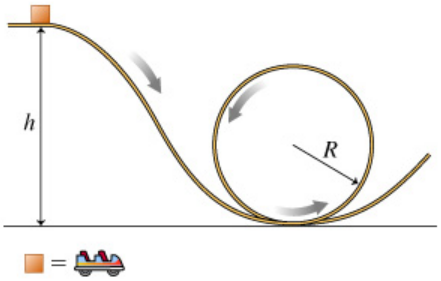
PHYSQ 124 – Particules et ondes **Mastering Physics**
Quiz 4 – 9 octobre 2014

A roller-coaster car may be represented by a block of mass 50.0kg . The car is released from rest at a height h = 51.0m above the ground and slides along a frictionless track. The car encounters a loop of radius R = 17.0m at ground level, as shown. As you will learn in the course of this problem, the initial height 51.0m is great enough so that the car never loses contact with the track.

A. Find an expression for the kinetic energy K of the car at the top of the loop.

B. Find the minimum initial height h_{min} at which the car can be released that still allows the car to stay in contact with the track at the top of the loop.



Solutions

A. K = mg(h – 2R) = 8330 J

B. h_{min} = 5R/2 = 42.5 m

If you solve the problem using variables instead of numbers, you will find that the minimum height required is given by $h_{min}=2.5R$.

For $h>2.5R$ the car can still complete the loop, of course. In this case, the normal force will be greater than zero even at the top of the loop.

For $h<R$ the car would oscillate in the bottom part of the loop. Could you predict this?

For $R<h<2.5R$, the car would lose contact with the track before reaching the top. That is why roller coasters must have a *lot* of safety features. If you like, you can check that the angle at which the car loses contact with the track is given by $\theta=\arcsin\frac{2}{3}(\frac{h}{R}-1)$.

Interestingly, if you try to check your result in a school or a univeristy lab with a steel or glass marble, you will see that the necessary minimum height is *greater* than $2.5R$. This is because a marble also has *rotational* kinetic energy in addition to *translational* kinetic energy.