Energy on an Inclined Plane

One focus of study in physics is the concept of energy. There are two forms of mechanical energy that are of interest to physicists – kinetic energy and potential energy. Kinetic energy is the energy associated with an object's motion (i.e., its velocity). Potential energy is the energy stored in an object as a result of its vertical position (height). The total amount of mechanical energy is the sum of these two forms of energy.

A group of physics students are studying the relationship between the potential energy (PE), kinetic energy (KE) and total mechanical energy (TME) for a cart rolling up and down an incline. A computer-interfaced motion detector is placed at the top of the incline to detect changes in the height and the speed of the cart. The students start the detector, hold the cart for about 1.0 seconds and then give it a gentle push up the hill. The computer generates plots showing the position and height as a function of time. See **Figure 1**.

Figure 1

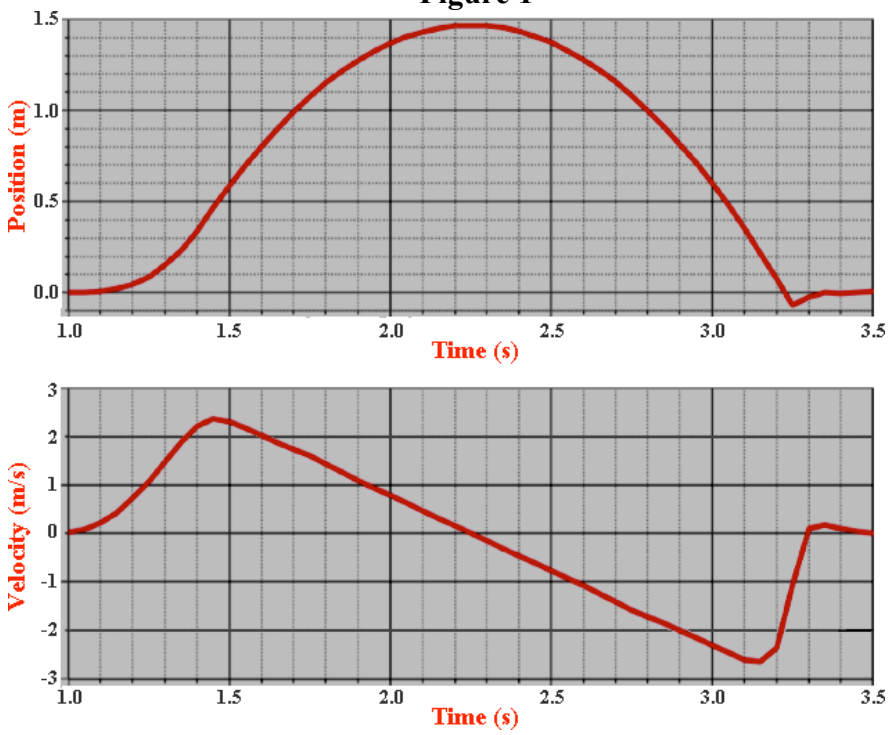
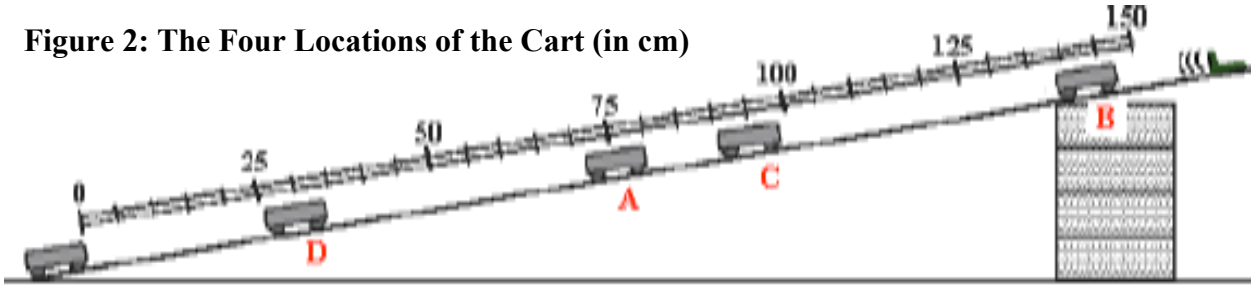


Figure 2: The Four Locations of the Cart (in cm)



The students analyze the graphs to determine the height above the table and the velocity at four different locations along the incline plane. See location labels (A, B, C and D) on **Figure 2**. The position values are in units of centimeters (cm). Location B is the highest point reached by the cart along the track. Using height and velocity values, the students calculate the KE, PE and TME for the four locations. See **Table 1**.

