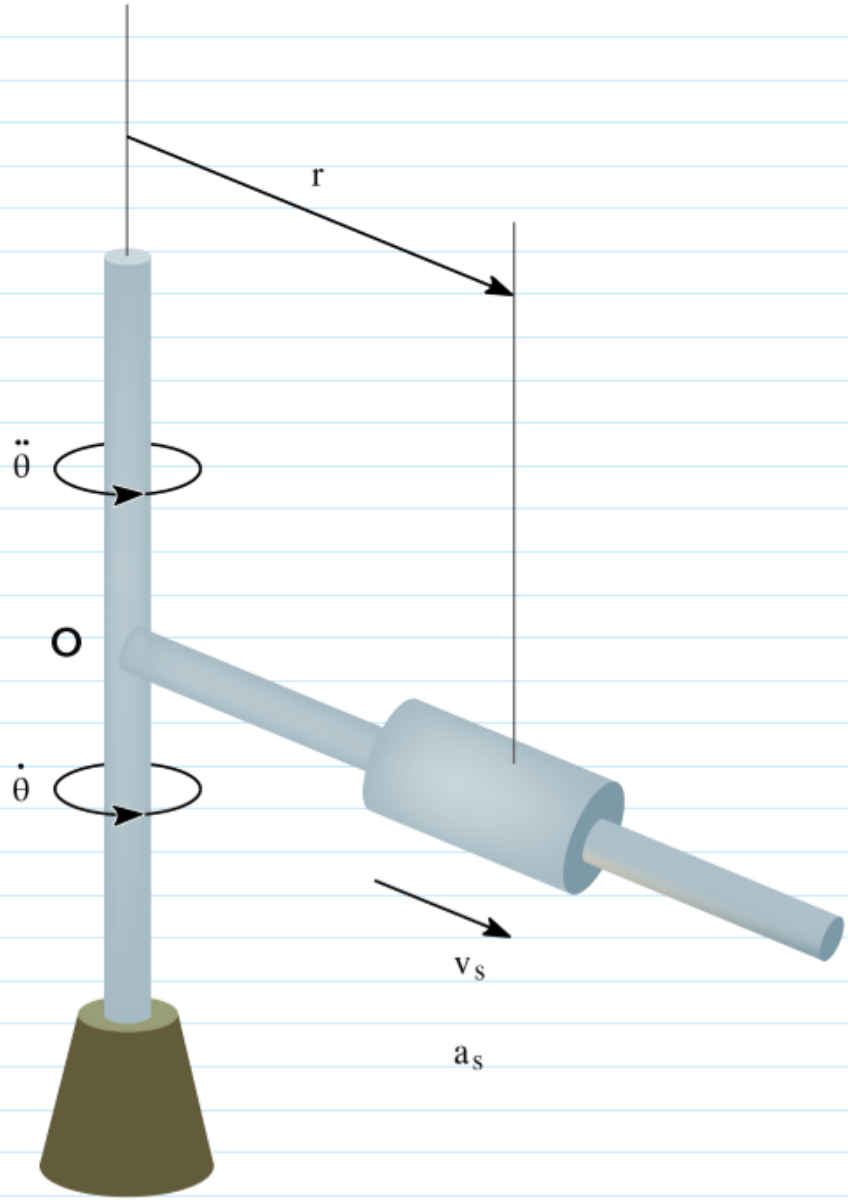
21-P-FA-GD-010



UBC Engineering

You have placed a linear ball bearing on a horizontal shaft that is rotating around O at $\dot{\theta}$. The rotation is increasing at $\ddot{\theta}$. The linear ball bearing has an outward velocity of v_s as indicated, with an acceleration of a_s, when the bearing is r_s from the center O.

What is the radial frictional force and the normal force on the bearing due to the shaft?

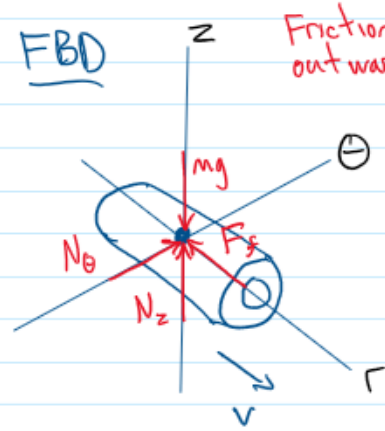
$r = r_s \quad \theta = ?$

$\dot{r} = \dot{r}_s \quad \dot{\theta} = \dot{\theta}_s$

$\ddot{r} = \ddot{r}_s \quad \ddot{\theta} = \ddot{\theta}_s$

FBD

Friction opposes outward motion



$$\begin{cases} a_r = \ddot{r} - r\dot{\theta}^2 \\ a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} \\ a_z = 0 \end{cases}$$

$\Sigma F_r = ma_r = -F_f$

$\Sigma F_\theta = ma_\theta = N_\theta$

$\Sigma F_z = ma_z^{\,0} = N_z - mg$

$N_\theta = m(r\ddot{\theta} + 2\dot{r}\dot{\theta})$

$N_z = mg$

$F_f = -m(\ddot{r} - r\dot{\theta}^2)$

$N = \sqrt{N_\theta^2 + N_z^2}$