Physics 113 – November 5, 2013

- Exam 2 – Nov 12 at 0800 in Hubbell Aud.
- 1 Side of 8.5 x 11 inch Sheet
- Material coverage sent out in email
- Q+A session ... need to schedule
- No prob set due this week
- Probably will have workshops next week ... but have not decided yet

Last Time

Rotational Motion

$s = r\theta$

$v = r\omega$

$a = r\alpha$

	Linear	angular
general	$x - x_0 = \int v\,dt$	$\theta - \theta_0 = \int \omega\,dt$
	$v - v_0 = \int a\,dt$	$\omega - \omega_0 = \int \alpha\,dt$
constant a / α	$v = v_0 + at$	$\omega = \omega_0 + \alpha t$
	$x = x_0 + v_0 t + \frac{1}{2}at^2$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
	$v^2 = v_0^2 + 2a(x - x_0)$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$
	$x - x_0 = \frac{1}{2}(v + v_0)t$	$\theta - \theta_0 = \frac{(\omega + \omega_0)}{2}t$
general	$F = ma$	$\tau = I\alpha$
	$KE = \frac{1}{2}mv^2$	$KE = \frac{1}{2}I\omega^2$

$F = ma$

$$\boxed{\tau = I\alpha}$$

Angular Acceleration

$a = r\alpha$

Torque

Moment of Inertia

