5-1. 30 rpm = 1 rev every 2 secs.
   (i) \( T = 2 \) sec
   (ii) \( \omega = \frac{2\pi}{T} = -3.14 \text{rad/s} \)
   (iii) \( t = 0 \)

\[ a_x = -19.7 \text{m/s}^2 \]
\[ V = -6.28 \text{m/s} \hat{y} \]

\( t = 1.5 \) sec

\[ V = 6.28 \text{m/s} \hat{x} \]
\[ a_x = -19.7 \text{m/s}^2 \hat{y} \]

5-3. The spring must stretch because it has to provide \( F_c = -MR\omega^2 \hat{r} \) and when it stretches \( F_{sp} = -k \Delta r \hat{r} \)

\[ \Delta r = \frac{MR\omega^2}{k} = 1.23 \times 10^{-3} \text{ m} \]

5-5. \[ \tan \theta = \frac{R\omega^2}{g} = 0.11 \]
\[ \theta = 6.4^\circ \]
5-7. You will lose contact if the apparent weight (normal force) goes to ZERO.

\[ N_R - Mg = \frac{-MV^2}{R} \]

\[ V = \sqrt{Rg} = \sqrt{20 \times 9.8} = 14 \text{ m/s}. \]

5-9. The physics is much the same as problem 5-5

\[ \tan \theta = \frac{V^2}{Rg} \]

\[ V = 60 \text{ mph} = 26.83 \text{ m/s} \]

\[ \theta = 13.8^\circ \]

5-11. To make particle separate out the \( F_c \) required to keep in circle must become larger than the available force \( 10^{-4} \text{ N} \).

\[ \omega = 14.1 \text{ rad/s} \]