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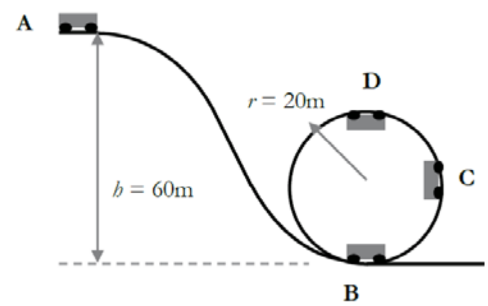
Quiz 6 Potential Energy

A roller coaster car of mass m = 200 kg is released from rest at the top of a 60 m high hill (position A), and rolls with negligible friction down the hill, through a circular loop of radius 20 m (positions B, C, and D),.

a. What is the velocity of the car at position B



This is a conservation of energy problem, with the gravitational potential energy of the car *U* being converted to kinetic energy *K* as the car rolls down the hill.

$$U = K$$

$$mgh = \frac{1}{2}mv^2$$

$$v = \sqrt{2gh} = \sqrt{2 \bullet 9.8 \bullet 60} = 34.3m/s$$

b. Determine the velocity of the car at position C.

At position **C**, some of the car's *K* has converted back to *U*.

$$U_i = K + U_f$$

$$mgh_A = \frac{1}{2}mv_C{}^2 + mgh_C$$

$$v_C = \sqrt{2g(h_A - h_C)} = \sqrt{2 \bullet 9.8(60 - 20)} = 28m/s$$

c. Determine the force (magnitude and direction) of the track on the car at position D.

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The velocity of the car at position **D** is determined using the same technique as in (b):

$$U_i = K + U_f$$

$$mgh_A = \frac{1}{2}mv_D^{\ 2} + mgh_D$$

$$v_D = \sqrt{2g(h_A - h_D)} = \sqrt{2 \bullet 9.8(60-40)} = 19.8m/s$$

The force of the track on the car at **D** can be determined by using Newton's 2nd Law of Motion to the circular motion:

$$F_c = \frac{mv^2}{r}$$

$$F_{track} + F_g = \frac{mv^2}{r}$$

$$F_{track} = \frac{mv^2}{r} - F_g$$

Here we're considering down (toward the middle of the circle) to be in the positive direction, and we're assuming that the force of the track and the force of gravity are both pointing down: the force of gravity is providing some of the force to keep the car moving in a circle, and the force of the track will provide the remaining.

In some cases, however—if the car is traveling very slowly, for example—a much smaller centripetal force will required, to the point that the track has to provide an *upwards* force. We would realize that this was the case if we calculated a Force for the track that was negative.

Continuing with our calculation:

$$F_{track} = \frac{mv^2}{r} - F_g$$

$$F_{track} = \frac{(200)(19.8)^2}{20} - (200)(9.8) = 1960N$$