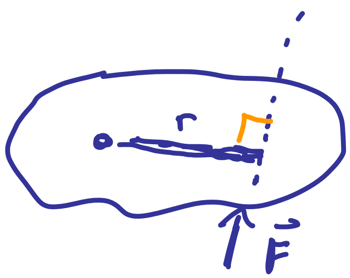
Torque $\rightarrow rF$

$$I = \sum_i (mr^2)_i$$

$$\Downarrow$$

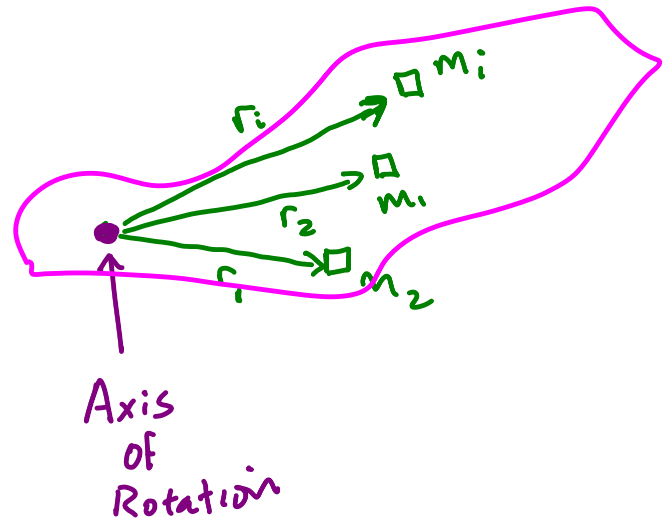
$$I = \int r^2 \, dm$$

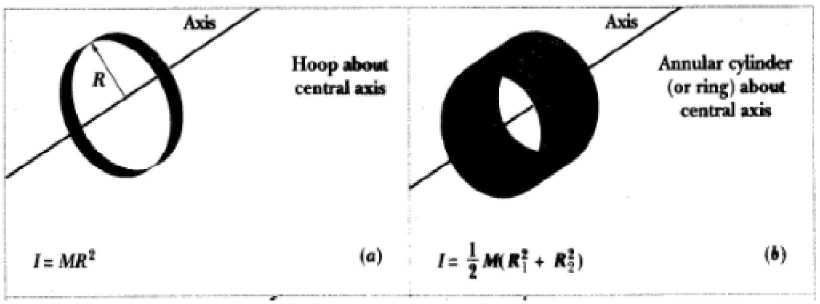
$$I = \int r^2 \rho \, dV$$



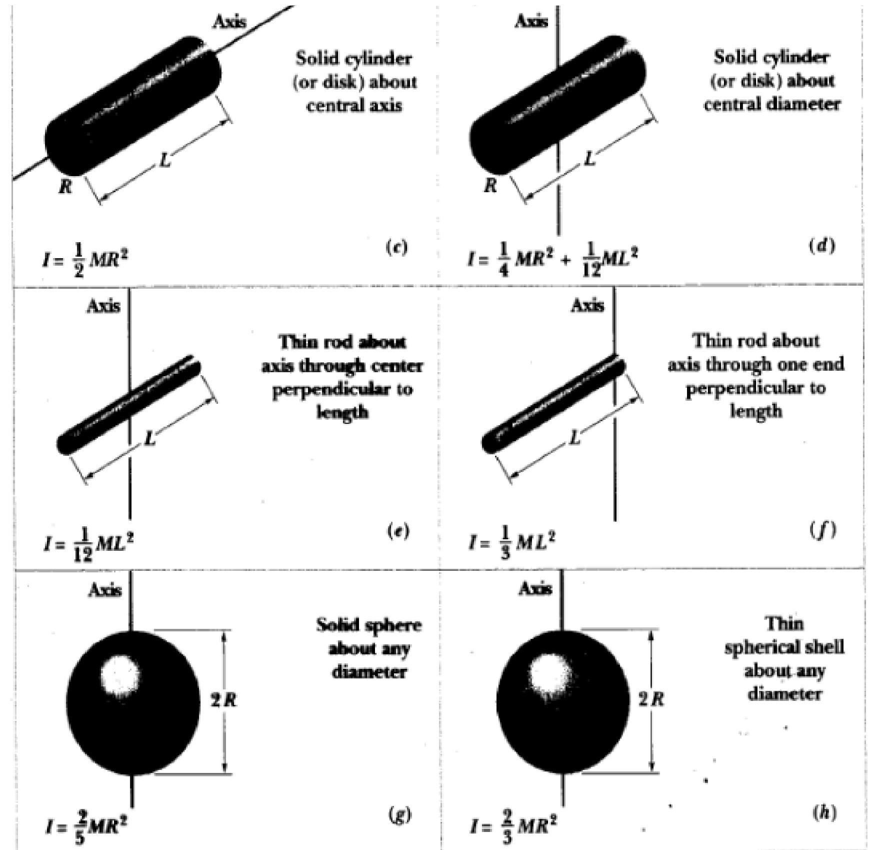
Vector equations

... Vector part coming soon





Moments of Inertia



How far up ramp will wheel go?

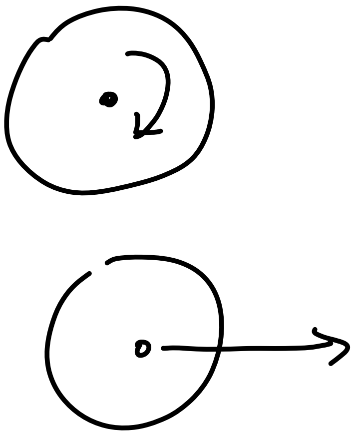
What is h?

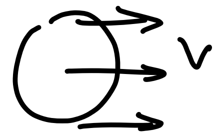
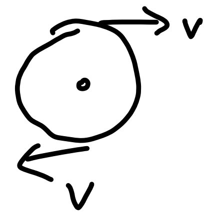
cylinder (wheel) rotates w/out slipping

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

$$\boxed{h = \frac{v^2}{2g}}$$

TOTAL KE wheel Moving w/out Slipping (Method I)



Total KE =  + 

Linear TRANS KE

Rotation About c.M.

$\frac{1}{2}Mv^2$

$S = R\theta$

$v = R\omega$

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

$\frac{1}{2}I\left(\frac{v}{R}\right)^2$

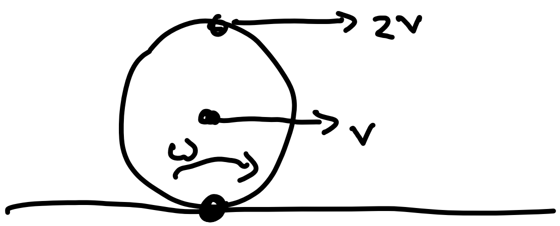
$\frac{1}{4}Mv^2 = \frac{1}{2}\left(\frac{1}{2}MR^2\right)\frac{v^2}{R^2}$

