

$m_1 = 9 \text{ kg}$   $m_2 = 1.5 \text{ kg}$   $\omega_0 = 2 \text{ rad/s}$   
 Conservation of angular momentum  
 $L_0 = I \omega_0 = \frac{m_1 r^2}{2} \omega_0 = L_1 = \frac{m_1 r^2}{2} \omega + m_2 r^2 \omega$   
 $\frac{m_1 \omega_0}{2} = \omega \left( \frac{m_1}{2} + m_2 \right)$   $\omega = \frac{m_1 \omega_0}{m_1 + 2m_2} = \frac{9}{9+3} \text{ rad/s} = 4.5 \text{ rad/s}$

$m_1 \text{ (1) } m_2 v = (m_1 + m_2) v_{cm}$   $v_{cm} = \frac{m_2}{m_1 + m_2} v$   $r_{cm} = \frac{x m_2}{m_1 + m_2}$   
 $(x - r_{cm}) m_2 v = I \omega = \left( \frac{m_1 \ell^2}{12} + r_{cm}^2 m_1 + m_2 (x - r_{cm})^2 \right) \omega$   $\omega = \frac{(x - r_{cm}) m_2 v}{I}$   
 $\text{(2) } m_1 = m_2 = m$   $x = \ell$   $r_{cm} v = I \omega = \left( \frac{m \ell^2}{12} + m r^2 \right) \omega$   
 $\omega = \frac{r v}{\frac{\ell^2}{12} + r^2}$   $J = \Delta p = m \omega r - m v$

$J_x = \Delta p_x = -m_2 v$   
 $I \omega = I' \omega'$   $\frac{m_1 \ell^2}{12} \omega = \left( \frac{m_1 \ell^2}{12} + \frac{m_2 \ell^2}{4} \right) \omega'$   $\omega' = \frac{m_1 \omega}{m_1 + 3m_2}$   
 $J_y = \Delta p_y = \frac{1}{2} m_2 \omega' \ell$   $J = \sqrt{J_x^2 + J_y^2}$   $\theta = \arcsin \frac{J_y}{J}$

$L \omega = I \omega'$   $\frac{1}{2} m_1 R^2 \omega = \left( \frac{1}{2} m_1 R^2 + m_2 d^2 \right) \omega'$   $\omega' = \frac{m_1 R^2 \omega}{m_1 R^2 + 2m_2 d^2}$   
 $J_y = m_2 \sqrt{egh}$  Impulse angular =  $J \ell$

$m v = 2 M v_{cm}$   $v_{cm} = \frac{v}{2}$   $L_f = 0 \Rightarrow \frac{1}{2} R m v = \frac{1}{2} R^2 \omega$   $\omega = \frac{v}{R}$   
 Polo: 0  $L_i = R m v \sin \theta - I \omega = \frac{1}{2} R m v - \frac{1}{2} m R^2 \omega$   
 $2 R \sin \theta = R$   $\sin \theta = \frac{1}{2}$   $\theta = \frac{\pi}{6}$

$\frac{GM}{R^2} = \frac{v^2}{R}$   $T = \frac{2\pi R}{v}$   $T^2 = \frac{4\pi^2 R^3}{v^2} = \frac{4\pi^2}{GM} R^3$   
 $P = m v_{cm} = 0$   $L = 3 R m v_h$   
 $\frac{M v^2}{R} = \frac{GMm}{R^2} + \frac{2GMm^2}{(2R \sin \theta)^2} = \frac{GMm}{R^2} + \frac{2GMm^2}{3R^2}$   $v_h = \sqrt{\frac{R}{3} \left( M + \frac{2}{3} m \right)}$   
 $T = \frac{2\pi R}{v_h}$

$E_{p0} \frac{1}{m} = \frac{1}{M} + \frac{3}{m} = \frac{m+3M}{Mm}$   $\mu = \frac{Mm}{m+3M}$   $E_{p0} = 3 \frac{GMm}{R} \Rightarrow 3 \frac{G \mu m^2}{(R \mu)}$