

**SPEED AND ACCELERATION – PRE LAB 2**

**Name:** \_\_\_\_\_ **ID Number:** \_\_\_\_\_

**Class:** \_\_\_\_\_ **Date::** \_\_\_\_\_

**1. Displacement and Velocity; Speed and Distance**

1. Read sections 2.1, 2.2, and 2.3 from you notes and write down the definitions of distance and displacement (you see that they are not always the same).

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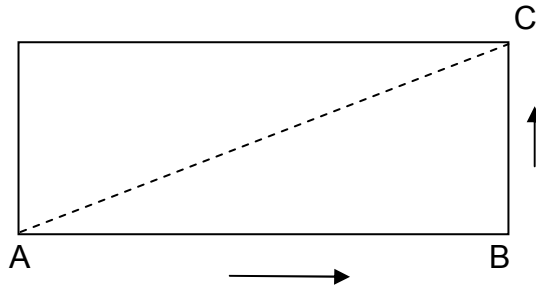
2. What are the differences between speed and velocity; a scalar and a vector quantity?

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3. Write also the definitions of average velocity, average speed and instantaneous velocity.

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4. A runner runs from A to B to C as shown in the figure below; where AB = 40 m and BC = 30 m. The time taken for a runner to cover the distance AB + BC is 10 s.



a.) What is the total distance covered by the runner?

The total distance = .....

b.) What is the displacement of the runner?

The displacement = .....

c.) What is the speed of the runner in m/s?

The speed of the runner = .....

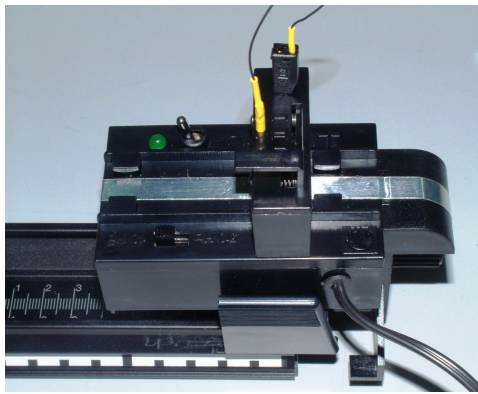
d.) What is the velocity of the runner in m/s?

The velocity of the runner = .....

e.) From the results calculate how long it takes to run the distance AC?

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## 2. USING TICKER TIMER-TROLLEY-METAL RAIL TO FIND THE ACCELERATION

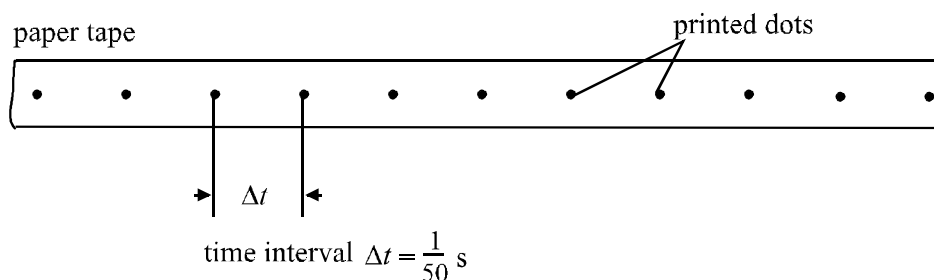


### Using a ticker timer

A ticker timer is used to measure the speed of moving objects. A ticker timer is connected to an alternating electricity supply and uses the mains electric frequency of 50 hertz to make 50 ticks or vibrations every second. A metal strip is made to vibrate up and down 50 times a second. The vibrating metal strip strikes a strip of paper tape through a carbon paper disc and so prints a dot on the tape 50 times a second. **The time interval ( $\Delta t$ ) between one dot and the next dot is always exactly 1/50 second or 0.02 s.**

- Thread a length of tape into the ticker timer, switch on and pull it through by hand.
- Look at the dots printed on the tape; they give a record of the movement of your hand.