Total KE $= \frac{3}{4}Mv^2$

$$\frac{3}{4}Mv^2 = mgh$$

$$h = \frac{3v^2}{4g}$$

TOTAL KE wheel Moving w/out Slipping (Method II)



$v = R\omega$

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

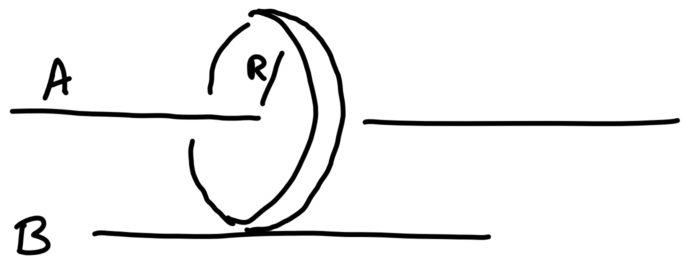
Think of "rotation only" about bottom point

$$KE = \frac{1}{2} I \omega^2 = \frac{3}{4} M v^2$$

I: ? $\frac{3}{2} M R^2$

ω^2: $\left(\frac{v}{R}\right)^2$

Parallel Axis Theorem

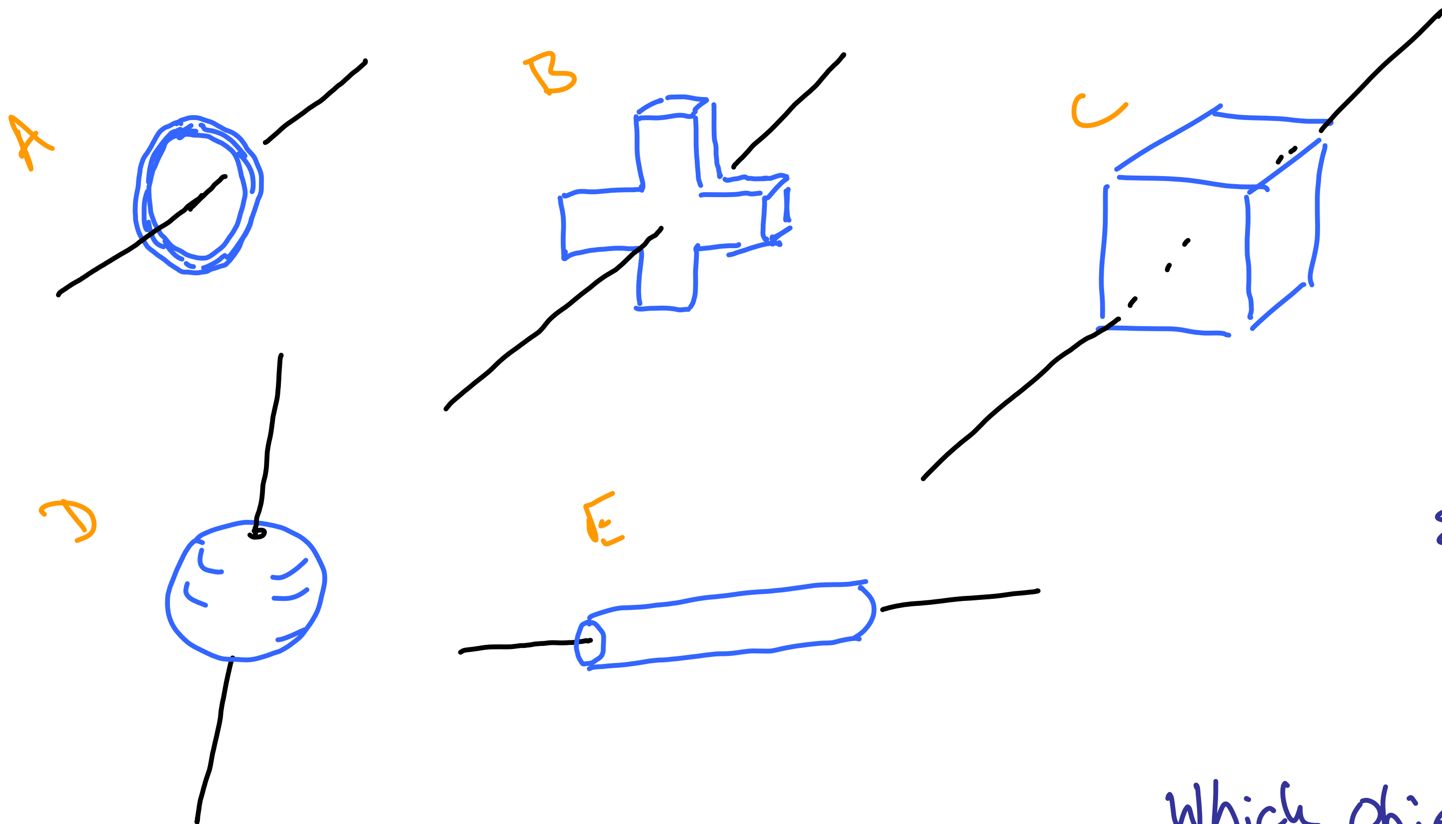


$$I_A = \frac{1}{2} M R^2$$

r = Dist bet Axes

parallel axis Theorem

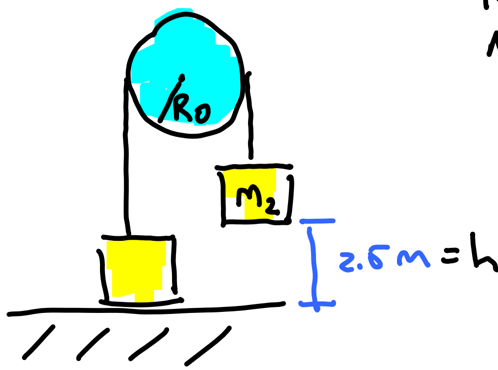
$$I_B = I_A + M r^2 = \frac{1}{2} M R^2 + M R^2 = \frac{3}{2} M R^2$$



All objects have the same Mass.

Each is solid and has uniform Density.

Which Object has the largest Moment of inertia about the Axes shown?



