CASE 4: (EXTRA ROD MASS WITH FUDGE FACTOR)

$$PE_0 = KE_1 + PE_1 \qquad PE_0 = (M_{CYL} + M_{TA} + M_{EXT})gh_0 - M\Theta$$

$$PE_1 = M_{EXT}\, g h_1$$

$$KE_1 = \tfrac{1}{2}(M_{CYL} + M_{TA})V^2 + \tfrac{1}{2}I_{EXT}\omega^2 + \tfrac{1}{2}I_c + \tfrac{1}{2}I_{EXT}\omega^2$$

$$V = R\omega$$

$$= \tfrac{1}{2}(M_{CYL} + M_{TA})R^2\omega^2 + \tfrac{1}{2}M_{EXT}\left[(R + r\cos\Theta)^2 + (r\sin\Theta)^2\right] + \tfrac{1}{2}I_c + \tfrac{1}{2}\left(\tfrac{1}{2}M_{EXT}R_{EXT}^2\right)\omega^2$$

$$= \omega^2\left[\tfrac{1}{2}\left([M_{CYL}+M_{TA}]R^2 + M_{EXT}\left[R^2 + 2Rr\cos\Theta + r^2\right] + I_c + \tfrac{1}{2}M_{EXT}R_{EXT}^2\right)\right]$$

$$PE_0 = KE_1 + PE_1$$

$$PE_0 - PE_1 = KE_1:$$

$$(M_{CYL} + M_{TA} + M_{EXT})gh_0 - M\Theta - M_{EXT}gh_1 = \omega^2\left[\tfrac{1}{2}\left([M_{CYL}+M_{TA}]\right)R^2 + M_{EXT}\left[R^2 + 2Rr\cos\Theta + r^2\right] + I_c + \tfrac{1}{2}M_{EXT}R_{EXT}^2\right)\right]$$

$$\omega^2 = \frac{2\left[(M_{CYL}+M_{TA}+M_{EXT})gh_0 - M\Theta - M_{EXT}gh_1\right]}{[M_{CYL}+M_{TA}]R^2 + M_{EXT}\left[R^2 + 2Rr\cos\Theta + r^2\right] + I_c + \tfrac{1}{2}M_{EXT}R_{EXT}^2}, \qquad \begin{array}{l} h_0 = R\Theta\sin(\beta) \\ h_1 = r(\cos(\Theta+\beta) - \cos(\beta)) \end{array}$$

$$\omega = \sqrt{\frac{2\left[(M_{CYL}+M_{TA}+M_{EXT})gR\Theta\sin\beta - M\Theta - M_{EXT}gr\left[\cos(\Theta+\beta) - \cos(\beta)\right]\right]}{[M_{CYL}+M_{TA}]R^2 + M_{EXT}\left[R^2 + 2Rr\cos\Theta + r^2\right] + I_c + \tfrac{1}{2}M_{EXT}R_{EXT}^2}}$$