Table 1: Energy Values of Cart

Location	KE (J)	PE (J)	TME (J)
A	0.505	0.603	1.108
B	0.000	1.107	1.107
C	0.366	0.743	1.109
D	0.845	0.263	1.108

Questions:

1. At which time does the cart have the greatest kinetic energy?
   a. At 1.45 seconds.
   b. At 2.25 seconds.
   c. At 2.50 seconds.
   d. At 3.40 seconds

2. At which time does the cart have the greatest potential energy?
   a. At 1.10 seconds.
   b. At 1.45 seconds.
   c. At 2.25 seconds.
   d. At 3.12 seconds.

3. The potential energy of the cart depends on the vertical position. The motion detector detects the position of the cart measured diagonally along the inclined plane. The diagonal distance is not the same as the vertical position. Which method described below would allow the students to determine the vertical position (i.e., height) from the diagonal distance?
   a. Subtract the diagonal distance from the maximum distance to determine the height.
   b. Simply measure the height along the vertical axis of the graph for the specified time.
   c. With the cart on the track at the specified position, measure the height above the table.
   d. Divide the diagonal distance by 2.0 since the height appears to be one-half this distance.

4. The formula for calculating the kinetic energy is **$KE = 0.5 \cdot m \cdot v^2$** where **m** represents the mass in kilograms and **v** represents the velocity in meter/second. How does the kinetic energy (KE) of the cart at 1.60 seconds compare to the kinetic energy (KE) of the cart at 1.92 seconds?
   a. The KE at 1.60 seconds is about the same as the KE at 1.92 seconds.
   b. The KE at 1.60 seconds is about one-half the value of the KE at 1.92 seconds.
   c. The KE at 1.60 seconds is about two times greater than the KE at 1.92 seconds.
   d. The KE at 1.60 seconds is about four times greater than the KE at 1.92 seconds.
   e. The KE at 1.60 seconds is about one-fourth the value of the KE at 1.92 seconds.

5. At which of the listed positions is the potential energy the least?
   a. 0.50 meters
   b. 1.00 meters
   c. 1.20 meters
   d. 1.45 meters

6. Which conclusion regarding the total mechanical energy (TME) of the cart is most consistent with the data?
   a. The TME increases as the cart rolls upward and decreases as it rolls down.
   b. The TME decreases as the cart rolls upward and increases as it rolls down.
   c. The TME decreases as the cart rolls upward and also decreases as it rolls down.
   d. The TME remains essentially constant during the cart's motion along the incline.

7. Location B is the highest point that the cart reaches as it moves along the track. Which conclusion regarding the kinetic energy (KE) and potential energy (PE) can be made for the motion of the cart from location B to location C?
   a. Both the KE and the PE increase.
   b. Both the KE and the PE decrease.
   c. The KE increases and the PE decreases.
   d. The KE decreases and the PE increases.

8. Which conclusion regarding the kinetic energy (KE) and potential energy (PE) can be made for the motion of the cart from location C to location D?
   a. Both the KE and the PE increase.
   b. Both the KE and the PE decrease.
   c. The KE increases and the PE decreases.
   d. The KE decreases and the PE increases.

9. The formula for calculating the kinetic energy is **KE = 0.5•m•v^2** where **m** represents the mass in kilograms and **v** represents the velocity in meter/second. For which of the following positions along the track does the cart have the smallest kinetic energy?
   a. 30 cm
   b. 50 cm
   c. 90 cm
   d. 140 cm

10. For which of the following positions along the track does the cart have the smallest potential energy?
   a. 30 cm
   b. 50 cm
   c. 90 cm
   d. 140 cm

11. Suppose that the cart gains 0.5 Joules of potential energy when rolling along the track from one location to another. What changes will be observed in the kinetic energy (KE) and the total mechanical energy (TME)?
   a. The KE and the TME will both decrease by 0.5 Joules.
   b. The cart will lose 0.5 Joules of KE and lose 1.0 Joules of TME.
   c. The KE and the TME will not be affected by such changes in the PE.
   d. The cart will lose 0.5 Joules of KE but the TME will remain constant.

12. Which one of the following changes do **NOT** take place as the cart rolls from the 50 cm mark to the 120 cm mark along the inclined plane?
   a. The kinetic energy decreases.
   b. The speed of the cart decreases.
   c. The position of the cart increases.
   d. The total mechanical energy of the cart increases.