$M_1 = 35.0\ kg$
$M_2 = 38.0\ kg$

Pulley: uniform cylinder w/ radius $R_0 = 0.3\,m$ and Mass $M = 4.8\,kg$

Init M_1 on ground M_2 at rest 2.5 m above grnd

Assume rope massless and does not slip

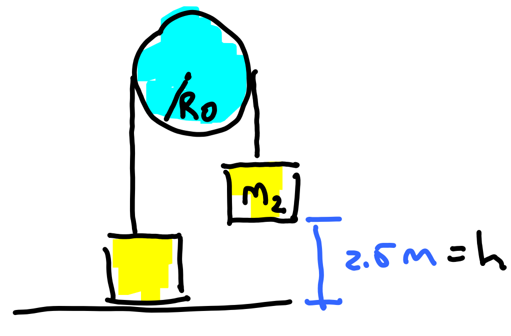
System released → what's speed of M_2 just before it hits the ground?

Two ways to solve this problem → Energy conservation
→ Newton's Laws

Energy Conservation

$$E_{START} = E_{end}$$

$\uparrow v \quad \downarrow v$



$$m_2 g h = m_1 g h + \frac{1}{2}M_1 v_1^2 + \frac{1}{2}M_2 v_2^2 + \frac{1}{2}I\omega^2$$

$$v_1 = v_2 = v = R_0\omega$$

$$I = \frac{1}{2}MR_0^2$$

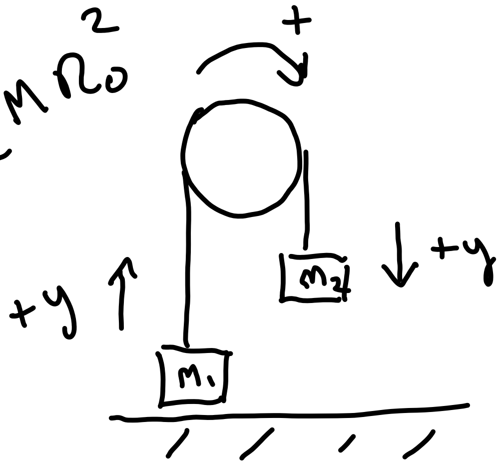
$$M_2 g h = M_1 g h + \frac{1}{2}(M_1 + M_2)v^2 + \frac{1}{2}\left(\frac{1}{2}MR_0^2\right)\frac{v^2}{R_0^2}$$

