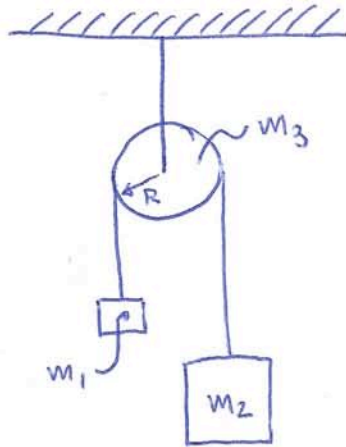


What is the tension in the ropes and what is the acceleration of the block system?



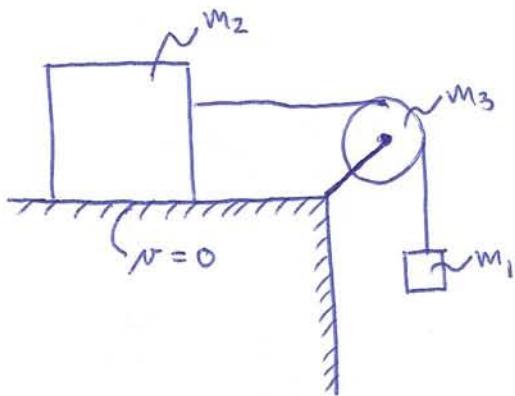
given:

m_1 , m_2 , m_3 and R

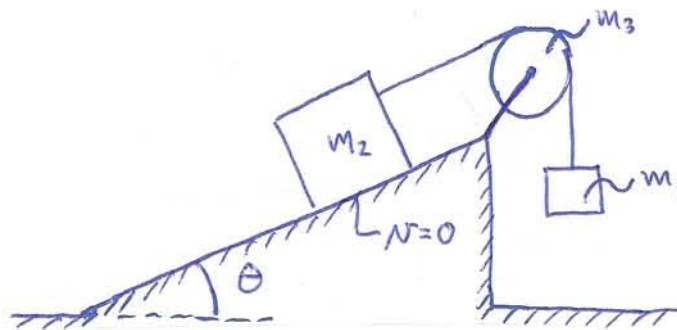
What is the tension in the ropes, the acceleration of the block system and the reaction force on the pulley?

given:

m_1 , m_2 , m_3 and R



What is the tension in the ropes, the acceleration of the block system and the reaction force on the pulley?



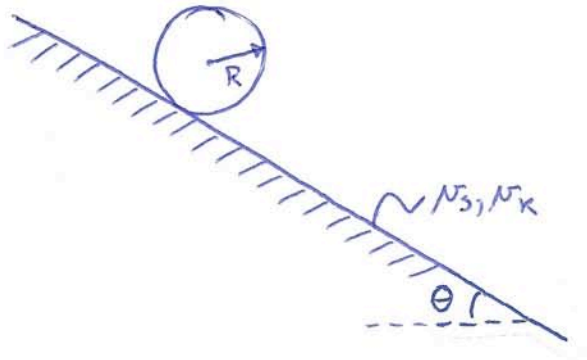
given:

m_1 , m_2 , m_3 , R and θ

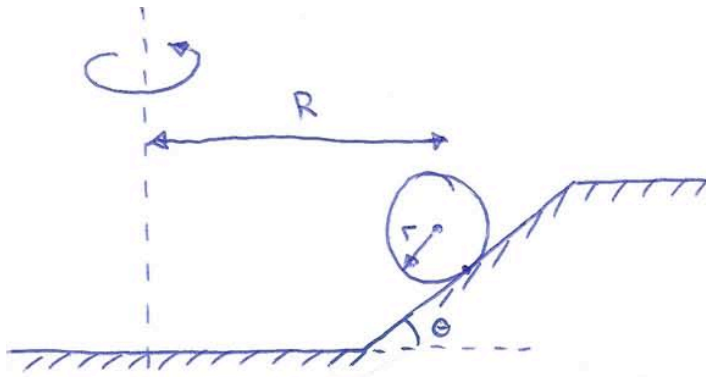
What is the acceleration of the object if it rolls without slipping and the maximum θ before the object would slip?

