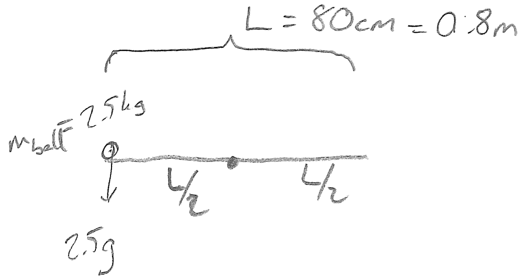
10.63



$m_{bar} = 3.80\,kg$ (uniform)

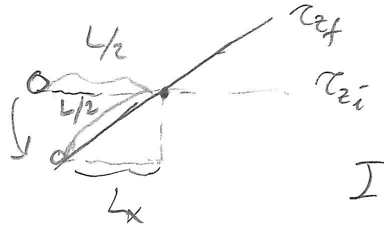
$$\tau_z = m_{ball}\, g \cdot \frac{L}{2} = I \alpha_z$$

$$I = I_{bar} + I_{ball} = \frac{1}{12} m_{bar} L^2 + m_{ball}\left(\frac{L}{2}\right)^2$$

$$= \frac{L^2}{4}\left(m_{ball} + \frac{m_{bar}}{3}\right)$$

$$\Rightarrow \alpha_z = \frac{\dfrac{m_{ball}\, g\, L}{2}}{\dfrac{L^2}{4}\left(m_{ball} + \dfrac{m_{bar}}{3}\right)} = 16.3\ rad/s^2$$

b)

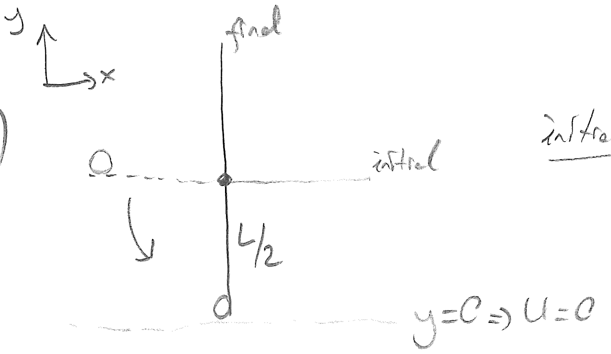


$$\left.\begin{aligned} \tau_{z_i} &= m_{ball}\, g \frac{L}{2} = I\alpha_{z_i} \\ I\alpha_{z_f} = \tau_{z_f} &= m_{ball}\, g\, L_x \;\;\&\;\; L_x < \frac{L}{2} \end{aligned}\right\} \Rightarrow \alpha_{z_f} = \frac{L_x}{L/2}\alpha_{z_i}$$

$$\Downarrow$$

$$\alpha_{z_f} < \alpha_{z_i}$$

c)



initial: $E = U + \cancel{K}^{\,0} = m_{ball}\, g \frac{L}{2}$

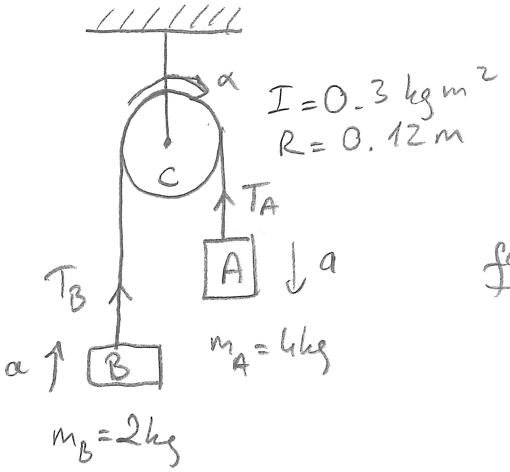
final: $E = \cancel{U}^{\,0} + K = \frac{1}{2} I \omega^2$

since total energy is conserved:

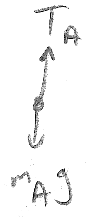
$$\frac{1}{2} I \omega^2 = \frac{1}{2}\left[\frac{L^2}{4}\left(m_{ball} + \frac{m_{bar}}{3}\right)\right]\omega^2 = m_{ball}\, g \frac{L}{2}$$

$$\Rightarrow \omega = 5.70\ rad/s$$

10.67

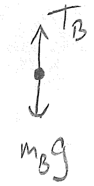


for A: $a \downarrow$



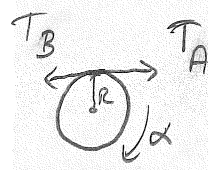
$\Rightarrow \Sigma F_y = m_A a = m_A g - T_A$

for B: $a \uparrow$



$\Rightarrow \Sigma F_y = m_B a = T_B - m_B g$

for C:



$\Rightarrow \Sigma \tau_z = I\alpha = (T_A - T_B)R$

$a = \alpha R$ (no ~~slipping~~ slipping) $\Rightarrow T_A - T_B = \frac{I}{R^2} a$

from the underlined equalities:

