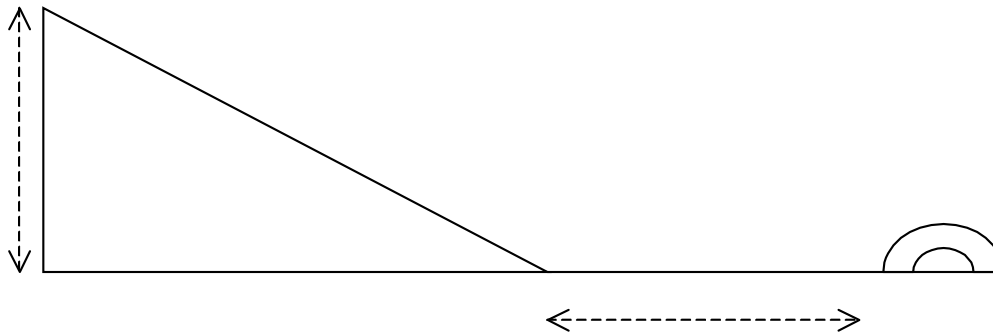


Question:

- 1 A particular waterslide will involve a hill with a 50m vertical drop. The hill surface will have a kinetic frictional coefficient of  $\mu=1.5 \cdot 10^{-1}$ . The hill is followed by a 5 m horizontal section with a kinetic coefficient of  $5 \cdot 10^{-2}$ . At the end of this section is a frictionless 'speedbump' with a rounded top of 3 m radius. If the riders are to feel as though they weigh half as much as usual at the top of the bump, at what angle should the hill be inclined with respect to the horizontal? *Hint: Use symbols as much as possible. Explicitly define some new ones if it simplifies your solution.*




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Numerical Answer: The angle should be around 9.26 degrees with respect to horizontal

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Reasoning:

Work-Energy with Non-conservative forces.

Assume motionless at top of hill, zero of potential energy at bottom of hill.

$$U_0 = mgH, U_f = mgr$$

$$K_o = 0, K_f = \frac{1}{2}mv^2_{\text{bump top}}$$

$$W_{NCF} = F_{fK} \cdot (L_{\text{hill}} + L_{\text{flat}})$$

So – writing it out...

$$mgH - \mu_{K1}mg \cos \theta_{\text{hill}} \left( \frac{H}{\sin \theta} \right) - \mu_{K2}mgL_{\text{flat}} = mgr + \frac{1}{2}mv^2_{\text{bump top}}$$

leading to

$$H - \mu_{K1} \cos \theta_{\text{hill}} \left( \frac{H}{\sin \theta} \right) - \mu_{K2}L_{\text{flat}} = r + \frac{1}{2}r \left( \frac{1}{2} \right)$$

$$H - \left( \frac{5}{4}r + \mu_{K2}L_{\text{flat}} \right) = \mu_{K1} \left( \frac{H}{\tan \theta} \right)$$

$$\theta = \tan^{-1} \left( \mu_{K1} \left( \frac{H}{H - \left( \frac{5}{4}r + \mu_{K2}L_{\text{flat}} \right)} \right) \right)$$

plug...chug...

Theta ~9.26 degrees

now, speed at top of bump set by apparent weight condition – want half normal weight  
At top of bump gravitational force is centripetal...

$$m \frac{v^2}{r} (-\hat{r}) = mg(-\hat{r}) + F_N(+\hat{r})$$

$$m \frac{v^2}{r} (-\hat{r}) = mg(-\hat{r}) + \frac{mg}{2}(+\hat{r})$$

$$\frac{v^2}{r} = g - \frac{g}{2}$$

$$v^2 = r \left( g - \frac{g}{2} \right)$$