## 1) Calculate the missing quantity in each case:

- average speed $=$ ?
- distance $=500 \mathrm{~m}$
- time $=5 \mathrm{~s}$
- average speed $=$ ?
- distance $=15000 \mathrm{~m}$
- time $=25 \mathrm{~s}$

- average speed $=$ ?
- distance $=10 \mathrm{~m}$
- time $=0.5 \mathrm{~s}$

- average speed $=$ ?
- distance $=750 \mathrm{~m}$
- time $=500 \mathrm{~s}$
- time $=80 \mathrm{~s}$
- time $=3.5 \mathrm{~s}$

- average speed $=$ ?
- distance $=1440 \mathrm{~m}$

- average speed $=0.001 \mathrm{~m} / \mathrm{s}$
- distance $=$ ?
- time $=120 \mathrm{~s}$

- average speed $=1.2 \mathrm{~m} / \mathrm{s}$
- distance $=6 \mathrm{~m}$
- time = ?
- average speed $=10.2 \mathrm{~m} / \mathrm{s}$
- distance $=100 \mathrm{~m}$
- time $=$ ?

For very long journeys of kilometres/miles which take hours to complete, average speeds are quoted in units of kilometres per hour ( $\mathbf{k m} / \mathbf{h}$ ) or miles per hour ( $\mathbf{m p h}$ ).

- You may have to solve problems involving these units in tests or in your Intermediate 2 Physics exam.

2) Convert the following speeds from kilometres per hour to metres per second.

Hint-Convert kilometres to metres (by multiplying by 1000 ), then divide by 3600 (since 1 hour $=3600$ seconds).

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

(a) 18 kilometres per hour.
(b) 72 kilometres per hour.
(c) 100 kilometres per hour.
3) Wendy takes 45 minutes to run a 10 kilometre race.
(a) What is Wendy's time in hours (expressed as a decimal)?

(b) Calculate Wendy's average speed in kilometres per hour.
4) A cruise ship takes a time of 5 hours 30 minutes to sail 33 miles.
(a) Express the time in hours in decimal form.
(b) Calculate the average speed of the ship in miles per hour.
5) The Eurostar train service from London
to Brussels takes
2 hours 45 minutes to cover the
340 kilometre track distance.
Calculate the average speed of the train in kilometres per hour.


Using information from these timetable extracts, calculate the train's average speed in miles per hour.
7) An extract from an express coach timetable is
 shown below.
Assuming the coach departs and arrives exactly on time, calculate the total distance travelled in kilometres if the average speed for the journey is
80 kilometres per hour.
Depart
Aberdeen
1400 hours
Arrive
Glasgow
1715 hours
8) A coach travels the 157.5 mile road distance

from Edinburgh to
Inverness at an average speed of 45 miles per hour.
Calculate the time taken for the journey in hours.

## - Measuring Average Speed: Human Timing

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

stopwatch measured distance
start
finish

1) With a $\mathrm{m}_{\ldots} \ldots \ldots \ldots \ldots$ t __-_, , measure (and mark with chalk) a distance of several metres on the ground.
2) With $a s$ $\qquad$ , 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:
average speed =

$\square$

## Sample Readings and Calculation

- distance travelled ( $d$ ) $=6 \mathrm{~m}$
- time taken $(\dagger)=1.5 \mathrm{~s}$

$$
\begin{aligned}
\bar{v} & =\frac{d}{\dagger} \\
& =\frac{6}{1.5} \\
& =4 \mathrm{~m} / \mathrm{s}
\end{aligned}
$$

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) $=9 \mathrm{~m}$
- time taken $(\mathrm{t})=1.8 \mathrm{~s}$


## Run 2

- distance travelled (d) $=12 \mathrm{~m}$
- time taken $(\mathrm{t})=2.5 \mathrm{~s}$


## Run 3

- distance travelled (d) $=15 \mathrm{~m}$ - time taken $(\mathrm{t})=6.0 \mathrm{~s}$