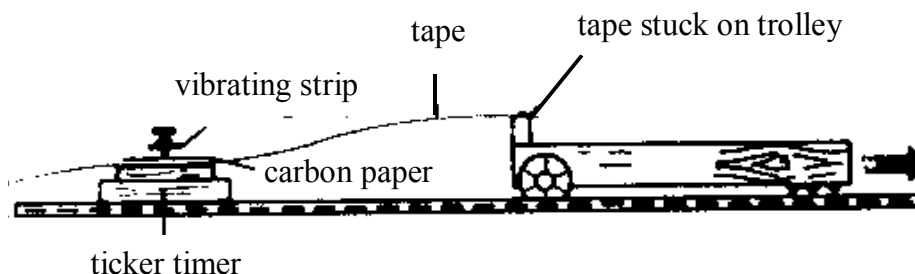
**Remember that 50 dots are printed in 1 second.** The figure below shows dots printed on paper tape by this method. The spacing of the dots varies when the speed of the tape varies but the time interval  $\Delta t$  between the dots is constant at 1/50 second. So the ticker timer is a kind of clock which measures time in 0.02 s intervals or ‘ticks’.



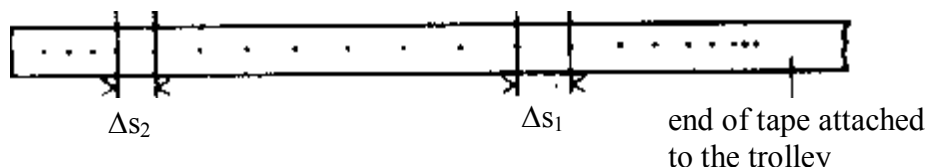
**Figure 1: Measuring speed using a ticker timer**

- The distance between one dot and the next is the change of distance or difference of distance  $\Delta s$  which the object (pulling the tape) has moved in the small time interval  $\Delta t$ . By measuring the small distance moved  $\Delta s$  in a small time interval  $\Delta t$  we can find the actual speed or instantaneous speed at that particular moment of time. This is because during a very small time interval there is little likelihood that the speed will vary much.

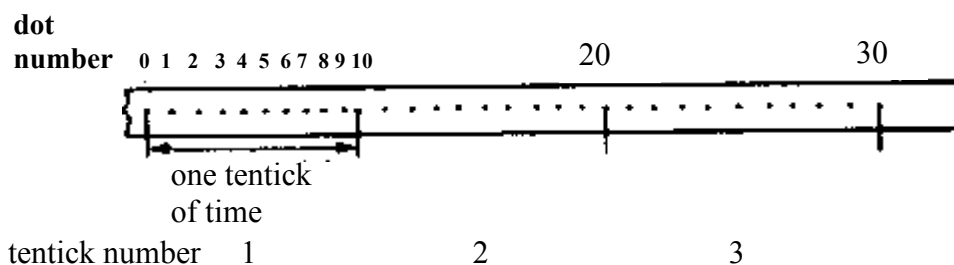
**Figure 2a** Producing a tape of the trolley's motion.



**Figure 2b** Finding the instantaneous speed.



**Figure 2c:** Making a tape chart; marking the tape.



- The instantaneous speed  $v$  of an object is given by:

$$v = \frac{\Delta s}{\Delta t}$$

which can be stated as the rate of change of distance moved with time.

