EXP.7:

# Conservation of Mechanical Energy

## Objectives

The goal of this experiment is to set a Mini-car in motion from rest on a step downhill like track and investigate the conservation of mechanical energy of this car at various points along the track. This track includes a circular loop configuration as well as a straight flat portion. The height from which the car must be released from rest on the downhill step so that it can just barely complete the loop can be predicted from conservation of energy and the centripetal acceleration. Furthermore, calculation of the normal force acting on the car at the top of the circular loop is carried out.

Mechanical energy $E$ is defined as the sum of both kinetic energy $K$ and the potential energy $U$ of all objects or particles in a given physical system.

$$E = K + U$$

The mechanical energy of any physical system is conserved provided if the system is isolated. This implies that the total amount of mechanical energy of the moving particles of the system is not subject of any changes as long as the system is isolated (i.e.; free of all frictional and other non-conservative forces). A decrease or increase in the kinetic energy of the system is accompanied by an equal increase or decrease in its potential energy. Thus kinetic and potential energies are transformed into each other during the motion of the particles of the system in such a way that the mechanical energy remains unchanged.

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The expression of conservation of mechanical energy at any point on the roller coaster track can be written simply as:

$$E_i = E_f$$

$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f \tag{1}$$

Where $i$ and $f$ both represent the initial and final state of the moving particles. In the presence of Non-conservative forces such as friction, initial and final mechanical energy will not be the same which leads to the fact that

$$\Delta E = E_f - E_i = W_{friction}$$

In this experiment (Figure 1), a single particle (Mini-car) is released from rest on the top of the hill at point (A), reaches the bottom of the hill at point (B), it then goes through a single vertical circular loop (B) and to a straight segment from (D) till it reaches point (E).

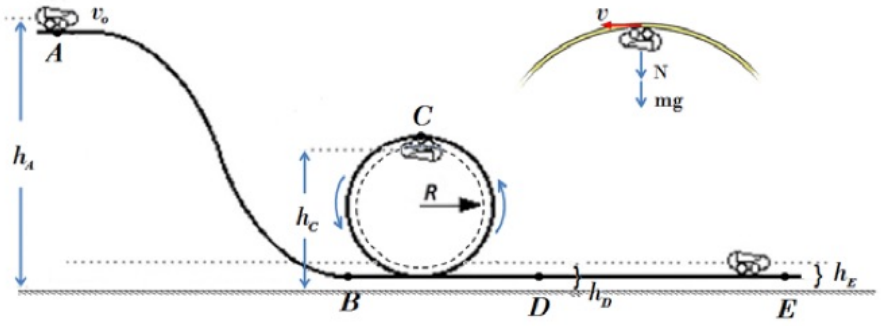



**Figure 1**. Experimental setup of the roller coaster.

The Normal force ($N$) acting on the Mini-car at the top of the circular loop (C) is calculated from Newton's second law along the $y$-direction:

$$\sum F_y = m\,a_c$$

Where ($F_y$) represent the sum of all $y$ components of the existing forces acting on the car, and ($a_c$) is the centripetal acceleration of the moving car in a uniform circular motion. Therefore;

$$N + mg = m\frac{v^2}{R}$$

$$N = m\left(\frac{v^2}{R} - g\right) \tag{2}$$

m $V_A = 0$ $v_A = 0$

Q1. An 850 kg roller-coaster is released from rest at Point A of the track shown in the figure. Assume there is no friction or air resistance between Points A and C. How fast is the roller-coaster moving at Point B?

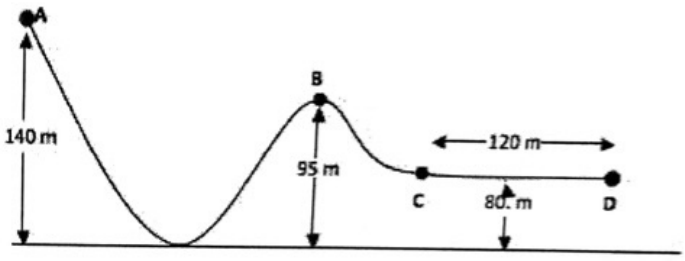
$$E_A = E_B$$

$$\frac{1}{2}mv_A^2 + mgh_A = \frac{1}{2}mv_B^2 + mgh_B$$

$$0 + 9.8(140) = \frac{1}{2}v_B^2 + 9.8(95)$$

$$\Rightarrow v_B = 29.7 \text{ m/s}$$

Figure 1:




2. Mechanical energy is not conserved when

A) Gravitational potential energy is converted to Kinetic energy

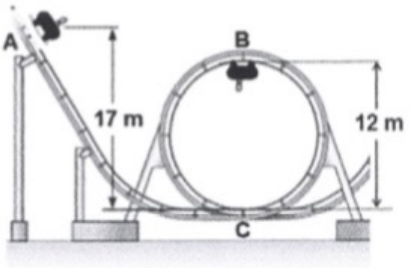
B) Kinetic energy is converted to gravitational potential energy

C) Kinetic energy is converted to elastic potential energy

D) Friction is not negligible

* increasing the mass of the car will,
↳ increase the total mechanical energy.

A 150 kg roller coaster car starts from rest at point A and slides down the **frictionless loop-the-loop shown.**




**a) What is the speed (in m/s) of the car at point B?**

$$E_A = E_B$$

$$\frac{1}{2}mv_A^2 + mgh_A = \frac{1}{2}mv_B^2 + mgh_B$$

$$9.8(17) = \frac{1}{2}v_B^2 + 9.8(12)$$

$$\Rightarrow v_B = 10 \text{ m/s}$$

**b) What is the normal force (in N) on the car by the track at point B?**




$$N + mg = m\frac{v^2}{R}$$

$$N + 150(9.8) = 150\frac{10^2}{6}$$

$$N = 1000 \text{ N}$$