Dynamics

N5 Physics

1.1	I can define scalar quantities and vector quantities a scalar has magnitude/size, and unit only, a vector has magnitude/size and unit + direction
1.2	I can identify vector and scalar quantities such as: force, speed, velocity, distance, displacement, acceleration, mass, time and energy.
1.3	I can calculate the resultant of two vector quantities in one dimension or at right angles.
1.4	I can determine displacement and/or distance using scale diagram or calculation.
1.5	I can determine velocity and/or speed using scale diagram or calculation.
1.6	I can perform calculations/ solve problems involving the relationship between speed, distance and time (d = vt, and $d = \bar{v}t$)
1.7	I can perform calculations/ solve problems involving the relationship between velocity, displacement and time ($s = \bar{v}t$) in one dimension
1.8	I can determine average and instantaneous speed.
1.9	I can describe experiments to measure average and instantaneous speed.
3.1	I can define acceleration as rate of change of velocity. Which is found from the final velocity subtract the initial velocity all divided by the time for the change.
3.2	I can use (a = Δv/t).to solve problems on acceleration, change in speed and time.
3.3	I can use (a = (v – u)/t).to solve problems involving acceleration, initial velocity (or speed) final velocity (or speed) and time of change.
3.4	I can find the acceleration from the gradient of velocity–time graphs.
3.5	**I can describe an experiment to measure acceleration**

Revision
Revision
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Revision

S3?

State the headings on the table

[redacted]	[redacted]
Energy	Velocity
Temperature	Acceleration
Pressure	Displacement
Time	(Momentum)- not required
Mass	Force
Current	(Weight/ friction etc)
Speed	Gravitational field strength
Volume	
Voltage	
Distance	
Area	
Resistance	
Frequency	

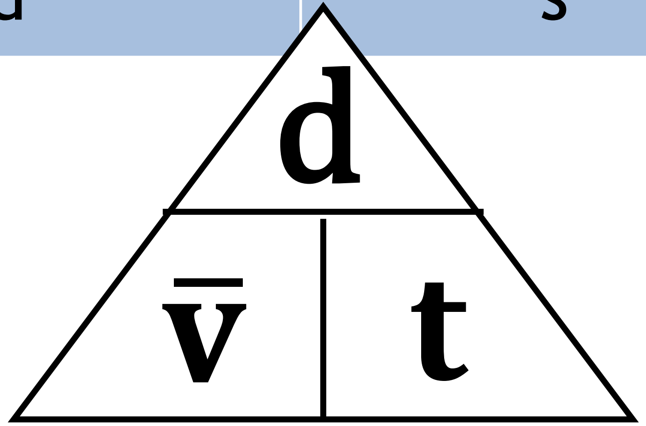
Speed is the distance travelled in unit time (distance travelled per second)

- Speed is described by the equation.
- Speed =distance ÷ time
- $speed = \frac{distance}{time}$
- $v = \frac{d}{t}$

Symbols and Units

Symbol	Definition	Unit	Unit Symbol
v	speed	metres per second	ms^{-1}
d	distance	metre	m
t	time	second	s

But don't use the triangle unless you absolutely have to.



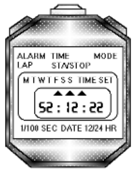
Average Speed

The **average** speed of an object is defined as the total distance travelled divided by the time for the journey, or the rate of covering a distance.

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

The bar over any quantity in Physics denotes that it is an average value

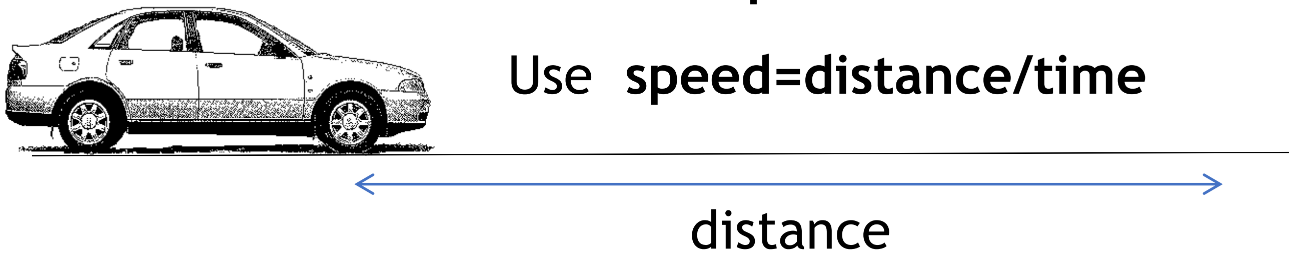
Measuring Average Speed



Measure the **distance travelled** by the car using a **trundle wheel**/tape measure etc.