- The total time  $t$  is given by the number of spaces between dots, each worth  $\frac{1}{50}$  s or 0.02 s. For example, if the total distance moved  $s = 142.5$  cm and there are 95 spaces between dots, the time taken  $t = 95 \times 0.02$  s = 1.9 s, and the average speed is

$$\frac{s}{t} = \frac{142.5 \text{ cm}}{1.9 \text{ s}} = 75 \text{ cm/s}$$

### Making a tape chart

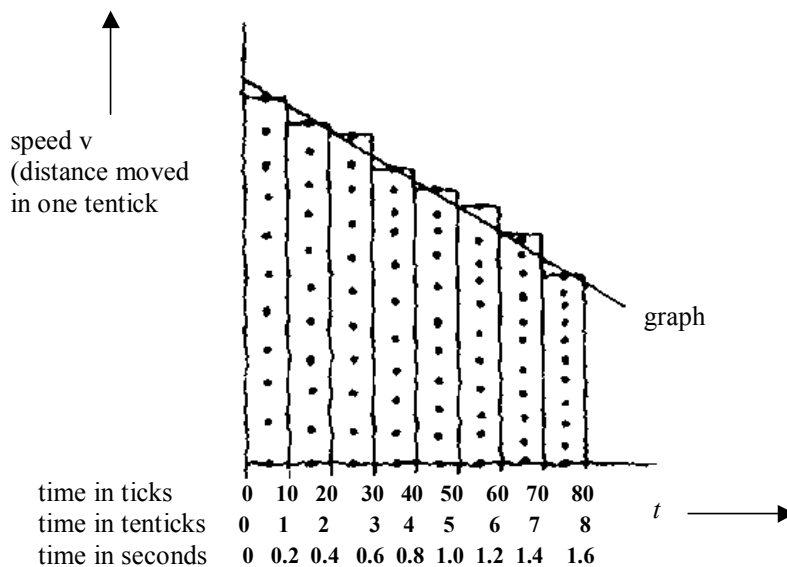
- The vibrations of the ticker timer are similar to the ticking of a clock, but the timer makes very rapid ticks: fifty every second. We can call the time from one dot to the next a 'tick' of time. So 1 tick of time =  $\frac{1}{50}$  s = 0.02 s.
- Usually the distance from one dot to the next dot on the tape is quite short, often less than 1 cm. So we find that a useful length of time is ten spaces between dots which we shall call a 'tentick' of time. One tentick of time is the time interval  $\Delta t$  from dot number 0 to dot number 10 on the tape:

$$1 \text{ tentick of time} = 10 \times 0.02 \text{ s} = 0.2 \text{ s or } \frac{1}{5} \text{ s.}$$

- The length of each tentick strip is the distance moved in one tentick of time, that is 0.2 s. So the length of a tentick is a measure of instantaneous speed  $v$ :

$$\text{instantaneous speed } v = \frac{\text{length of a tentick strip}}{0.2 \text{ s}}$$

- The lengths of the tentick strips may change as shown in figure 1. This shows you how the speed of the trolley changed. The strips show you the distances moved in equal times of one tentick.



**Figure 3: Making a tape chart**

### Measuring the acceleration of a trolley

- *Acceleration is the rate of change of velocity with time.*
- So we calculate acceleration from the change of velocity which occurs in unit time:

$$\text{acceleration} = \frac{\text{change of velocity}}{\text{time taken for the change}} \quad a = \frac{\Delta v}{\Delta t}$$

- An example of a tape chart obtained from an accelerating trolley is shown in **figure 3**. We can make the following observations about this tape chart:
  - a. The tentick strips of tape which show the distance moved in one tentick of time (0.2 s) are increasing in length so the velocity of the trolley is increasing i.e. The trolley is accelerating.
  - b. The steps up from the top of the tentick strip to the top of the next are equal. These steps show the increase in velocity from one tentick to the next and so the equal steps show equal increases in the velocity of the trolley. We call this **constant acceleration**, or **uniform acceleration**.

- **Uniform, or constant, acceleration**

An object has uniform, or constant, acceleration if its velocity changes by equal amounts in equal successive time intervals. The equal changes in velocity are the equal steps up from the top of one strip to the top of the next strip. The equal successive time intervals are the tentick time intervals of the tape strips placed in order along the bottom of the tape chart. The uniform acceleration of the trolley is also shown by the upwards sloping straight line which can be drawn through the tops of the tape strips.