given:

m , R , μ_s , μ_k and θ



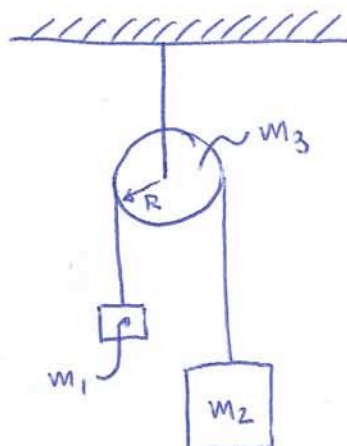
Determine the parameters that the ball would roll around a slanted wall.



given:

m , r , R , μ_s , μ_k and θ

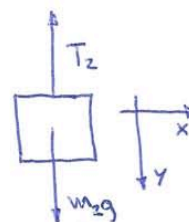
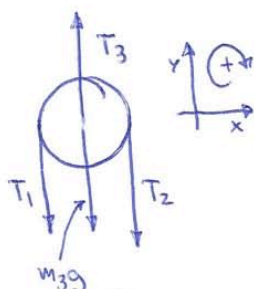
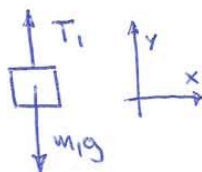
What is the tension in the ropes and what is the acceleration of the block system?



given:

m_1, m_2, m_3 and R

FBD:



$$\sum F_y = m_1 a_y = T_1 - m_1 g$$

$$(i) \sum F_y = m_3 a_y = T_3 - T_1 - T_2 - m_3 g$$

$$\sum M_o = I_o \alpha_o = T_2 R - T_1 R$$

$$(2) \sum F_y = m_2 a_y = m_2 g - T_2 \quad (4)$$

$$(3)$$

Kinematics: $a_{y1} = a_{y2} = a_y$ (5), $a_y = \alpha_o R$ (6)

solve for T_1 & T_2 in (1) & (4)

$$T_1 = m_1 g + m_1 a_y \quad (1a) \quad T_2 = m_2 g - m_2 a_y \quad (4a)$$

sub (1a), (4a) & (6) into (3) and solve for a_y :

$$I_o \left[\frac{a_y}{R} \right] = [m_2 g - m_2 a_y] R - [m_1 g + m_1 a_y] R$$

$$I_o a_y = m_2 g R^2 - m_2 a_y R^2 - m_1 g R^2 - m_1 a_y R^2$$

$$a_y (I_o + m_2 R^2 + m_1 R^2) = g R^2 (m_2 - m_1)$$

$$a_y = \frac{g (m_2 - m_1) R^2}{I_o + m_1 R^2 + m_2 R^2} = \frac{g (m_2 - m_1)}{\frac{I_o}{R^2} + m_1 + m_2}$$

sub into (2)

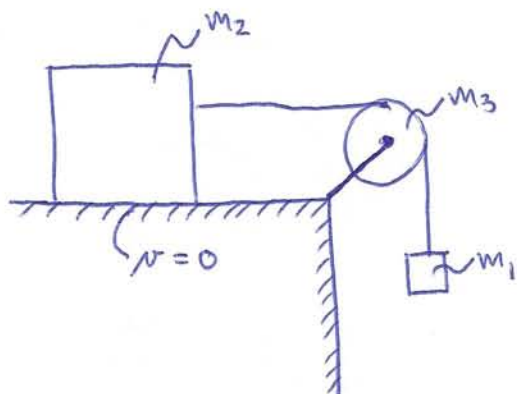
$$0 = T_3 - T_1 - T_2 - m_3 g \Rightarrow$$