Measure the **time for the journey** with a **stopwatch.**

Use **speed=distance/time**



- To measure the average speed you need to **measure the distance for the whole journey** and measure **the time taken for the whole journey**. The distance can be measured with a trundle wheel, tape measure etc., and the time can be measured with a stop watch. Use the formula:
- $\bar{v} = \frac{d}{t}$
- …to calculate the average speed for the journey.

Instantaneous Speed

- The **instantaneous** speed of an object is defined as the length of the vehicle divide by the time to pass a point.

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

Measuring the Average Speed of a Vehicle

Aim: Measurement of average speed of a trolley

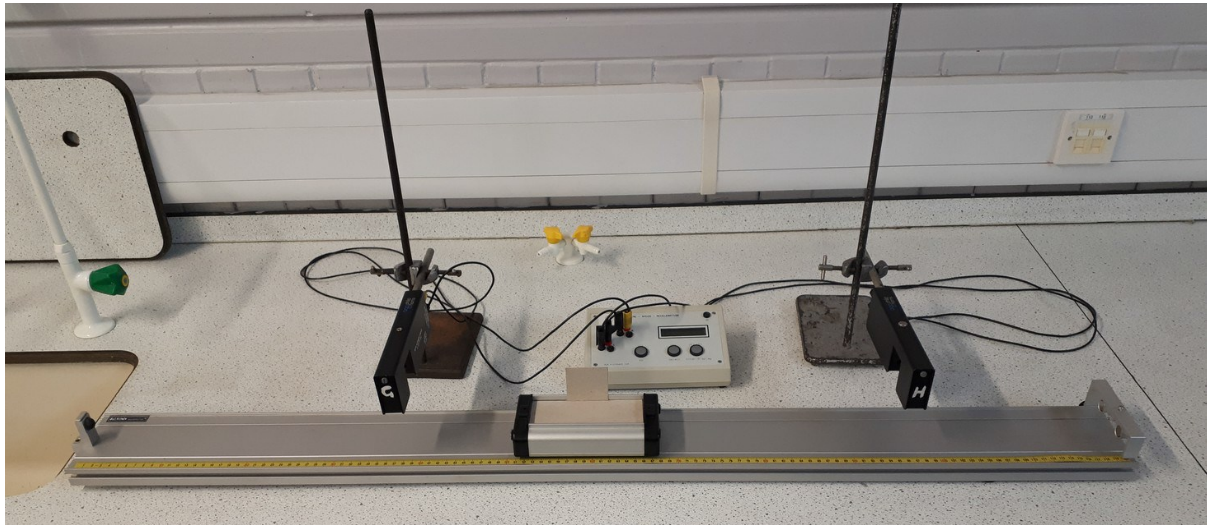
Apparatus: Runway, trolley with single mask, light gate, computer timer, metre rule

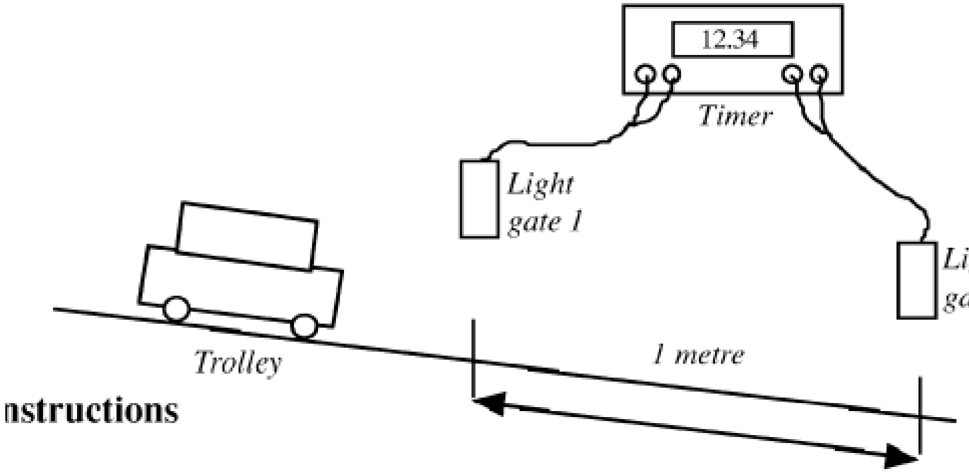
Instructions

1. Measure distance, d, between the two light gates.
2. Set the computer to measure the time between the trolley passing through the light gates.
3. Release the trolley and record the time, t.
4. Calculate average speed $\tilde{v} = d / t$
5. Repeat several times and calculate an average.

