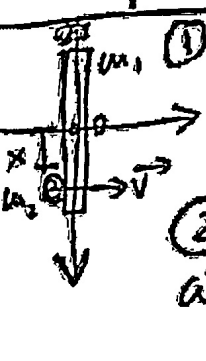

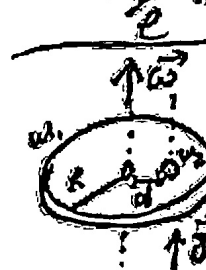



$m_1 = 9 \text{ kg}$   $m_2 = 1.5 \text{ kg}$   $\omega_0 = 2 \text{ rad/s}$   
 Conservation of angular momentum  
 $L_0 = I \omega_0 = \frac{m_1 r^2}{2} \omega_0 = L_1 = \frac{m_1 r^2}{2} \omega + m_2 r^2 \omega$   
 $\frac{m_1 \omega_0}{2} = \omega \left( \frac{m_1}{2} + m_2 \right)$   $\omega = \frac{m_1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


 ①  $m_2 v = (m_1 + m_2) v_{cm}$   $v_{cm} = \frac{m_2}{m_1 + m_2} v$   $r_{cm} = \frac{x m_1 l}{m_1 + m_2}$   
 $(x - r_{cm}) m_2 v = I \omega = \left( \frac{m_1 l^2}{12} + r_{cm}^2 m_1 + m_2 (x - r_{cm})^2 \right) \omega$   $\omega = \frac{(x - r_{cm}) m_2 v}{I}$   
 ②  $m_1 = m_2 = m$   $x = \frac{l}{2}$   $r_{cm} = \frac{l}{4}$   $v_{cm} = \frac{v}{2}$   
 $\omega = \frac{r_{cm} v}{\frac{l^2}{12} + m r^2}$   $J = \Delta p = m \omega r - m v$


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


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


 1:  $m, R, v \neq 0, \omega = 0$   
 2:  $m, R, v = 0, \omega \neq 0$   
 3:  $m, R, v \neq 0, \omega \neq 0$   
 $L_f = 0 \Rightarrow R m v = \frac{m R^2 \omega}{2}$   $\omega = \frac{2v \sin \theta}{R}$   
 $\omega = \frac{v}{R}$   $\theta = \frac{\pi}{6}$

$\frac{G M m}{R^2} = \frac{v^2}{R}$   $T = \frac{2\pi R}{v}$   $T^2 = \frac{4\pi^2 R^3}{v^2} = \frac{4\pi^2}{G M} R^3$   
 $P = m v_{cm} = 0$   $L = 3 R m v_{cm}$   
 $\frac{m v^2}{R} = \frac{G M m}{R^2} + \frac{2 G m^2}{(2 R \sin \theta)^2}$   $v = \sqrt{\frac{G}{R} \left( M + \frac{4}{3} m \right)}$   
 $T = \frac{2\pi R}{v}$   $\frac{1}{M} = \frac{1}{M} + \frac{3}{m} = \frac{m + 3M}{M m}$   $M = \frac{M m}{m + 3M}$   $E_{pot} = 3 \frac{G M m}{R} \Rightarrow 3 \frac{G m^2}{(R \sqrt{3})}$