$$T_3 = T_1 + T_2 + m_3 g = m_3 g + g(m_1 + m_2) + a_y(m_1 - m_2)$$

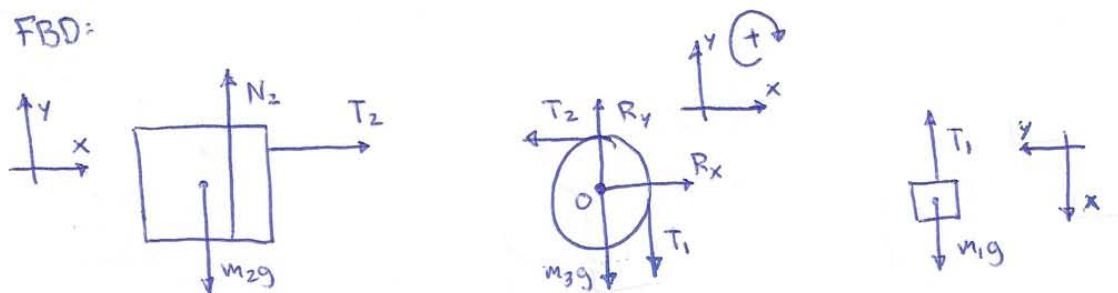
What is the tension in the ropes, the acceleration of the block system and the reaction force on the pulley?

given:

m_1, m_2, m_3 and R



FBD:



$$\sum F_x = m_2 a_{x_2} = T_2$$

(1)

$$\sum F_x = m_3 a_{x_3} = R_x - T_2$$

(3)

$$\sum F_x = m_1 a_{x_1} = m_1 g - T_1 \quad (6)$$

$$\sum F_y = m_2 a_{y_2} = N_2 - m_2 g$$

(2)

$$\sum F_y = m_3 a_{y_3} = R_y - m_3 g - T_1$$

(4)

$$\sum M_o = I_o \alpha_o = T_1 r - T_2 r$$

(5)

$$\text{Kinematics: } a_{x_2} = a_{x_1} = a_x \text{ (sub in) }, a_x = \alpha_o r \quad (7)$$

Solve for T_1 and T_2 in eqn. (6) and (1):

$$T_1 = m_1 (g - a_x) \quad (6a), \quad T_2 = m_2 a_x \quad (1a)$$

sub (1a), (6a) and (7) into (5) and solve for a_x :

$$I_o \left[\frac{a_x}{r} \right] = [m_1 (g - a_x)] r - [m_2 a_x] r \Rightarrow a_x = \frac{m_1 r^2 g}{I_o + m_1 r^2 + m_2 r^2} \quad (5a)$$

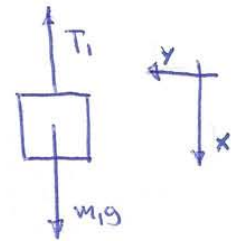
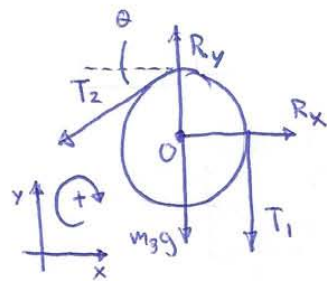
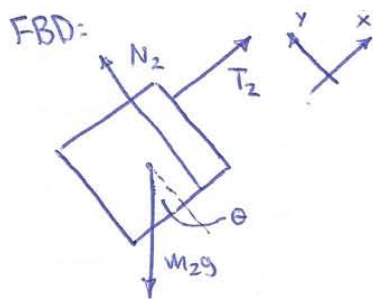
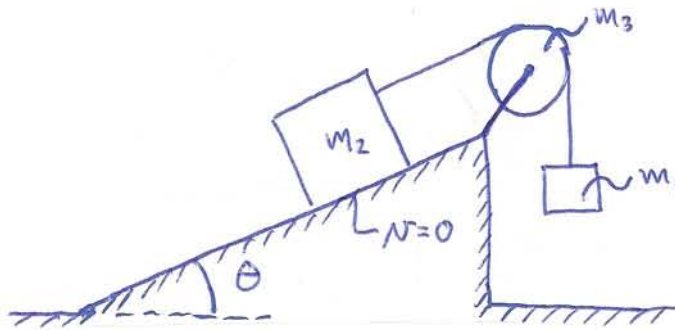
Solve for R_x and R_y in eqn. (3) and (4):

$$R_x = T_2 \quad (3a), \quad R_y = T_1 + m_3 g \quad (4a)$$

What is the tension in the ropes, the acceleration of the block system and the reaction force on the pulley?

