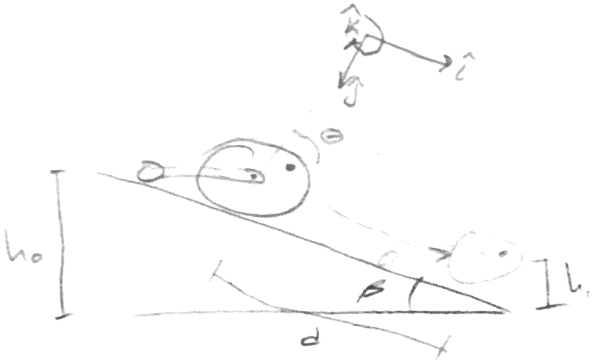

$\cancel{KE_1}^{0} + PE_1 = KE_2 + PE_2$, $d = 15R$

$PE_1 = m_0 g h_0 + M g h_0 + m g(h_0 + r\cos(\beta))$, $h_0 = 15R\sin\beta$

$PE_2 = m_0 g h_1 + M g h_1 + m g(h_1 + r\cos(\theta+\beta))$, $h_1 = (15-\theta)R\sin\beta = 15R\sin\beta - R\theta\sin\beta$

$KE_2 = \frac{1}{2} m_0 v_G^2 + \frac{1}{2} M v_G^2 + \frac{1}{2} I_G \omega^2 + \frac{1}{2} m v_m^2$, $\vec{V}_G = \omega R\,\hat{i}$, $I_G = Mk^2$

$$\vec{V}_m = \vec{V}_G + \vec{\omega}\times\vec{r} \Rightarrow \vec{V}_m = \omega R\hat{i} + \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 0 & \omega \\ r\sin\theta & -r\cos\theta & 0 \end{vmatrix} \Rightarrow \vec{V}_m = \omega R\hat{i} + \omega r\cos\theta\,\hat{i} + \omega r\sin\theta\,\hat{j} \Rightarrow \vec{V}_m = (\omega R + \omega r\cos\theta)\hat{i} + \omega r\sin\theta\,\hat{j}$$

$$\|\vec{V}_m\| = \omega\sqrt{(R + r\cos\theta)^2 - r^2\sin^2\theta}$$

$$PE_1 - PE_2 = m_0 g h_0 + M g h_0 + m g h_0 + m g r\cos(\beta) - m_0 g h_1 - M g h_1 - m g h_1 - m g r\cos(\theta+\beta)$$

$$\Rightarrow \cancel{m_0 g 15R\sin\beta} + \cancel{Mg15R\sin\beta} + \cancel{mg15R\sin\beta} + mgr\cos(\beta) - \cancel{m_0 g15R\sin\beta} + m_0 g R\theta\sin\beta - \cancel{Mg15R\sin\beta} + MgR\theta\sin\beta - \cancel{mg15R\sin\beta} + mgR\theta\sin\beta - mgr\cos(\theta+\beta)$$

$$\Rightarrow mgr\cos\beta + m_0 g R\theta\sin\beta + MgR\theta\sin\beta + mgR\theta\sin\beta - mgr\cos(\theta+\beta)$$

$$\Rightarrow gR\theta\sin\beta(m_0 + M + m) + mgr(\cos\beta - \cos(\theta+\beta))$$

$$KE_2 = \frac{1}{2} m_0 \omega^2 R^2 + \frac{1}{2} M\omega^2 R^2 + \frac{1}{2} Mk^2\omega^2 + \frac{1}{2} m\omega^2((R + r\cos\theta)^2 + (r\sin\theta)^2)$$

$$\Rightarrow \frac{1}{2}\omega^2(m_0R^2 + MR^2 + Mk^2 + m((R + r\cos\theta)^2 + (r\sin\theta)^2))$$

$$\omega = \sqrt{\frac{2(PE_1 - PE_2)}{KE_\circ}} \Rightarrow \omega = \sqrt{\frac{2(gR\theta\sin\beta(m_0+M+m) + mgr(\cos\beta - \cos(\theta+\beta)) - P\theta)}{m_0R^2 + MR^2 + Mk^2 + m((R + r\cos\theta)^2 + (r\sin\theta)^2)}}$$ [MODEL_3]

Model 4 → add KE of rotation → $\frac{1}{2} I_m \omega^2$ → $I_m = \frac{1}{2} m r_0^2$

$$\Rightarrow \omega = \sqrt{\frac{2(gR\theta\sin\beta(m_0+M+m) + mgr(\cos\beta - \cos(\theta+\beta)) - P\theta)}{m_0R^2 + MR^2 + Mk^2 + m((R + r\cos\theta)^2 + (r\sin\theta)^2) + \frac{1}{2} m r_0^2}}$$ [MODEL_4]