Finish Chapter 8
Read 8.8 - 8.9

H.w #9 Due today
H.w #10 (Last one!) available

Class evaluations next week

Make up exam
Wednesday 23rd 3-6 p.m
my office

ex) A cylindrical 3.0 kg pulley with radius R = 0.4 m is used to lower a 2.0 kg bucket. The bucket starts from rest and falls for 3.0 s

a) what is linear acceleration of bucket

b) How far does it drop

c) what is angular acceleration of pulley

$+\downarrow$

$\theta = 90°$

$\tau = rF\sin\theta$

$a_T = r\alpha$

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

$\Sigma F = ma$

$\Sigma \tau = I\alpha$

$-T + mg = ma$

hanging mass

$rT\sin 90° = I\alpha$

$rT = \left(\frac{1}{2}Mr^2\right)\left(\frac{a}{r}\right)$

$T = \frac{1}{2}Ma$

mass pulley

algebra

② $T = \frac{1}{2} M a$

put into ①

M = pulley mass
m = bucket mass

$$mg - \frac{1}{2} M a = ma$$

$$a = \left(\frac{mg}{m + \frac{M}{2}} \right) = \frac{(2\,kg \times 9.8\,m/s^2)}{2\,kg + \frac{3\,kg}{2}} = \underline{5.6\,m/s^2}$$

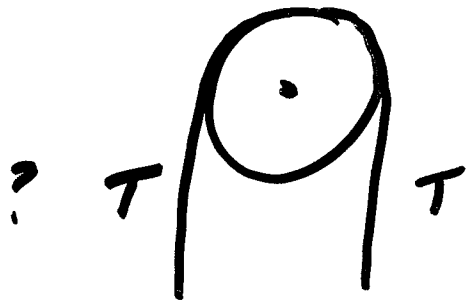
$$M = 0 \quad a = \frac{mg}{m+0} = \underline{g}$$

b) $y = y_0 + v_{y_0}^{0} t + \frac{1}{2} a t^2$

$$y - y_0 = 0 + \frac{1}{2}(5.6\,m/s^2)(3.5)^2 = \underline{25.2\,m}$$

c) $\alpha = \frac{a}{R} = \frac{5.6\,m/s^2}{0.4\,m} = 14.0\,rad/s^2$

massless pulley



massive pulley

$I = \frac{1}{2}mr^2$

α

$\tau_{net} = I\alpha$

T' must be different than T

so a net torque so I can have angular acceleration

Rolling motion

Rotational Kinetic Energy

First: Translational kinetic Energy

Translational	Rotational
x	θ
v	ω
a	α
m	I

Translational $K.E = \frac{1}{2} m v^2$

Rotational $K.E = \frac{1}{2} I \omega^2$

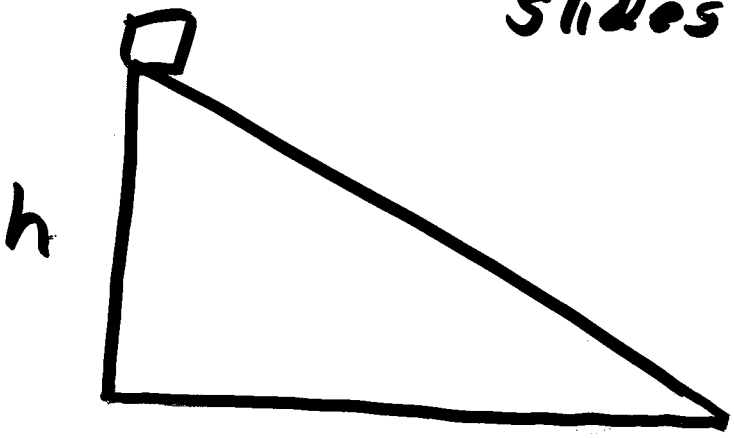
$\frac{1}{2} m v^2$

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

$\frac{1}{2} m v^2 + \frac{1}{2} I \omega^2$

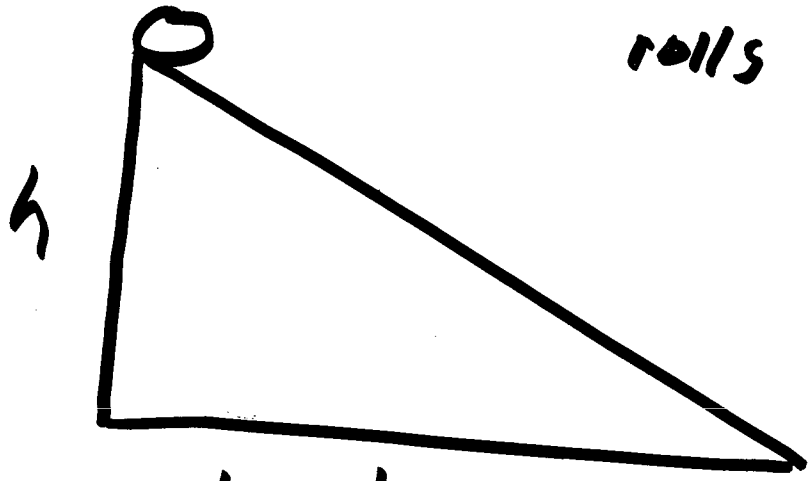
slides

Conservation of Energy



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

rolls



$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

<u>Note</u> Velocity smaller

Some energy goes into rotation

so less energy for translation

Interactive Question

A hollow cylinder of mass M and radius R rolls down an inclined plane. A block of mass M slides down an identical inclined plane. If both objects are released at the same time

A) the block will reach the bottom first.
B) the cylinder will reach the bottom first.
C) the block will reach the bottom with greater kinetic energy
D) the cylinder will reach the bottom with greater kinetic energy
E) both the block and the cylinder will reach the bottom at the same time.