Solve for v

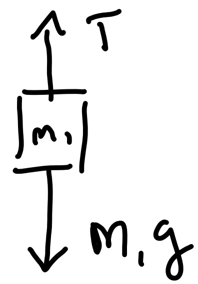
$$v = \pm\sqrt{\frac{(M_1 - M_2)gh}{\frac{M}{4} + \frac{M_2}{2} + \frac{M_1}{2}}} = \pm 1.4\ m/s$$

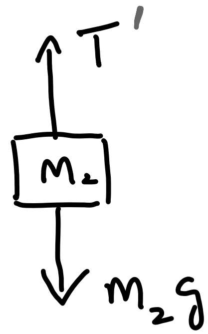
1.4 m/s

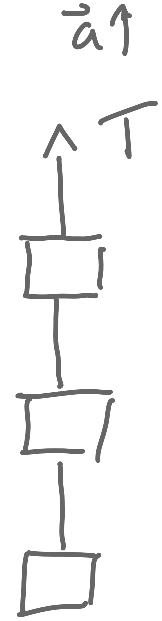
$$I = \frac{1}{2} M R_0^2$$



FBD's

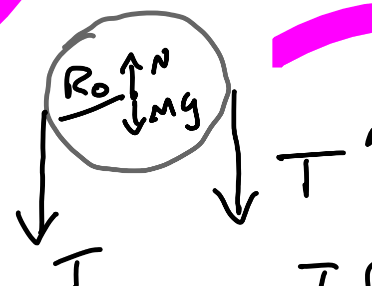






$$\sum F_y = m_1 a = T - m_1 g$$

$$\sum F_y = m_2 a = m_2 g - T'$$



$$\sum \tau = I\alpha$$

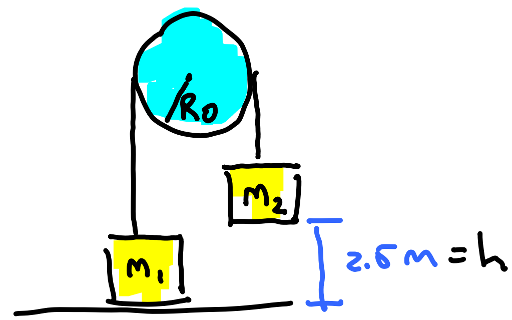
$$\frac{1}{2} M R_0^2 \frac{a}{R_0} = I\alpha = R_0 T' - R_0 T$$

$$\frac{1}{2} M R_0 a = R_0 T' - R_0 T$$

$$a = \frac{(m_2 - m_1)g}{\frac{1}{2}M + m_1 + m_2}$$

const a

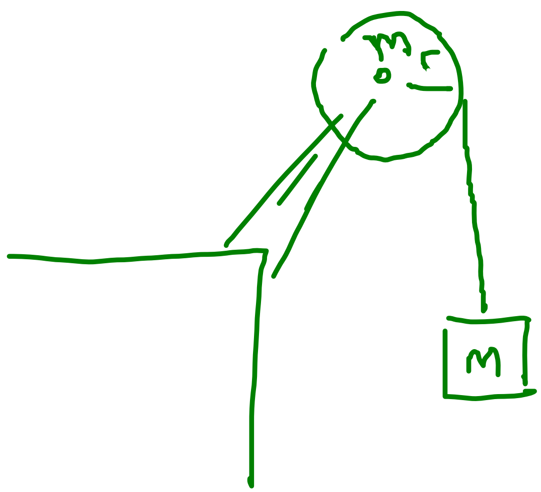
$$a = 0.4\ m/s^2$$



$$V_2^2 = \cancel{V_{02}^2}_{0} + 2ah$$

$$V_2^2 = 2(.4)(2.5) = 2$$

$$V_2 = 1.4\ m/s$$



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

correct expr.
for a

1) g

2) $\left(\frac{M-m}{M+m}\right) g$

3) $\left(\frac{1}{2} m r^2 + M\right) g$

4) $\left(\frac{2M}{2M+m}\right) g$