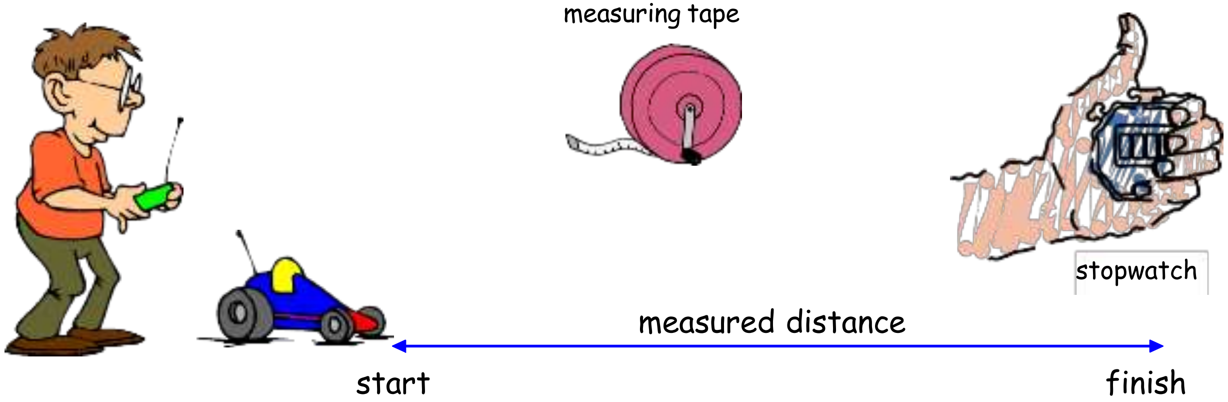
- Measuring Average Speed: Human Timing

To measure the **average speed** ($\bar{v}$) of a moving object (for example, a **radio-controlled toy car**), we can use a **measuring tape** and **stopwatch**:



1) With a **m** _ _ _ _ _ _ _ _ _ _ **t** _ _ _ , measure (and mark with chalk) a distance of several metres on the ground.

2) With a **s** _ _ _ _ _ _ _ _ _ _ , time how long it takes the radio-controlled toy car to travel this distance.

3) Calculate the **average speed** of the toy car using the formula:

$$\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$v = \frac{d}{t}$$

Sample Readings and Calculation

- distance travelled (d) = 6 m
- time taken (t) = 1.5 s
- average speed ($\bar{v}$) = ?

$$\bar{v} = \frac{d}{t}$$

$$= \frac{6}{1\cdot5}$$

$$= 4 \text{ m/s}$$

9) The following readings were obtained during 3 runs of the radio-controlled car.

For each set of readings, calculate the **average speed** of the radio-controlled car:

Run 1

- distance travelled (d) = 9 m
- time taken (t) = 1.8 s

Run 2

- distance travelled (d) = 12 m
- time taken (t) = 2.5 s

Run 3

- distance travelled (d) = 15 m
- time taken (t) = 6.0 s

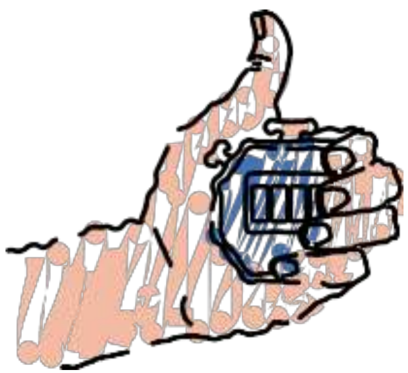
- Measuring Average Speed: Electronic Timing

