Loop-the-Loop

P4-2010

BACKGROUND:

This apparatus demonstrates phenomena of traveling upside down in a vertical circle and not falling when moving at a high enough speed. The problem requires the application of the conservation of mechanical energy with the laws of centripetal force.

Demonstration: The apparatus allows the student top predict the minimum height a ball needs to be release on the track in order to complete the loop-the-loop. The theoretical height required (where friction is negligible) is ½ the radius of the loop above its highest point . That is, if the circular loop has a diameter of 60 cm, the starting height would be 75cm (60cm + 15 cm).

CALCULATIONS:

Starting with the law of centripetal force, we need to calculate a speed at the top of the loop that produces an acceleration equal to gravity (9.81 m/s/s).

$$\frac{v^2}{r} = g \ \ therefore \ v^2 = gr$$

From the law of conservation of energy the loss of gravitational potential energy as the ball descends is equal to its gain in kinetic energy.

$$\Delta\, mgh = -\Delta \frac{1}{2} mv^2$$

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Substituting for v^2 in the energy equation results in:

$$mgh = \frac{1}{2}mgr$$

Therefore: $h = \frac{1}{2}r$

As seen in the above calculations the mass of the ball cancels out and therefore is not a factor. This can be demonstrated by using a ball of a different mass. Since there is some friction involved, you will need to start the ball slightly higher the predicted calculation.