A hollow cylinder is rotating about a vertical axis with angular velocity \( \omega \), as shown, and as demonstrated in class. A small block, of mass \( m \), is on the inside of the cylinder. A string exerts a constant force \( P \), equal to 3 times the weight of the block, in a direction 30° from the vertical, as shown. The coefficients of friction between the block and the wall are \( \mu_s = 0.65 \), \( \mu_k = 0.60 \). The radius \( R \) is 1.25 m, and the block is small. Find the minimum angular velocity of the cylinder such that the block does not slide up.

\[
\begin{align*}
\text{Velocity:} & \quad v = R \omega \\
\text{Inward:} & \quad a_{\text{in}} = \frac{v^2}{R} = \frac{N + P \sin \theta}{M} \\
\text{Vertical:} & \quad a_{\text{ver}} = 0 = \frac{P \cos \theta - F - Mg}{M} \\
\text{Friction:} & \quad F = \mu_s N \\
\end{align*}
\]

Therefore

\[
F = P \cos \theta - Mg = \mu_s N \\
\therefore N = \frac{F}{\mu_s} (P \cos \theta - Mg)
\]

\[
\therefore v^2 = \frac{R}{M} \left( \frac{F}{\mu_s} (P \cos \theta - Mg) + P \sin \theta \right) = \frac{R}{\mu_s} \left( P (\cos \theta + \mu_s \sin \theta) - Mg \right)
\]

If \( P = 3Mg \), \( \theta = 30^\circ \), \( \mu_s = 0.65 \), \( g = 9.8 \text{ m/s}^2 \) and \( R = 1.25 \text{ m} \),

\[
\begin{align*}
\therefore v & = \sqrt{\frac{R^2 g}{\mu_s} (3 (\cos \theta + \mu_s \sin \theta) - 1)} = \sqrt{\frac{1.25 \times 9.8 \times 3 (\cos 30^\circ + 0.65 \sin 30^\circ) - 1}{0.65}} \\
& = 6.964 \text{ m/s}
\end{align*}
\]

\[
\therefore \omega = \frac{v}{R} = \frac{6.964 \text{ m/s}}{1.25 \text{ m}} = 5.571 \text{ rad/s}
\]

\[
\begin{align*}
\text{Mistakes:} & \quad \text{Careless} -1 \\
& \quad \text{Little bit bad} -2 \\
& \quad \text{Serious} -5
\end{align*}
\]