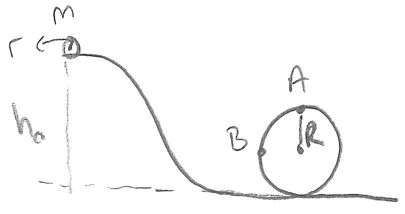
$$(m_A - m_B)g = \left(m_A + m_B + \frac{I}{R^2}\right)a \quad \Rightarrow \quad a = 0.73\ m/s^2$$

$$\alpha = \frac{a}{R} = 6.08\ rad/s^2$$

$T_A = m_A(g - a)$ $\qquad T_A = 36.3\ N$

$T_B = m_B(g + a)$ $\qquad T_B = 21.1\ N$

10.76 shell



Since shell rolls without slipping:

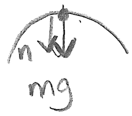
$$E_i = mgh_0 = E_A = mg2R + K_A$$

$$K_A = \frac{1}{2} m v_A^2 + \frac{1}{2} I \omega_A^2 \qquad \omega_A = \frac{v_A}{r}$$

$$K_A = \frac{5}{6} m v_A^2 \qquad I = \frac{2}{3} m r^2 \text{ for spherical shell}$$

$$\Rightarrow mgh_0 = mg2R + \frac{5}{6} m v_A^2$$

at point A:



$$\Sigma F = \frac{m v_A^2}{R} = mg + n \qquad v_A = \sqrt{gR}$$

$$\Rightarrow \boxed{h_0 = \frac{17}{6} R}$$

for minimum v_A : $n \to 0$

b) at point B:

$$\Sigma F = m \frac{v_B^2}{R} = n$$

$$E_i = mgh_0 = E_B = mgR + \frac{5}{6} m v_B^2 = mg \frac{17}{6} R$$

$$v_B^2 = \frac{11}{5} gR \Rightarrow n = m \frac{v_B^2}{R} = \frac{11}{5} mg$$

c) No friction $\Rightarrow$ no roll $\Rightarrow K = \frac{1}{2} m v^2$

at A: $\frac{1}{2} m v_A'^2 = mg(h_0 - 2R) = \frac{5}{6} m v_A^2 \Rightarrow v_A' = \sqrt{\frac{5}{3}}\, v_A \Rightarrow v_A' > v_A$

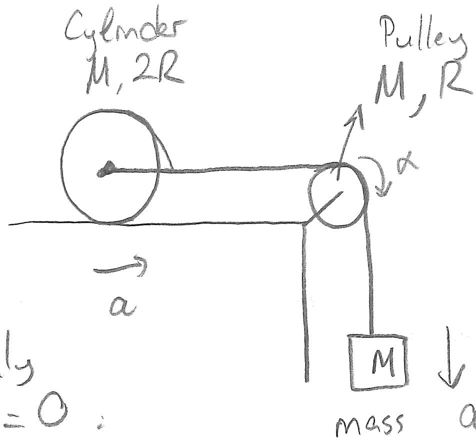
$\Downarrow$

makes a complete loop

d) from part a: $\Sigma F = \frac{m v_A'^2}{R} = mg + n \Rightarrow n = m\left(\frac{5}{3} \frac{v_A^2}{R} - g\right)$

$$n = m \cdot \frac{2}{3} g$$

10.87



$a = ?$

$I_{cyl} = \frac{1}{2} M (2R)^2$

$I_{pul} = \frac{1}{2} M R^2$

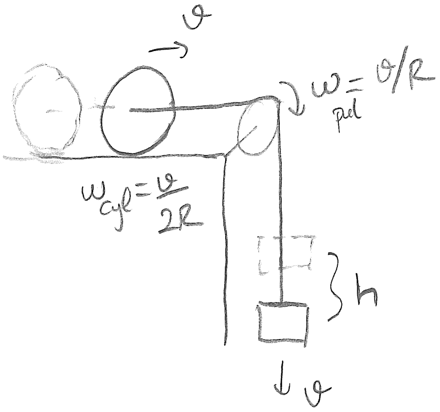
$a = \text{const.}$

initially at $t = 0$:

$v_{cyl} = v_{mass} = 0$

$E_i = U + \cancel{K}^{0} = mgh$

finally at $t = t_0$:



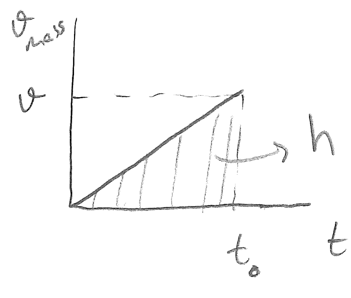
$E_f = \cancel{U}^{0} + K = K_{cyl} + K_{pul} + K_{mass}$

$K_{mass} = \frac{1}{2} M v^2$

$K_{pul} = \frac{1}{2} I_{pul} \omega_{pul}^2 = \frac{1}{4} M v^2$

$K_{cyl} = \frac{1}{2} I_{cyl} \omega_{cyl}^2 + \frac{1}{2} M v^2 = \frac{3 M v^2}{4}$

from Energy conservation: $E_i = E_f \Rightarrow mgh = \frac{3}{2} M v^2 \Rightarrow v^2 = \frac{2}{3} gh$



$h = \frac{1}{2} a t_0^2 \Rightarrow h = \frac{v^2}{2a} \Rightarrow v^2 = 2ah$

$\Rightarrow 2ah = \frac{2}{3} gh$

$\underline{\underline{a = g/3}}$

$v = a t_0$