Interactive Question

A solid sphere (S), a thin hoop (H), and a solid disk (D), all with the same radius, are allowed to roll down an inclined plane without slipping. In which order will they arrive at the bottom? (The fist one down listed first).

A) H,D,S

B) H,S,D

C) S,D,H

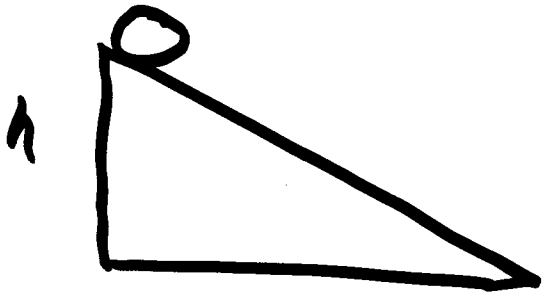
D) S,H,D

E) D,H,S

$I_S = \frac{2}{5} mR^2$

$I_H = mR^2$

$I_D = \frac{1}{2} mR^2$



$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$ $\quad v = \omega r$

$I = \frac{1}{2}mr^2$ $\quad \omega = \frac{v}{r}$

$mgh = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{1}{2}mr^2\right)\left(\frac{v^2}{r^2}\right)$

$gh = \frac{1}{2}v^2 + \frac{1}{4}v^2$

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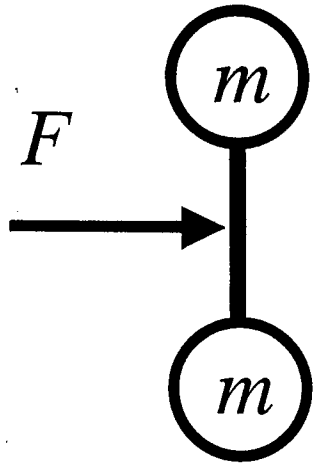
independent of mass and radius

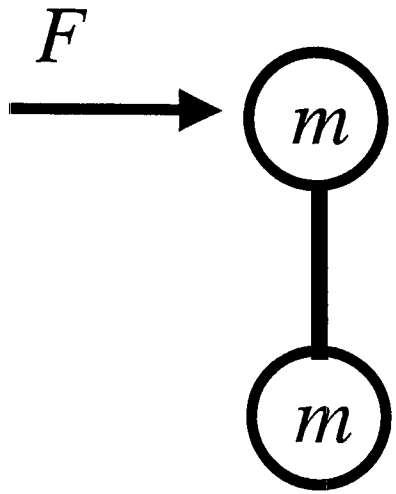
Interactive Question

A force F is applied to a dumbbell for a time interval Δt, first as in (a) and then as in (b). In which case does the dumbbell acquire the greater energy?

(a)



(b)



A) (a)

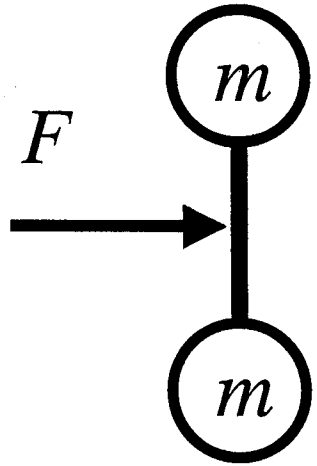
B) (b)

C) no difference

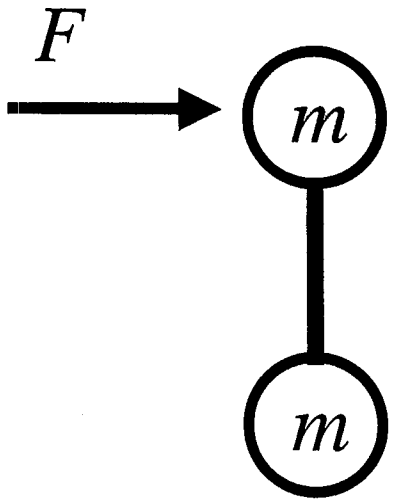
Interactive Question

A force F is applied to a dumbbell for a time interval Δt, first as in (a) and then as in (b). In which case does the dumbbell acquire the greater center-of-mass speed?

(a)



(b)



A) (a)

B) (b)

C) no difference

ex) Two bicycles roll down a hill 20 m high. Both have a mass of 12 kg and wheels of radius .35 m. 1st bicycle has wheels that are 0.6 kg each. 2nd bicycle has wheels that are 0.3 kg each. Which bicycle has faster speed at bottom?

conservation of Energy

$K_i + U_i = K_f + U_f$

$0 + mgh = \frac{1}{2}mv_f^2 + \frac{1}{2}I\omega^2 + 0$

$mgh = \frac{1}{2}mv_f^2 + 2\cdot\frac{1}{2}I\omega^2$

m = mass of bike

2 tires/bike

$I = MR^2$

M = mass of tire

$mgh = \frac{1}{2}mv_f^2 + MR^2\left(\frac{v}{R}\right)^2$

$v = \omega R$

$\omega = \frac{v}{R}$

$mgh = \frac{1}{2}mv_f^2 + Mv_f^2$

$v_f = \sqrt{\frac{mgh}{\frac{1}{2}m + M}}$ (algebra)

$M = 0.3$ kg $\quad v_f = 17.3$ m/s

$M = 0.6$ kg $\quad v_f = 18.9$ m/s