$E_o = E_c$

$$Mg\frac{\ell}{2}(1-\cos\theta_f) + mg\ell(1-\cos\theta_f) = \frac{1}{2}(I+m\ell^2)\omega_c^2$$

$$\left(\frac{1}{2}M+m\right)g\cancel{\ell}(1-\cos\theta_f) = \frac{1}{2}\left(\frac{1}{3}M+m\right)\ell^{\cancel{2}}\omega_c^2$$

$$1-\cos\theta_f = \frac{1}{2}\,\frac{\frac{1}{3}M+m}{\frac{1}{2}M+m}\,\frac{\ell}{g}\,\omega_c^2$$

$$\boxed{\cos\theta_f = 1 - \frac{1}{2}\,\frac{\frac{1}{3}M+m}{\frac{1}{2}M+m}\,\frac{\ell}{g}\,\omega_o^2} = 0.9957$$

$$\Rightarrow \theta_f = 5.3^\circ$$

Problem 2

(a) $F = \text{const} \Rightarrow W = F\cdot d$

$$W = \Delta K$$

$$F\cdot d = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 \qquad \underbrace{\omega = \frac{v}{R}}_{\text{rolling w/o slipping}}$$

$$= \frac{1}{2}Mv^2 + \frac{1}{2}(M\cancel{R^2})\left(\frac{v}{\cancel{R}}\right)^2$$

$$= Mv^2$$

$$\Rightarrow \boxed{v^2 = \frac{F}{M}d}$$

(b) Const acceleration from rest

$$v^2 = 2ad \Rightarrow 2a = \frac{F}{M} \qquad \boxed{a = \frac{1}{2}\frac{F}{M}}$$