetic energy of the box, and (f) the final speed of the box.

$\sum F_y = ma_y:$ $\qquad n - 392\ \text{N} = 0$

$$n = 392\ \text{N}$$

$$f_k = \mu_k n = (0.300)(392\ \text{N}) = 118\ \text{N}$$




(a) $W_F = F\Delta r\cos\theta = (130)(5.00)\cos 0° = \boxed{650\ \text{J}}$

(b) $\Delta E_{\text{int}} = f_k\Delta x = (118)(5.00) = \boxed{588\ \text{J}}$

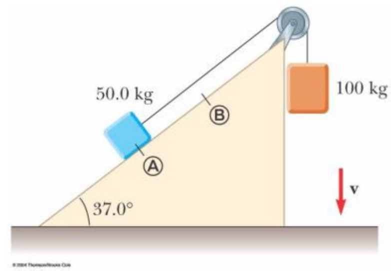
(c) $W_n = n\Delta r\cos\theta = (392)(5.00)\cos 90° = \boxed{0}$

(d) $W_g = mg\Delta r\cos\theta = (392)(5.00)\cos(-90°) = \boxed{0}$

(e) $\Delta K = K_f - K_i = \sum W_{\text{other}} - \Delta E_{\text{int}}$

$$\frac{1}{2}mv_f^2 - 0 = 650\text{ J} - 588\text{ J} + 0 + 0 = \boxed{62.0\text{ J}}$$

6 A 50.0-kg block and 100-kg block are connected by a string as in Figure P8.36. The pulley is frictionless and of negligible mass. The coefficient of kinetic friction between the 50-kg block and incline is 0.250. Determine the change in the kinetic energy of the 50-kg block as it moves from A to B, a distance of 20.0 m.




$$\sum F_y = n - mg\cos 37.0° = 0$$

$$\therefore n = mg\cos 37.0° = 400\text{ N}$$

$$f = \mu n = 0.250(400\text{ N}) = 100\text{ N}$$

$$-f\Delta x = \Delta E_{mech}$$

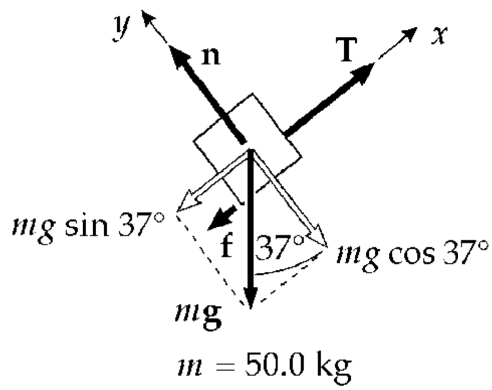
$$(-100)(20.0) = \Delta U_A + \Delta U_B + \Delta K_A + \Delta K_B$$

$$\Delta U_A = m_A g(h_f - h_i) = (50.0)(9.80)(20.0\sin 37.0°) = 5.90\times 10^3$$

$$\Delta U_B = m_B g(h_f - h_i) = (100)(9.80)(-20.0) = -1.96\times 10^4$$

$$\Delta K_A = \frac{1}{2}m_A\left(v_f^2 - v_i^2\right)$$

$$\Delta K_B = \frac{1}{2}m_B\left(v_f^2 - v_i^2\right) = \frac{m_B}{m_A}\Delta K_A = 2\Delta K_A$$




Adding and solving, $\Delta K_A = \boxed{3.92\text{ kJ}}$.