Physics 301  
Winter Quarter 1990  
March 15, 1990  
George Williams

\[ \bar{x} = 14.27 \]  
\[ \sigma = 8.31 \]  
\[ N = 186. \]

**FINAL EXAM**

Name (print)  **MARK REEVE**  
Name (signed)  **Mark Reeve**

Discussion Instructor (circle one): Baselgia  
Morrill  
Reeve  
Stoops  
Zhang

Discussion Section #

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

A cylinder of radius \( R \) (not small) and mass \( M \) rolls without sliding on a surface with the shape shown. It starts from rest.

(a) Calculate the largest possible value of \( h \), such that the cylinder does not leave the surface when it passes over the hump. \( h \) is measured to the center of mass of the cylinder. Express this in terms of \( R \) and \( A \) (the radius of curvature of the top of the hump). The top of the hump is \( 2A \) above the ground.

\[ E_{\text{total}} = Mgh \quad \text{[Not } Mgh(h+R) \text{ because } h \text{ is measured to the center of mass of the cylinder]} \]

\[ E_{\text{hump}} = Mg(2A+R) + \frac{1}{2} Mv^2 + \frac{1}{2} I \omega^2 \]

\[ E_{\text{total}} = E_{\text{hump}} \Rightarrow Mgh = Mg(2A+R) + \frac{1}{2} Mv^2 + \frac{1}{2} I \omega^2 \]

Putting it all together: 
\[ Mgh = Mg(2A+R) + \frac{1}{2} Mv^2 + \frac{1}{2} I \omega^2 \]

\[ h = 2A + R + \frac{1}{2} (A+R) + \frac{1}{2} (A+R) \]

\[ h = \frac{1}{4} (7R + 11A) \]

(b) For the starting value of \( h \) calculated in (a), the apparent weight of the cylinder at \( C \) is found to be 4 Mg. Find the radius of curvature at \( C \).

\[
\begin{align*}
V_C &= 3g(R_c-R) \\
V_C &= R_w \\
E_{\text{conservation}} &= \frac{1}{2} Mv_C^2 + \frac{1}{2} I \omega_C^2 + Mgh \\
\Rightarrow Mgh &= \frac{1}{2} Mv_C^2 + \frac{1}{2} I \omega_C^2 + Mgh \\
\Rightarrow h &= R + \frac{g}{3} (R_c-R) \\
&= \frac{R_c}{4} (12R+11A)
\end{align*}
\]