## - 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
 , 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 I $\qquad$ ).
2) Read the time taken for the trolley to travel from the top light gate to the bottom light gate from the $\mathbf{e}$ $\qquad$ t $\qquad$ -.
3) Calculate the average speed of the trolley using the formula:

$$
\text { average speed }=\frac{\text { distance travelled }}{\text { time taken }} \quad v=\frac{d}{t}
$$

## Sample Readings and Calculation

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

$$
\begin{aligned}
\bar{v} & =\frac{d}{t} \\
& =\frac{1.25}{0.500} \\
& =2.5 \mathrm{~m} / \mathrm{s}
\end{aligned}
$$

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


## - Instantaneous Speed

The instantaneous speed $(v)$ of a moving object is its speed at a particular instant of time.


Note that for 11 instantaneous speed 11, there is NO bar (-)above the v-

The instantaneous speed of a car is shown on its speedometer.
As the instantaneous speed of the car changes, the speedometer reading changes.

## a car speedometer

The instantaneous speed of a moving object is estimated by measuring the distance the object travels in a very short time - Much less than 1 second.
The smaller the measured time, the better will be the estimate for the object's instantaneous speed.
For times longer than about $\mathbf{0 . 0 0 5}$ seconds, the speed determined is really the average speed.

The method used to measure the time of travel has an effect on the estimated value for instantaneous speed.

A stopwatch cannot be used because we are not able to press the start and stop buttons quickly enough - Slow human reaction time.
We have to use
electronic
timing which
can measure
very small time
intervals - For
example,
0.001
seconds.


## - Measuring Instantaneous Speed: Electronic Timing

To measure the instantaneous speed (v) of a moving object (for example, a trolley rolling down a slope) at a particular point on the slope, we employ electronic timing - 1 light gate is connected to an electronic timer. A short mask (about a 1 or 2 cm length of thick card) is fixed on top of the trolley - No light can pass through the mask.


When the front edge of the mask enters the light beam of the light gate, the electronic timer is automatically switched on.
When the back edge of the mask leaves the light beam of the light gate, the electronic timer is automatically switched off.
The electronic timer shows the time the mask takes to travel through the light gate.

1) With $a r$ r $\qquad$ , measure the I $\qquad$ of the short mask.
2) Place the I $\qquad$ g $\qquad$ at the particular point on the slope where you want to measure the trolley's $\mathbf{i}$ $\qquad$ speed.
3) Put the trolley at the top of the slope and let it run down the slope (so that the short mask passes through the I $\qquad$ of the I $\qquad$ $\mathbf{g}_{-\quad \text {. }}$. .)
4) Calculate the instantaneous speed of the trolley using the formula:
instantaneous speed $=$
distance (length of mask)
time taken for mask to travel through light gate

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

## Sample Readings and Calculation

- distance (length of mask) $=0.01 \mathrm{~m}$
- time taken ( $\dagger$ ) for mask to travel through light gate $=0.002 \mathrm{~s}$
- instantaneous speed ( $v$ ) = ?

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

$=\frac{0.01}{0.002}$
$=5 \mathrm{~m} / \mathrm{s}$
11) The following readings were obtained during 3 separate runs of the trolley down the slope.

For each set of readings, calculate the instantaneous speed of the trolley as it passed through the light gate:

## Run 1

- distance (length of mask) $=0.01 \mathrm{~m}$
- time taken ( t ) for mask to travel through
light gate $=0.001 \mathrm{~s}$


## Run 2

- distance (length of mask) $=0.015 \mathrm{~m}$
- time taken (t) for mask to travel through
light gate $=0.003 \mathrm{~s}$


## Run 3

- distance (length of mask) $=0.02 \mathrm{~m}$
- time taken (t) for mask to travel through
light gate $=0.005 \mathrm{~s}$


## - Comparing Instantaneous and Average Speeds

In most cases, at any particular instant of time, the instantaneous speed of a moving object will have a different value from its average speed - because most objects speed up and slow down during their journey.

