Experiment 7

Free fall-Conservation of mechanical energy

1- Objects of the experiment

To observe the changes in potential energy, kinetic energy, and total mechanical energy of a rolling body, and to ascertain graphically whether the total mechanical energy remains constant.

2- Principles

Kinetic energy of a mass *m* moving with speed *v*, is defined as:

$$K = \frac{1}{2} m v^2 \qquad (1)$$

The product of the magnitude of the gravitational force ***mg*** acting on an object and the height ***h*** of the object is named the gravitational potential energy U, and so the defining equation for gravitational potential energy is

$$U = m\,g\,h \qquad (2)$$

An object held at some height *h* above the floor has no kinetic energy (v=0). However, the gravitational potential energy of the object-Earth system is equal to *mgh*. If the object is dropped, it falls to the floor; as it falls, its speed and thus its kinetic energy increase, while the potential energy of the system decreases. In other words, the sum of the kinetic ***K*** and potential energies ***U*** – the total mechanical energy ***E*** – remains constant. This is an example of the principle of **conservation of mechanical energy**.

$$E \equiv K + U \qquad (3)$$

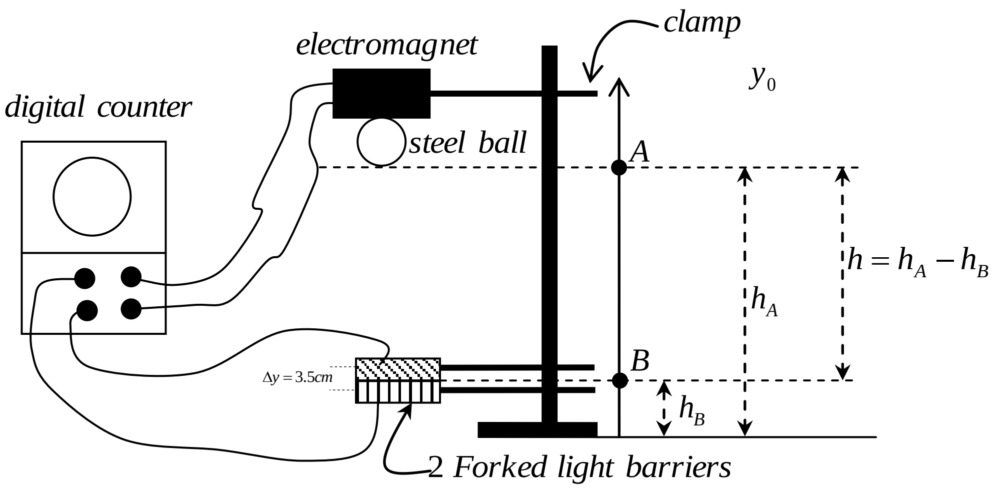

Figure1. Experiment's setup.

$$\begin{cases} E_A = mgh_A + \frac{1}{2}mv_A^2 \\ E_B = mgh_B + \frac{1}{2}mv_B^2 \end{cases} \quad (4)$$

$$\Delta E = E_B - E_A = (mgh_B + \frac{1}{2}mv_B^2) - (mgh_A + \frac{1}{2}mv_A^2)$$

$$\Delta E = mg(h_B - h_A) + \frac{1}{2}m(v_B^2 - v_A^2)$$

v_A is equal to zero because at point *A*, the trolley is at rest ($v_A = 0$), and $h_B - h_A = -h$

It follows that:

$$\Delta E = -mgh + \frac{1}{2}mv_B^2 \quad (5)$$

where

$$\Delta K = K_B - K_A = \frac{1}{2}mv_B^2 \quad (6)$$

$$\Delta U = U_B - U_A = -mgh \quad (7)$$

In Equation (5), $\Delta E = 0$ represents the condition for the mechanical energy to be conserved.

4- Method and results

- Setup the experiment as shown in Figure 1.

- Position the two combination light barriers in such a way that they touch each other and the half distance between them corresponds to the position h_B.
- Make the distance $h=h_A-h_B=0.3m$
- The distance between the two light barriers is equal to $\Delta y=0.035m$ and it is fixed. To determine the speed at point B, you should follow this expression:

$$v_B = \frac{\Delta y}{t_{avr}}$$

- Release the motion by pressing the START/STOP key at the counter S.
- Write down the time from the counter S.
- Reset the counter S to zero by pressing the RESET key.
- Position the two combination light barriers at other distances as shown in Table 1 and repeat the measurement as mentioned above.

Table 1. Time t_i as function of height h. Take the position h_A always constant.

h_A =								
$h = h_A - h_B\,(m)$	t_1 (s)	t_2 (s)	t_3 (s)	t_{avr} (s)	v_B (m/s)	ΔK (J)	ΔU (J)	ΔE(J)
0.3								
0.4								
0.5								
0.6								
0.7								

- Prepare a sheet of graph paper for plotting ***ΔK, ΔU and ΔE*** versus ***d***. You should make ***d*** the horizontal axis, and ***ΔK, ΔU and ΔE*** the vertical axis.
- Plot the measured values.
- Draw the three best fit lines to the points on your graph.
- Determine the slopes, $S_{\Delta K}$, $S_{\Delta U}$ and $S_{\Delta E}$ of best fit lines.

5- Conclusions

Discuss your results