given:

m_1, m_2, m_3, R and θ



$$\begin{aligned} \sum F_x = m_2 a_{x2} &= T_2 - m_2 g \cos \theta & (1) & \sum F_x = m_3 a_{x3} = R_x - T_2 \cos \theta & (3) \sum F_y = m_1 a_{y1} = m_1 g - T_1 & (6) \\ \sum F_y = m_2 a_{y2} &= N_2 - m_2 g \sin \theta & (2) & \sum F_y = m_3 a_{y3} = R_y - m_3 g - T_1 - T_2 \sin \theta & (4) \\ & & & \sum M_O = I_O \alpha_O = T_1 r - T_2 r & (5) \end{aligned}$$

Kinematics: $a_{x2} = a_{x1} = a_x$ (sub in), $a_x = \alpha_O r$ (7)

Solve for T_1 and T_2 in (6) and (1):

$$\boxed{T_1 = m_1 (g - a_x)} \quad (6a) \quad , \quad \boxed{T_2 = m_2 (a_x + g \cos \theta)} \quad (1a)$$

sub (1a), (6a) and (7) into (5) and solve for a_x :

$$I_O \left[\frac{a_x}{r} \right] = [m_1 (g - a_x)] r - [m_2 (a_x + g \cos \theta)] r \Rightarrow \boxed{a_x = \frac{m_1 r^2 g (1 + \cos \theta)}{I_O + m_1 r^2 + m_2 r^2}} \quad (5a)$$

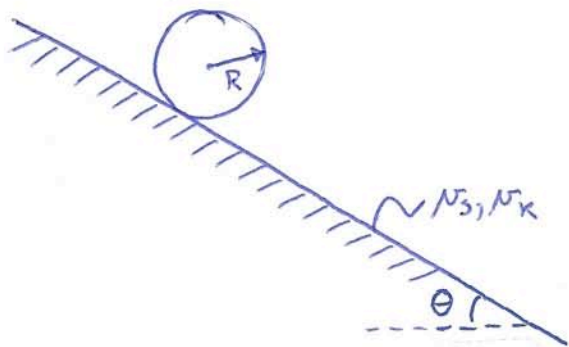
solve for R_x and R_y in (3) and (4):

$$\boxed{R_x = T_2 \cos \theta} \quad (3a) \quad , \quad \boxed{R_y = m_3 g + T_1 + T_2 \sin \theta} \quad (4a)$$

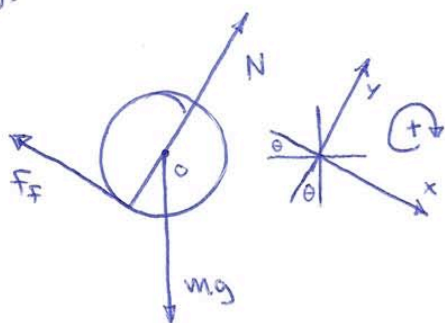
What is the acceleration of the object if it rolls without slipping and the maximum θ before the object would slip?

given:

m , R , μ_s , μ_k and θ



FBD:



Newton's 2nd Law

$$\sum F_x = m a_x = m g \sin \theta - F_f \quad (1)$$

$$\sum F_y = m a_y = N - m g \cos \theta \quad (2)$$

$$\sum M_o = I_o \alpha = F_f R \quad (3)$$

kinematics:

$$a_x = \alpha_o R \quad (\text{rolling without slipping}) \quad (4)$$

Solve for F_f in (1):

$$F_f = m g \sin \theta - m a_x \quad (1a)$$

sub (1a) & (4) into (3) and solve for a_x :

$$I_o \left[\frac{a_x}{R} \right] = [m g \sin \theta - m a_x] R$$

$$\left(\frac{I_o}{R^2} \right) a_x + m a_x = m g \sin \theta$$

$$a_x \left[\frac{I_o}{R^2} + m \right] = m g \sin \theta$$

$$a_x = \frac{m g \sin \theta}{\frac{I_o}{R^2} + m}$$

sub a_x solution into (1a):

$$F_f = m g \sin \theta - m \left[\frac{m g \sin \theta}{\frac{I_o}{R^2} + m} \right]$$

