SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

The diagram is a cross section of a banked road. The car (you are looking at the back end) shown is travelling into the paper. The road is icy and the coefficients of friction between the tires and road are \( \mu_s = 0.25 \) and \( \mu_k = 0.15 \). The road is curved and has a radius of curvature of \( R = 200 \) m. Assume the wheels are rolling freely with no braking. Calculate the range of speeds \( (V_{\text{min}}, V_{\text{max}}) \) such that the car doesn't slide off the road. For full credit you must show clear free body and force diagrams for both the \( V_{\text{min}} \) and \( V_{\text{max}} \) calculations.

1. As seen by an inertial reference frame on the ground the car traverses a circle in the horizontal plane with radius \( R \).
2. There are two situations as if the speed is small, the car slides down - \( \vec{F_s} \) is along \( \theta \) and the speed is large, the car needs a friction down \( \theta \).
3. Case A: \( V_{\text{min}} \)

\[
\begin{align*}
N_s \sin \theta - f_s \cos \theta &= m V_{\text{min}} / R \quad (1) \\
N_s \cos \theta + f_s \sin \theta &= mg \quad (2) \\
\end{align*}
\]

\[
\begin{align*}
f_s \leq N_s \mu_k \quad (3)
\end{align*}
\]

Plug 3 in 2 and divide 0/2!

\[
\begin{align*}
V_{\text{min}} &= \sqrt{\frac{gR (\tan \theta - \mu_s)}{1 + \mu_k \tan \theta}} \\
&= 14.3 \text{ m/s}
\end{align*}
\]

4.

5. Case B: \( V_{\text{min}} \)

\[
\begin{align*}
N_s \sin \theta + f_s \cos \theta &= m V_{\text{max}} / R \quad (4) \\
N_s \cos \theta - f_s \sin \theta &= mg \quad (5) \\
\end{align*}
\]

\[
\begin{align*}
V_{\text{max}} &= \sqrt{\frac{gR (\tan \theta + \mu_s)}{1 - \mu_k \tan \theta}} \\
&= 36.4 \text{ m/s}
\end{align*}
\]

6. Answer in m/s ((14.3 \leq V \leq 36.4))