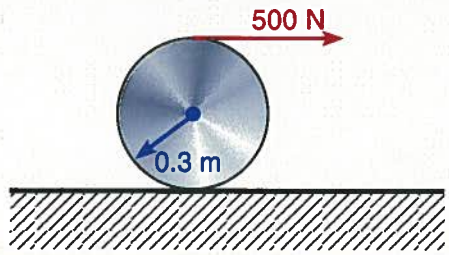
Problem 5 – The 100 kg cylindrical disk is at rest when a force F = 500 N is applied to a cord wrapped around it. Both the static and kinetic coefficients of friction between the disk and the surface equals 0.2. Determine the initial angular acceleration magnitude of the disk and whether the disk slips.



Solution

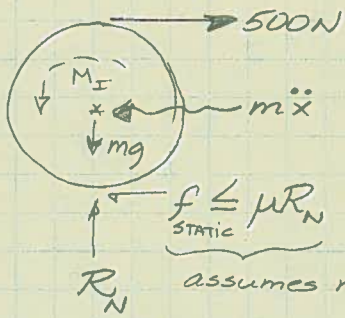
DOF: x = horizontal motion of C.M. from rest

Kinematics: $R\theta = x$ (assume no slip)

R = disk radius = 0.3 m

θ = rotation about CM

FBD - Assuming disk rolls (clockwise = + accord our Kinematics)



$$M_I = \left(\frac{mR^2}{2}\right)\ddot{\theta} = \left(\frac{mR}{2}\right)\ddot{x}$$

$m = 100$ kg

Apply Equilibrium - take moments pt. application friction

$$M_I + (m\ddot{x})R - (500N)(2R) = 0$$

$$\left(\frac{m\cancel{R}}{2} + m\cancel{R}\right)\ddot{x} = (500N)\,2\cancel{R}$$

$$\ddot{x} = 1000N / 1.5m = \frac{1000N}{1.5(100kg)} = 6.667\ m/s^2$$

(a) $$\ddot{\theta} = \ddot{x}/R = \frac{6.6667\ m/s^2}{0.3\ m} = \underline{\underline{22.22\ RAD/s^2}}$$

(b) Does disk slip? In other words, check if our assumption of rolling without slip is OK.

Need to see if $|f| < (f_{max} = \mu R_N)$

$\sum F_x = 0 \rightarrow m\ddot{x} + f - 500N = 0$

$f = 500N - m\ddot{x} = 500 - (100)(6.667)$

$f = -166.67$ Newtons

$f_{max} = \mu R_N = \mu(mg) = (0.2)(100)(9.81\,m/s^2)$

$f_{max} = 196.2$ Newtons

Since: $|f| < f_{max}$ $\quad 166.67 < 196.2$

<u>The disk does not slip</u>

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