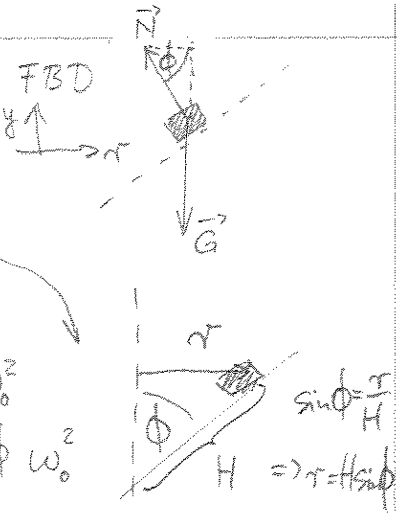
a) Newton for y:

$$-mg + N\sin\phi = m a_y = 0$$



$$\Rightarrow N = \frac{mg}{\sin\phi}$$

Newton for r:

$$-N\cos\phi = -m r \omega_0^2$$

$$\Rightarrow \frac{mg}{\sin\phi}\cos\phi = m H \sin\phi\, \omega_0^2$$

$$\Rightarrow H = \frac{g}{\omega_0^2}\,\frac{\cos\phi}{\sin^2\phi}$$

b) Newton for y:

$$-mg + N\sin\phi + f\cos\phi = 0 \qquad (I)$$

Newton for r:

$$-N\cos\phi + f\sin\phi = -m r \omega^2 \qquad (II)$$

$$(I) \Rightarrow N = mg - f\cos\phi$$

$$\text{in}(II) \Rightarrow -(mg - f\cos\phi)\cos\phi + f\sin\phi = -mr\omega^2$$

$$\Rightarrow f\sin\phi + f\cos^2\phi = mg - mr\omega^2$$

$$\Rightarrow f = \frac{mg - mr\omega^2}{\sin\phi + \cos^2\phi} = m\,\frac{g - H\sin\phi(\omega t)^2}{\sin\phi + \cos^2\phi}$$

c)

$$L_i = L_f$$

$$J_i\,\omega_i = J_f\,\omega_0$$

$$(J_s + 2R^2 m)\,\omega_i = (J_s + 2(R+b)^2 m)\,\omega_0$$

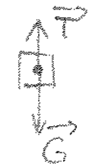
$$\Rightarrow \omega_i = \frac{J_s + 2(R+b)^2 m}{J_s + 2R^2 m}\,\omega_0$$

(you can also assume that the solar panels are included in J_s. Then:

$J_i = J_s$ and

$J_f = J_s - 2R^2 m + 2(R+b)^2 m$)

4a) FBD 1:

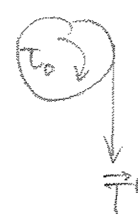


Newton:

$$aM = T - G = T - Mg \qquad (I)$$

$$\Rightarrow T = (a+g)M$$

FBD 2:



Newton: clockwise

$$\alpha J_p = -\tau_0 - RT \qquad (II)$$

$$\alpha = \frac{a}{R} \quad \text{„without slipping“}$$

$$\frac{a}{R} J_p = -\tau_0 - R(a+g)M$$

$$\Rightarrow \frac{a}{R} J_p + MRa = -\tau_0 - RMg$$

$$\Rightarrow a = -\frac{\tau_0 + RMg}{\frac{J_p}{R} + MR} = -\frac{\tau_0 + R^2Mg}{J_p + MR^2}$$

4b) (I) stays the same: $T = (a+g)M$

(II) becomes: $\alpha J_p = -\tau_0 + \beta\omega - R(a+g)M$

constant angular velocity $\Rightarrow \alpha = 0 \Rightarrow a =$

$$\Rightarrow (II) \quad 0 = -\tau_0 + \beta\omega - RgM$$

$$\Rightarrow \omega = -\frac{\tau_0 + RgM}{\beta}$$

2a) FBD

Newton for r:

$$F_r = m_m a_r = m_m(-R\omega^2)$$

$$\Rightarrow |a_r| = R\omega^2$$

Simulate gravity $\Rightarrow |a_r| = g \Rightarrow g = R\omega^2$

$$\Rightarrow \omega = \sqrt{\frac{g}{R}}$$

b)

$$\vec{F} = m\vec{a} = m\left[\cancelto{0}{\frac{d^2r}{dt^2}} - R\omega^2\right]\vec{\imath}_r + m\left[2\frac{d\theta}{dt}\cancelto{0}{\frac{dr}{dt}} + R\underbrace{\frac{d^2\theta}{dt^2}}_{\alpha}\right]\vec{\imath}_\theta$$

$$\tau = J_s \cdot \alpha \Rightarrow \alpha = \tau / J_s$$

$$\alpha = \text{const} \Rightarrow \omega = \alpha \cdot t$$

$$\Rightarrow \vec{F}(t) = m\vec{a}(t) = \left(-mR\frac{\tau}{J_s}\cdot t\right)\vec{\imath}_r + \left(mR\frac{\tau}{J_s}\right)\vec{\imath}_\theta = \frac{mR\tau}{J_s}\left(-t\vec{\imath}_r + 1\cdot\vec{\imath}_\theta\right)$$

3)

$$L_i = L_f$$

$$J_L\omega_L - J_R\omega_R = (J_L + J_R)\omega_f$$

clockwise counterclockwise

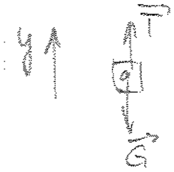
$$\Rightarrow \omega_f = \frac{J_L\omega_L - J_R\omega_R}{J_L + J_R}$$

$$P_i = P_f$$

$$\underbrace{Mv_0 + M(-v_0)}_{=0} = (M+M)v_f$$

$$\Rightarrow v_f = 0$$

4a) FBD 1:



Newton

$$aM = T - G = T - Mg \quad (I)$$

$$\Rightarrow T = (a+g)M$$

FBD 2:

Newton

(τ_O) $\alpha J_P = -\tau_0 - RT \quad (II)$

$\alpha = \frac{a}{R}$ („without slipping")

$$\Rightarrow \frac{a}{R}J_P = -\tau_0 - R(a+g)M$$

$$\Rightarrow \frac{a}{R}J_P + MRa = -\tau_0 - RMg$$

$$\Rightarrow a = -\frac{\tau_0 + RMg}{\frac{J_P}{R} + MR} = -\frac{\tau_0 + R^2Mg}{J_P + R^2M}$$

4b) (I) stays the same: $T = (a+g)M$

(II) becomes $\alpha J_P = -\tau_0 + \beta\omega - R(a+g)M$

constant angular velocity $\Rightarrow \alpha = 0 \Rightarrow a = 0$

$$\Rightarrow (II) \quad 0 = -\tau_0 + \beta\omega - RgM$$

$$\Rightarrow \omega = -\frac{\tau_0 + RgM}{\beta}$$