Stopwatches and Human Reaction Time

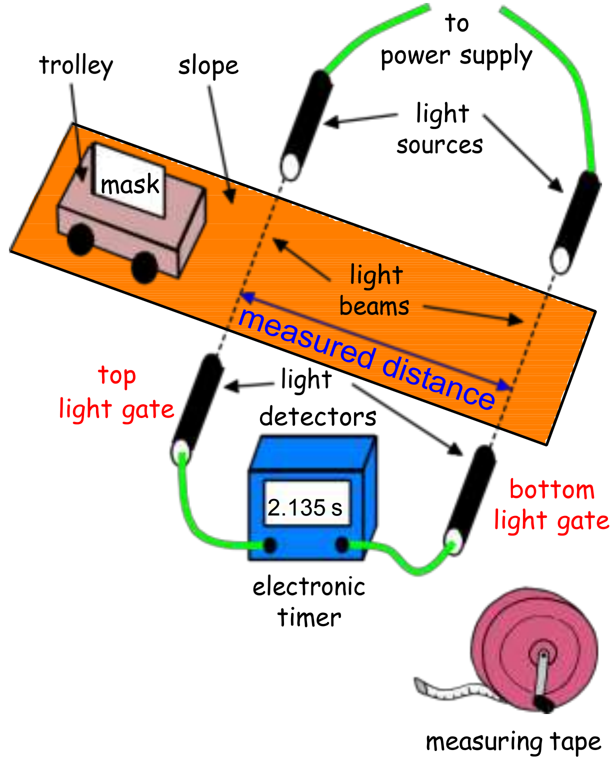
Using a **stopwatch** to time moving objects does **not** give us a very **accurate** value for the time taken. This is due to **human reaction time**.

For example, imagine you are timing a radio-controlled toy car from the moment it starts to the moment it has travelled 5 metres. When your eyes see the car start to move, they send a message to your brain. Your brain processes this message then sends another message to your finger telling it to press the **start button** on the stopwatch - but it takes a fraction of a second for all this to happen, so the car is **already moving** before the **start button** is pressed. When the car reaches the 5 metre mark, the same signalling/reaction process takes place in your body - the car will have **travelled past** the 5 metre mark before the **stop button** is pressed. Because of this, the timing of the car journey is **not accurate**.

This is particularly important when timing sprint races where a difference of less than 0.001 seconds can mean the difference between first and second place! In cases like this, **electronic timing** is used - This does not involve humans pressing buttons (no **human reaction time**) so is far **more accurate** than **human timing**.



To measure the **average speed** ($\bar{v}$) of a moving object (for example, a **trolley** rolling down a slope) with **electronic timing**, we use a **measuring tape** and **2 light gates** connected to an **electronic timer**.
A **mask** (**thick card**) is fixed on top of the trolley - No light can pass through the mask.



When the **mask** breaks the **light beam** of the **top light gate**, the electronic timer is automatically switched **on**.

When the **mask** breaks the **light beam** of the **bottom light gate**, the electronic timer is automatically switched **off**.

The electronic timer shows the time the trolley takes to travel from the **top light gate** to the **bottom light gate**.

1) With a **m _ _ _ _ _ _ _ _ _ t _ _ _**, measure the distance between the 2 light gates.

2)Put the trolley at the top of the slope and let it run down the slope (so that the mask passes through the **l _ _ _ _ b _ _ _** of both **l _ _ _ _ g _ _ _ _**).

3) Read the **time** taken for the trolley to travel from the top light gate to the bottom light gate from the **e _ _ _ _ _ _ _ _ _ t _ _ _ _**.

3) Calculate the **average speed** of the trolley using the formula:

$$\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$v = \frac{d}{t}$$

Sample Readings and Calculation

- distance travelled (d) between light gates = 1.25 m
- time taken (t) to travel between light gates = 0.500 s
- average speed ($\bar{v}$) = ?

$$\bar{v} = \frac{d}{t}$$

$$= \frac{1{\cdot}25}{0{\cdot}500}$$

$$= \underline{2{\cdot}5\ m/s}$$

10) The following readings were obtained during 3 separate runs of the trolley down the slope.

For each set of readings, calculate the **average speed** of the trolley as it ran down the slope:

Run 1

- distance travelled (d) between light gates = 1.25 m
- time taken (t) to travel between light gates = 0.250 s

Run 2

- distance travelled (d) between light gates = 0.80 m
- time taken (t) to travel between light gates = 0.500 s

Run 3

- distance travelled (d) between light gates = 1.50 m
- time taken (t) to travel between light gates = 0.750 s