- **The change of velocity  $\Delta v$**

The change in velocity  $\Delta v$  is given by the difference between the final velocity  $v$  and the initial velocity  $v_0$ .

$$\Delta v = v - v_0$$

From **figure 3c** we can see that the change of velocity is given by:

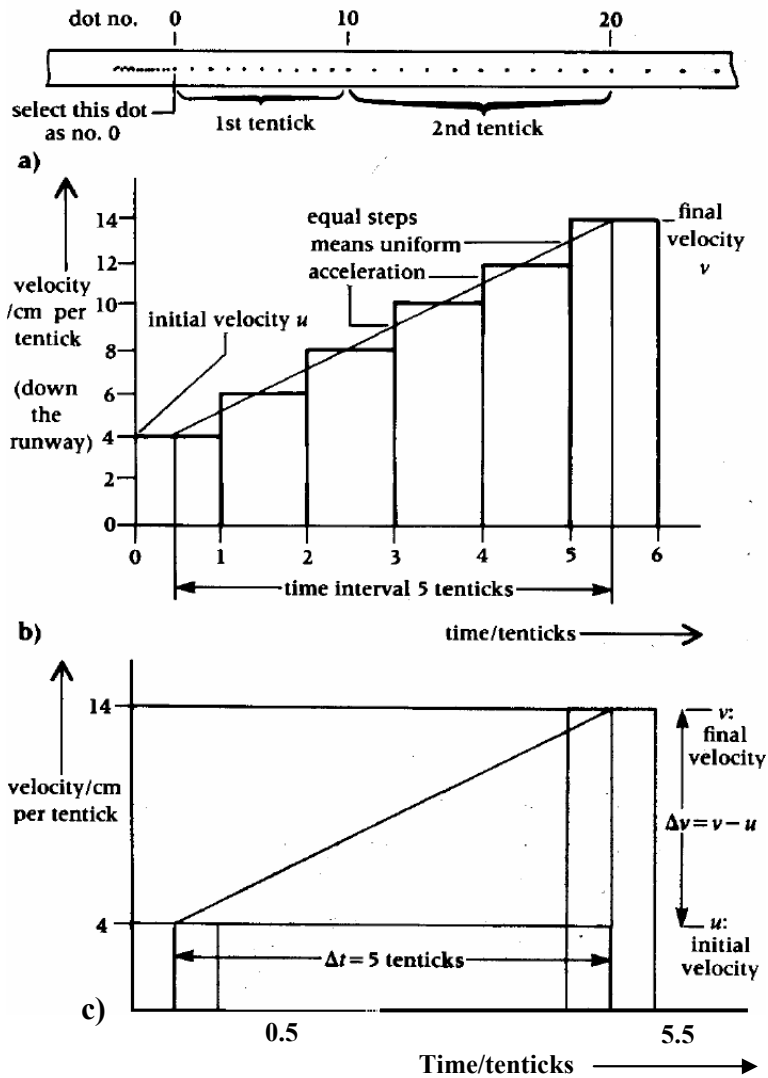
$$\Delta v = 14 \frac{\text{cm}}{\text{tentick}} - 4 \frac{\text{cm}}{\text{tentick}} = 10 \frac{\text{cm}}{\text{tentick}}$$

or 10 cm per tentick. Now as one tentick of time =  $\frac{1}{5}$  s of 0.2 s ( $10 \times \frac{1}{50}$  s), we can convert the units of  $\Delta v$  from cm per tentick to cm per second:

$$\Delta v = 10 \text{ cm per tentick} = 10 \text{ cm in each } \frac{1}{5} \text{ s}$$

$$\Delta v = 5 \times 10 \text{ cm in each full second}$$

$$\Delta v = 50 \text{ cm/s.}$$



**Figure 4:** Measuring acceleration from a tape chart

**N.B:** If the trolley is moving at constant velocity; the top of the velocity-time chart would be horizontal and the gradient is zero, indicating there is no acceleration.