UNIVERSITY OF OTTAWA
Principles of Physics
PHY1321/1331 FALL 2016
Dr. A. Czajkowski

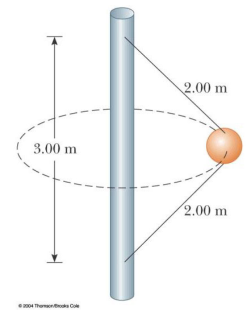
STUDENT #: ______________

NAME:______________________

ASSIGNEMENT 9 : Forces.
Work, Energy
Assigned : Nov 11 Due Nov 18; 6PM

1 The answers may vary

A 4.00-kg object is attached to a vertical rod by two strings, as in Figure P6.11. 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:

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

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

$$\theta = 48.6°$$

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

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

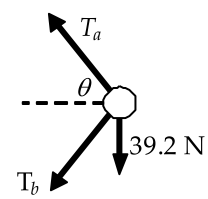
$$T_a \cos 48.6° + T_b \cos 48.6° = \frac{(4\ \text{kg})(6\ \text{m/s})^2}{1.32\ \text{m}}$$

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

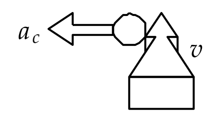
$$\sum F_y = ma_y$$

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

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



forces



motion

(a) To solve simultaneously, we add the equations in T_a and T_b:

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

$$T_a = \frac{217\ \text{N}}{2} = \boxed{108\ \text{N}}$$

(b) $T_b = 165\ \text{N} - T_a = 165\ \text{N} - 108\ \text{N} = \boxed{56.2\ \text{N}}$

2 A crate of eggs is located in the middle of the flat bed of a pickup truck as the truck negotiates an unbanked curve in the road. The curve may be regarded as an arc of a circle of radius 35.0 m. If the coefficient of static friction between crate and truck is 0.600, how fast can the truck be moving without the crate sliding?

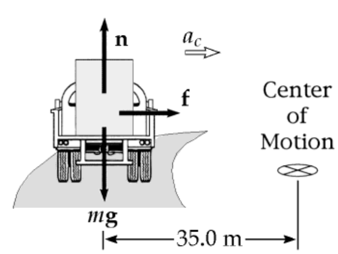
$n = mg$ since $a_y = 0$

The force causing the centripetal acceleration is the frictional force f.

From Newton's second law $f = ma_c = \dfrac{mv^2}{r}$.

But the friction condition is $f \le \mu_s n$

i.e., $\dfrac{mv^2}{r} \le \mu_s mg$



$$v \le \sqrt{\mu_s r g} = \sqrt{0.600(35.0\ \text{m})(9.80\ \text{m/s}^2)}$$

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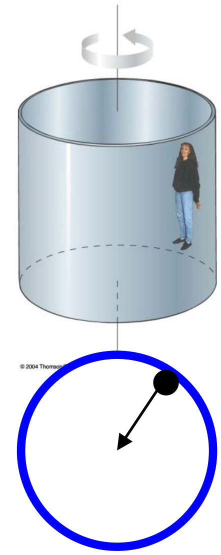
3 An amusement park ride consists of a large vertical cylinder that spins about its axis fast enough that any person inside is held up against the wall when the floor drops away . The coefficient of static friction between person and wall is μ_s, and the radius of the cylinder is R.
(a) Show that the 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 μ_s = 0.400. How many revolutions per minute does the cylinder make?



$$\text{(a)}\; n = \frac{mv^2}{R} \qquad f - mg = 0 \qquad f = \mu_s n \qquad v = \frac{2\pi R}{T}$$

$$T = \boxed{\sqrt{\frac{4\pi^2 R\mu_s}{g}}}$$

$$\text{(b)}\; T = \boxed{2.54\ \text{s}} \qquad \#\ \frac{\text{rev}}{\text{min}} = \frac{1\ \text{rev}}{2.54\ \text{s}}\left(\frac{60\ \text{s}}{\text{min}}\right) = \boxed{23.6\ \frac{\text{rev}}{\text{min}}}$$

4. a) A force $\mathbf{F} = \left(4x\hat{\mathbf{i}} + 3y\hat{\mathbf{j}}\right)\text{N}$ acts on an object as the object moves in the x direction from the origin to x = 5.00 m. Find the work $W = \int \mathbf{F}\cdot d\mathbf{r}$ done on the object by the force.

Displacement is along x axis so work is given by

$$W = \int_0^5 \vec{F}\cdot\overrightarrow{dx} = \int_0^5 (4x\vec{\imath} + 3y\vec{\jmath})\cdot dx\vec{\imath} = \int_0^5 4x dx = 2x^2|_0^5 = 50(\text{N})$$

b)A shopper in a supermarket pushes a cart with a force of 35.0 N directed at an angle of 25.0° downward from the horizontal. Find the work done by the shopper on the cart as he moves down an aisle 50.0 m long.

$$W = \int_0^5 \vec{F}\cdot\overrightarrow{dr} = \vec{F}\cdot\overrightarrow{\Delta r} = |\vec{F}||\overrightarrow{\Delta r}|cos\theta = (35N)(50m)cos20 = 1644J$$

5. 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,

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

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

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

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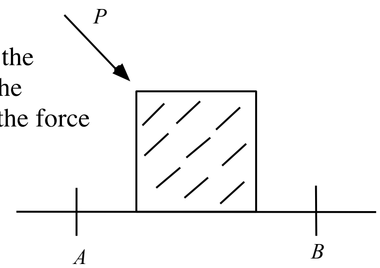
6 A block is pushed across a rough horizontal surface from point A to point B by a force (magnitude P = 5.4 N) as shown in the figure. The magnitude of the force of friction acting on the block between A and B is 1.2 N and points A and B are 0.5 m apart. If the kinetic energies of the block at A and B are 4.0 J and 5.6 J, respectively, how much work in J is done on the block by the force P between A and B?



$$\Delta E_{kin} = 1.6J$$

$$\Delta E_{kin} = W_{total} = W_f + W_P = \vec{f} \cdot \overrightarrow{\Delta r} + \vec{P} \cdot \overrightarrow{\Delta r}$$

$W_P = \Delta E_{kin} - W_f$ so that $W_P = \Delta E_{kin} + \vec{f} \cdot \overrightarrow{\Delta r} = 1.6J - (1.2)(0.5)J$=1.0J

ANS: Force P does 1 joule of work from A to B.

7 The skier of mass M slides from on an icy (frictionless) hemispherical mountain of radius R.
a) Draw the free body diagram, and write Newton's Second Law for the block of mass M as it is at some point on the slope
b) At what angle α with vertical will she loose contact with the surface ?

ANS $\cos\theta = 2/3$ so $\theta = 48.2^{\circ}$