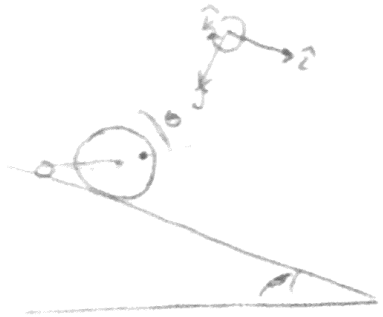

$$U = Mg\sin\beta R\theta + m_0 g\sin\beta R\theta + mg\sin\beta r\theta - P\theta$$

$$KE = \frac{1}{2}m_0 v_0^2 + \frac{1}{2}Mv_0^2 + \frac{1}{2}I_0\omega^2 + \frac{1}{2}mv_m^2, \quad \vec{v}_0 = \omega R\hat{i}, \quad \vec{v}_m = \vec{v}_0 + \vec{\omega}\times\vec{r}$$

$$\Rightarrow \vec{v}_m = \omega R\hat{i} + \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 0 & \omega \\ r\sin\theta & r\cos\theta & 0 \end{vmatrix}$$

$$\Rightarrow \vec{v}_m = \omega R\hat{i} + \omega r\cos\theta\hat{i} + \omega r\sin\theta\hat{j}$$

$$\Rightarrow \vec{v}_m = \omega(R + r\cos\theta)\hat{i} + \omega r\sin\theta\hat{j}$$

$$\Rightarrow Mg\sin\beta R\theta + m_0 g\sin\beta R\theta + mg\sin\beta r\theta - P\theta = \frac{1}{2}m_0\omega^2R^2 + \frac{1}{2}M\omega^2R^2 + \frac{1}{2}Mk^2\omega^2 + \frac{1}{2}m\omega^2((R+r\cos\theta)^2 + (r\sin\theta)^2)$$

$$\Rightarrow g\sin\beta\theta(R(M+m_0)+mr) - P\theta = \omega^2\left(\frac{1}{2}m_0R^2 + \frac{1}{2}MR^2 + \frac{1}{2}Mk^2 + \frac{1}{2}m((R+r\cos\theta)^2 + (r\sin\theta)^2)\right)$$

$$\Rightarrow \omega = \sqrt{\frac{2g\sin\beta\theta(R(M+m_0)+mr) - P\theta}{R^2(M+m_0) + Mk^2 + m((R+r\cos\theta)^2 + (r\sin\theta)^2)}}$$