The instantaneous and average speeds will only have the same value over a long period of time if the object:

- does not move.
- does not speed up or slow down.


12) (a) Why do we use the term average speed to describe the movement of objects which travel a large distance? $\qquad$
(b) Describe and explain the movement of a bus on a typical journey from Edinburgh to Glasgow: $\qquad$ -
$\qquad$
13) (a) What do we mean by the instantaneous speed of an object? $\qquad$
(b) What device in a car shows the instantaneous speed of the car?
(c) Explain whether we can use a stopwatch to determine the instantaneous speed of an object:
(d) Why is electronic timing used to determine the instantaneous speed of an object?
14) (a) In most cases, at any particular moment in time, does the instantaneous speed of an object have the same or a different value from its average speed?
(b) Explain why:
(c) Give $\underline{2}$ examples of when the instantaneous and average speeds of an object have the same value:

## - Scalar and Vector Quantities

The following are some of the quantities you will meet in the Intermediate 2 Physics course:

| distance | displacement |
| :--- | :--- |
| speed | velocity |
| force |  |
| time |  |
| Quantities can be divided into 2 groups: |  |

## SCALARS

These are specified by stating their magnitude (size) only, with the correct unit-

## VECTORS

These are specified by stating their magnitude (size), with the correct unit, and a direction.

Some scalar quantities have a corresponding vector quantity. Other scalar and vector quantities are independent. For example:

| corresponding scalar <br> quantity | corresponding vector <br> quantity |
| :---: | :---: |
| distance $\left(e \cdot g^{\cdot}, 25 \mathrm{~m}\right)$ | displacement $\left(e \cdot g^{\cdot}, 25 \mathrm{~m}\right.$ North $)$ |
| speed $\left(e \cdot g^{\cdot}, 10 \mathrm{~m} / \mathrm{s}\right)$ | velocity $\left(e \cdot g^{\cdot}, 10 \mathrm{~m} / \mathrm{s}\right.$ East $)$ |
| time $\left(e \cdot g^{\cdot}, 12 \mathrm{~s}\right)$ | NONE |
| NONE | force $\left(e \cdot g^{\cdot}, 10 \mathrm{~N}\right.$ to the right $)$ |

## DISTANCE and DISPLACEMENT

- Distance (a scalar quantity) is the total length of path travelled.
[A unit must always be stated].
- Displacement (a vector quantity) is the length and direction of a straight line drawn from the starting point to the finishing point.
[A unit and direction must always be stated, unless the displacement is zero, in which case there is no direction].

For example:

1) Bill drives 90 km along a winding road.


- Distance travelled $=90 \mathrm{~km}$
- Displacement $=50 \mathrm{~km}$ bearing $77^{\circ}$ from North

2) Ben jogs once around the centre circle of a football pitch.


- Distance travelled $=25 \mathrm{~m}$ - Displacement $=0 \mathrm{~m}$. (He is back where he started, so the length of a straight line drawn from his starting point to his finishing point is 0 m ).


## SPEED and VELOCITY

- Speed (a scalar quantity) is the distance travelled every second.

- Velocity (a vector quantity) is the change of displacement every second.
velocity $=$ displacement
time
[A unit and direction must always be stated, unless the velocity is zero, in which case there is no direction].

For example:
Bill drives 90 km along a winding road in a time of 2 hours:
N winding road,


- Distance travelled $=90 \mathrm{~km}$
- Displacement $=50 \mathrm{~km}$ bearing $77^{\circ}$ from North

15) (a) How would you specify a scalar quantity? $\qquad$
(b) Give three examples of scalar quantities: $\qquad$
16) (a) How would you specify a vector quantity? $\qquad$
(b) Give three examples of vector quantities:
17) State the difference between distance and displacement:
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
18) Explain the terms speed and velocity: $\qquad$
$\qquad$
$\qquad$
$\qquad$
$=25 \mathrm{~km} / \mathrm{h}$
bearing $77^{\circ}$ from Nort