Evaluation

Look over your results and comment on the accuracy and precision





Measuring the Instantaneous Speed of a Vehicle

Aim: Measuring the instantaneous speed of a vehicle

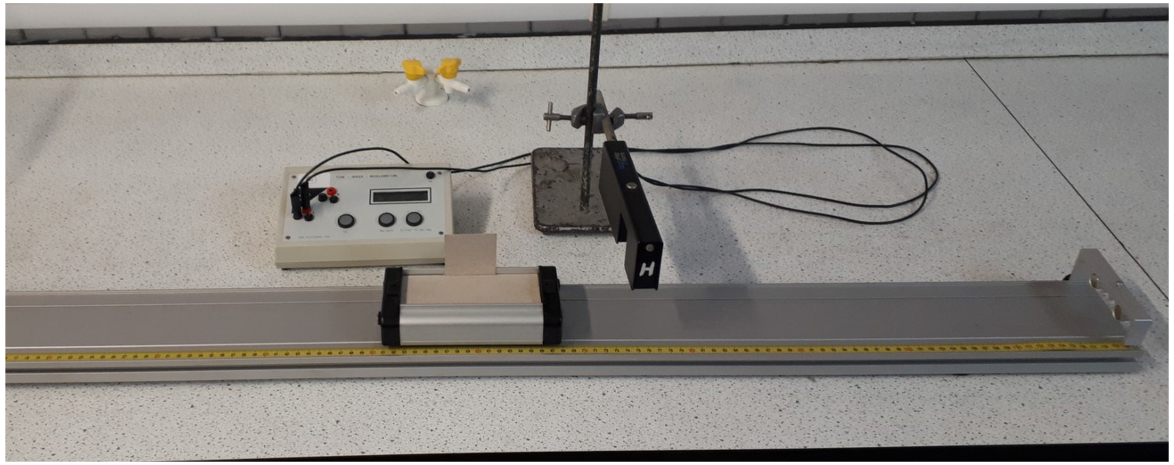
Apparatus Runway, trolley with single mask, light gate, computer timer, ruler.

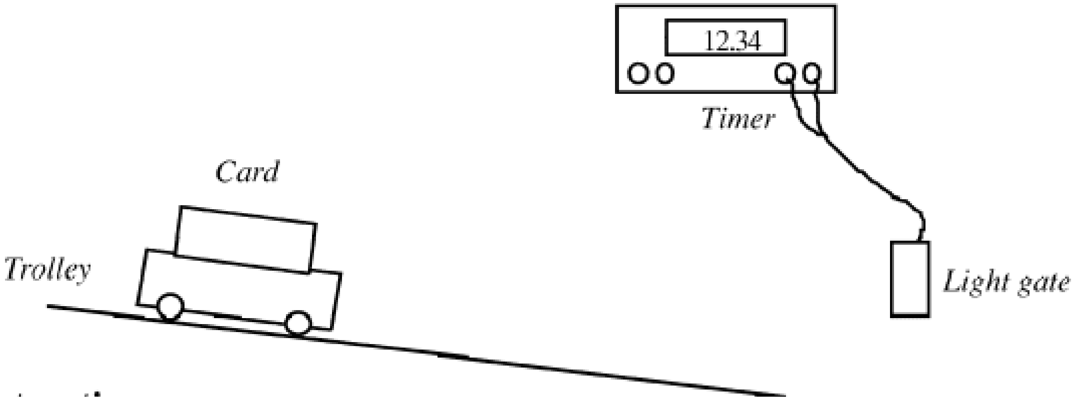
Instructions

1. Measure distance, d, between the two light gates.
2. Set the computer to measure the time between the trolley passing through the light gates.
3. Release the trolley and record the time, t.
4. Calculate average speed $\tilde{v} = d / t$
5. Repeat several times and calculate an average.

