83. (Third problem in **Cluster 1**)

An appropriate picture for this problem is Fig. 12-7 in the textbook. We make the unconventional choice of *clockwise* sense as positive, so that the angular velocity in this problem is positive; we choose *downhill* positive for the x axis (which is parallel to the incline surface) so that $a_{\text{com}} = R\alpha$ holds. For simplicity, we refer to a_{com} as a. We examine the rotational (about the center of mass) and linear forms of Newton's second law:

$$\begin{aligned}
\sum \tau_z &= f_s R = I\alpha = I\frac{a}{R} \\
\sum F_x &= Mg\sin\theta - f_s = Ma \\
\sum F_y &= N - Mg\cos\theta = 0
\end{aligned}$$

Combining the first two of these equations, we obtain

$$f_s = \frac{Mg\sin\theta}{1 + \frac{MR^2}{I}} \quad .$$

We now let $f_s = f_{s,\,\text{max}} = \mu_s N$ and combine this with the third equation above:

$$\mu_s Mg\cos\theta = \frac{Mg\sin\theta}{1 + \frac{MR^2}{I}} \implies \theta = \tan^{-1}\left(\mu_s + \frac{MR^2\mu_s}{I}\right) \; .$$