$$\text{set } F_f = \mu_s N = \mu_s [m g \cos \theta]$$

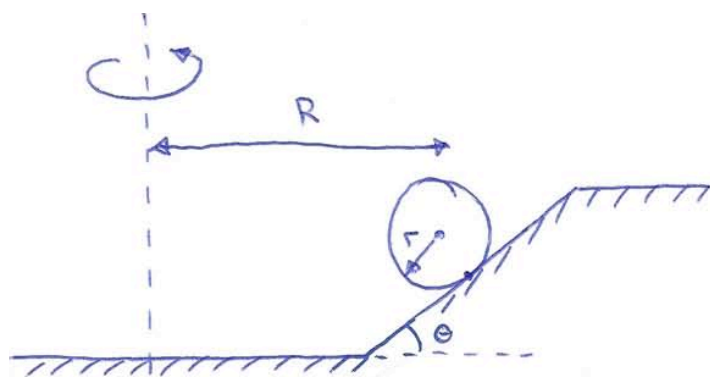
$$\mu_s m g \cos \theta = m g \sin \theta - m \left[\frac{m g \sin \theta}{\frac{I_o}{R^2} + m} \right]$$

solve for θ :

$$\mu_s = \tan \theta \left[1 - \frac{m}{\frac{I_o}{R^2} + m} \right]$$

$$\theta_{\max} = \tan^{-1} \left[\mu_s \frac{\left(\frac{I_o}{m R^2} + 1 \right)}{\frac{I_o}{m R^2}} \right]$$

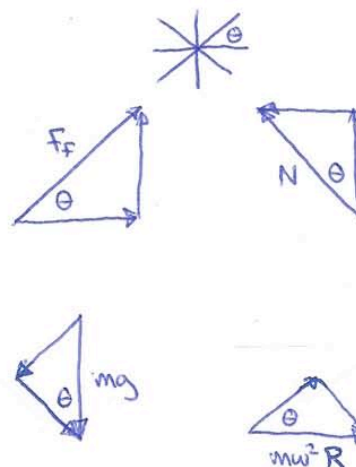
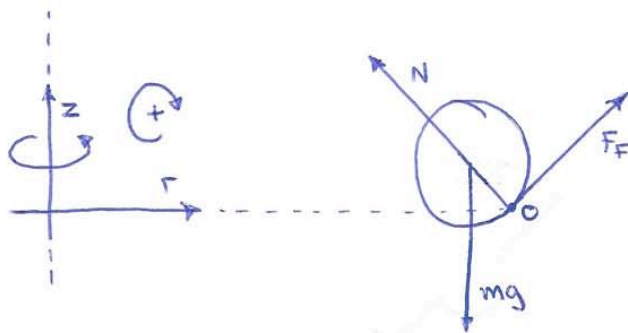
Determine the parameters that the ball would roll around a slanted wall.



given:

m, r, R, μ_s, μ_k and θ

FBD:



Newton's 2nd Law:

$$\sum F_r = m(-\omega^2 R) = F_f \cos \theta - N \sin \theta \quad (1)$$

$$\sum F_z = ma_z = N \cos \theta + F_f \sin \theta - mg \quad (2)$$

$$\sum M_o = I_o \alpha_o = (m\omega^2 R \cos \theta)(r) - (mg \sin \theta)(r) \quad (3)$$

Set $a_z = 0$ & solve equ. (2) for N :

$$0 = N \cos \theta + F_f \sin \theta - mg \quad (\text{set } a_z = 0)$$

$$N = \frac{1}{\cos \theta} (mg - F_f \sin \theta) \quad (2a)$$

sub (2a) into equ. (1) and solve for F_f :

$$-m\omega^2 R = F_f \cos \theta - \left[\frac{1}{\cos \theta} (mg - F_f \sin \theta) \right] \sin \theta$$

$$-m\omega^2 R \cos \theta = F_f \cos^2 \theta - mg \sin \theta + F_f \sin^2 \theta$$

$$-m\omega^2 R \cos \theta = F_f - mg \sin \theta$$

$$F_f = mg \sin \theta - m\omega^2 R \cos \theta$$

from equ (3) if $F_f \neq 0$ then the ball will rotate up or down.