

PROJECT 3

A_{IM}

To investigate changes in the velocity of a body under the action of a constant force and to determine its acceleration.

A_{PPARATUS AND MATERIAL REQUIRED}

Ticker-timer, a horizontal table, a bumper (a heavy rectangular block of wood), a trolley, three G-clamps, long paper tape, a pulley, strong thread, a few bricks, hanger, slotted weights, plug-key and a spring balance.

P_{RINCIPLE}

The acceleration of a moving body is constant when force acting on it is kept constant. The principle and working of a ticker-timer has already been discussed in Project P1. Suppose the experimental arrangement allows you to mark the position of a moving object as a dot on the tape of the ticker-timer. The time interval between two successive dots is the same but the dots may not be necessarily equally spaced. Equally spaced dots would represent uniform motion while unequally spaced dots would represent non-uniform motion.

For calculation of speed of a given object from the tape, take one of the tapes used in the experiment. Let S_1, S_2, S_3, \dots be the distances between two successive dots, say of ten dots, on the tape measured from point A by a metre scale as shown in the Fig. P 3.1.

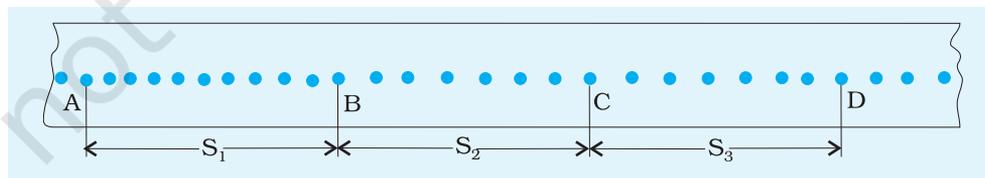


Fig.P 3.1: Dots on tape

The frequency of the vibrator of ticker-timer

= Frequency of the A.C. supply

= 50 Hz.

The time interval between two successive dots = $\frac{1}{50}$ s

The time taken for covering 10 dots i.e., for displacements S_1, S_2, S_3, \dots
 $= \frac{1}{50} \times 10 = 0.2$ s

The average speed v_1 over the distance $S_1 = \frac{S_1(\text{cm})}{0.2\text{s}} = \dots$ cm s⁻¹

The average speed v_2 over the distance $S_2 = \frac{S_2(\text{cm})}{0.2\text{s}} = \dots$ cm s⁻¹

So, the increase in speed in the time interval of 0.2 s

$$= \frac{S_2}{0.2\text{s}} - \frac{S_1}{0.2\text{s}} = \dots \text{ cm s}^{-1}$$

The average acceleration = $\frac{(S_2 - S_1)}{0.2 \times 0.2} = \dots$ cm s⁻²

PROCEDURE

1. Setup the ticker-timer at one end of a long horizontal table and fix the bumper at its other end with the help of G-clamps as shown in Fig. P 3.2.
2. Place the trolley between the timer and the bumper. Attach one end of a strong thread of suitable length to the trolley and pass it over a frictionless pulley fixed on the bumper. Attach a hanger at the free end of the thread.
3. Adjust the length of the thread in such a manner that when the trolley is brought near the timer, the hanger stands at its highest position near the pulley.
4. Bring the trolley near the ticker-timer and release it, observe its motion.
5. Place one or two small bricks on the trolley if it moves too fast. Adjust the weights on the hanger so that the trolley moves with a moderate speed.
6. Hold the trolley in position near the timer. Check that the tape is passing under the carbon paper disc. Switch the ticker-timer on and release the trolley. Ensure that the trolley gains speed till the pan touches the ground, thereafter it is stopped by the bumper.
7. Encircle the mark on the tape which was under the point of the vibrator of the timer at the instant when the pan touches the ground because there after the force ceases to act on the

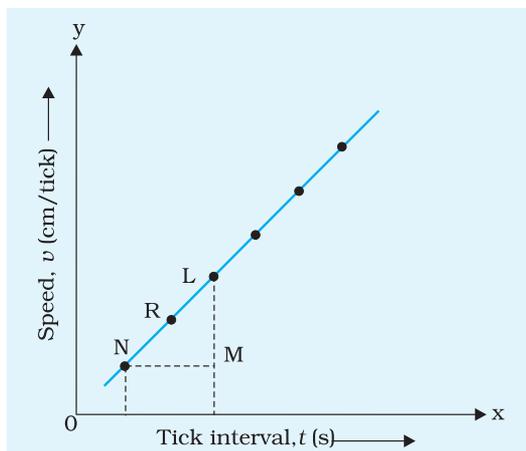


Fig. P 3.3: Graph between speed and time under a constant force

trolley, label this mark as P. Encircled mark P is the limiting position upto which the trolley was accelerated by constant force before it touched the ground.

8. Remove the part of tape where dots are marked, from the timer.
9. Choose a dot, close to the starting point, mark it as A and take it as the reference point for measurement of displacements.
10. Divide the entire motion of the trolley in about 10 equal intervals of time. To do this, count the total number of dots marked on the tape during the motion of trolley. From A, mark the positions as B, C, D etc. at the end of 10 ticks on the paper.

11. Measure the distance AB, BC, CD etc. and record them as shown in Table P 3.1. Compute average speed between different time intervals (Table P 3.1). This can be taken as instantaneous velocity at the mid point of the time interval tabulate. The computed values of the average speeds against the mid point of the time intervals.
12. The instantaneous speed at the mid point of time intervals would be nearly the same as the average speed during the interval in each case.
13. Plot a graph showing the values of speed against time which depicts the motion of the trolley under a constant force. Find the slope of speed-time graph to calculate the instantaneous acceleration (Fig. P 3.3).

OBSERVATIONS

- (a) Mass of the pan ... g.
- (b) Mass of the pan + Mass of the weights in the pan = ... g.
- (c) Mass of the trolley + mass placed in the trolley = ... g.

Table P 3.1: Instantaneous speed of the body

S. No.	Time interval (in units of tick interval) (s)	Distance, s (cm)	Average velocity $v_{av} = s/t$ (cm s ⁻¹)	Time (in mid of interval), t (tick interval) (s)
1	0 – 10	S_1	...	5
2	10 – 20	S_2	...	15
3	20 – 30	S_3	...	25

Table P 3.2: Acceleration of the body

S. No.	Point chosen	Time, t (No. of ticks)	Interval		Slope, $\frac{ML}{NM} =$ acceleration cm/tick^2
			ML (cm/tick)	NM (tick)	

RESULT

1. The speed of the trolley increases with time as constant force acts on it.
2. The acceleration of the trolley is found to be ... roughly constant within the limitations of the experiment.

PRECAUTIONS

1. Make sure that the ticker-timer and bumper are rigidly fixed.
2. The ticks in the beginning when the trolley just begins to move and at the time when the force ceases to act, be encircled properly for the purpose of measurement of distances and calculation of velocity and acceleration.

SELF ASSESSMENT

Is the acceleration calculated equal to ' g '? If not, why? With increase in mass in the pan, does the acceleration approach to acceleration due to gravity?

SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES

1. Study the variation of acceleration for different masses placed on the trolley for constant force.
2. Study the variation of acceleration for different forces, by changing the mass placed on the pan.