Experiment 6

Linear motion and Newton's second law

1-Objects of the experiment:

- Measuring the time required by a trolley of mass m_1 to cover a certain path "d".
- Representing the relation between path and time in an d-t^2 diagram.
- Calculating the acceleration "a" of the trolley of mass m_1 with different masses of the falling object of mass m_2.

2-Principles

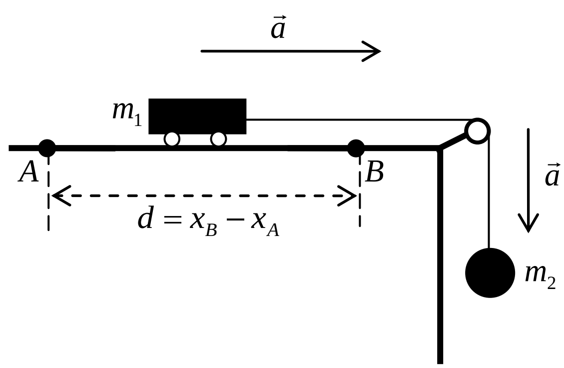


Figure 1.

If the acceleration is constant, we can use the following kinematics equation:

$$d = v_0 t + \frac{1}{2} a t^2 \quad (1)$$

$v_0 = v_A = 0$, then

$$d = \frac{1}{2} a t^2 \quad (2)$$

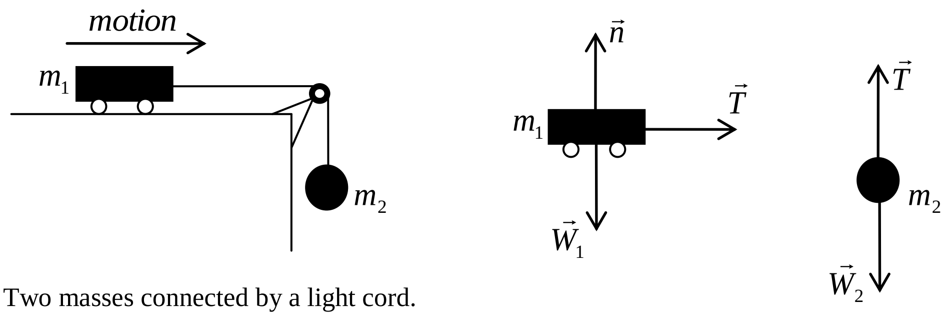
Rearrangement of Equation 2 gives us:

$$t^2 = \frac{2}{a} d \quad (3)$$

The Newton's second law:

$$\sum \vec{F} = m_1 \vec{a} \qquad (4)$$

where $\sum \vec{F}$ is the resultant force exerted on the mass m_1 (or m_2) and $\vec{a}$ is its acceleration.



Two masses connected by a light cord.

<u>Fig. 2</u>: Free- body diagrams for the two masses:

By using (Equation 4), we can find the acceleration as:

$$a = \frac{m_2}{m_1 + m_2} g \qquad (5)$$

3- Carrying out the experiment

- Align the track horizontally.
- Adjust the voltage at the holding magnet so that the trolley with the additional weight is just held.
- Define the starting point with the movable interrupter flag on the trolley, and read it from the scale of the track.
- Position the light barrier at a distance of 20 cm from the starting point.
- Release the motion by pressing the START/STOP key at the stopclock.
- Wait until the interrupter flag passes the light barrier, and read the time from the stopclock.
- Reset the stopclock to zero by pressing the RESET key.
- Repeat the measurement at distances 30 cm, 40 cm, 50 cm, and 60 cm from the starting point.

4- Measurements

Table 1. Distance as a function of time with $\mathbf{m_1=0.486kg}$ and $\mathbf{m_2=0.0252kg}$.

d (m)	$t_1(s)$	$t_2\ (s)$	$t_3\ (s)$	***Average t***	t^2
0.2					
0.3					
0.4					
0.5					
0.6					

- Graph distance **d** versus time squared $\mathbf{t^2}$ (d is the axis-x and t^2 is the axis-y)

- Draw the best line.

- Determine the acceleration "***a***" by finding a relation between the **slope** and the acceleration (use Equation 3).

- Determine the acceleration "***a***" by repeating the measurement as above but with m_2= 0.0452kg.

Table 2. Distance as a function of time with $\mathbf{m_1=0.486kg}$ and $\mathbf{m_2=0.0452kg}$.

d (m)	$t_1(s)$	$t_2\ (s)$	$t_3\ (s)$	***Average t***	t^2
0.2					
0.3					
0.4					
0.5					
0.6					

- Discuss your results.