Evaluation

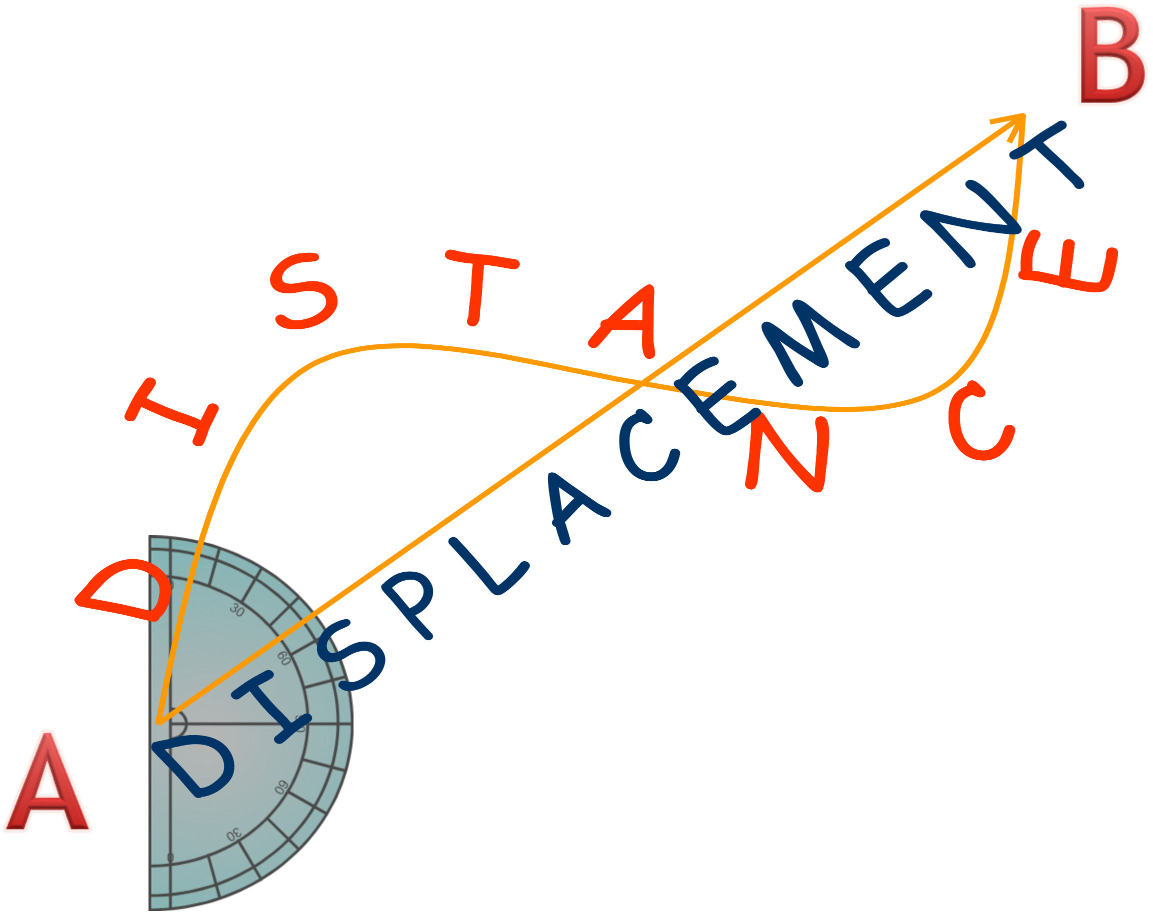
Look over your results and comment on the accuracy and precision





Use a small width of card (this is too big)

Speed velocity, distance and Displacement

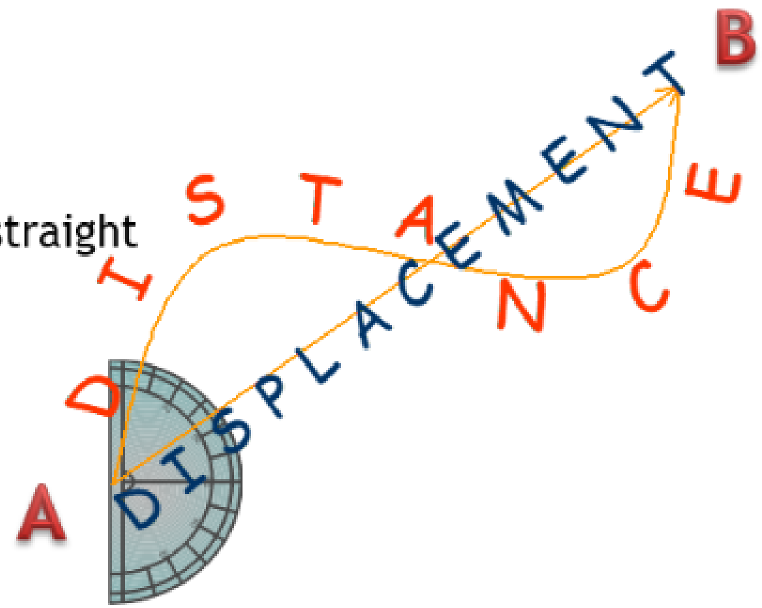


Distance = “how far we’ve travelled”

- symbol *d*
- units metres, m
- scalar quantity

Displacement = “how far we’ve travelled in a straight line (from A to B)” (include your direction)

- symbol *s*
- units, metres, m
- Vector quantity
- Must quote the direction



Speed is a scalar quantity (metres per second) Speed = $\frac{\text{distance}}{\text{time}}$ $\left(\frac{\text{metres}}{\text{seconds}}\right)$

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

Velocity is a vector quantity so quote a direction. (metres per second) Velocity = $\frac{\text{displacement}}{\text{time}}$ $\left(\frac{\text{metres}}{\text{seconds}}\right)$

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

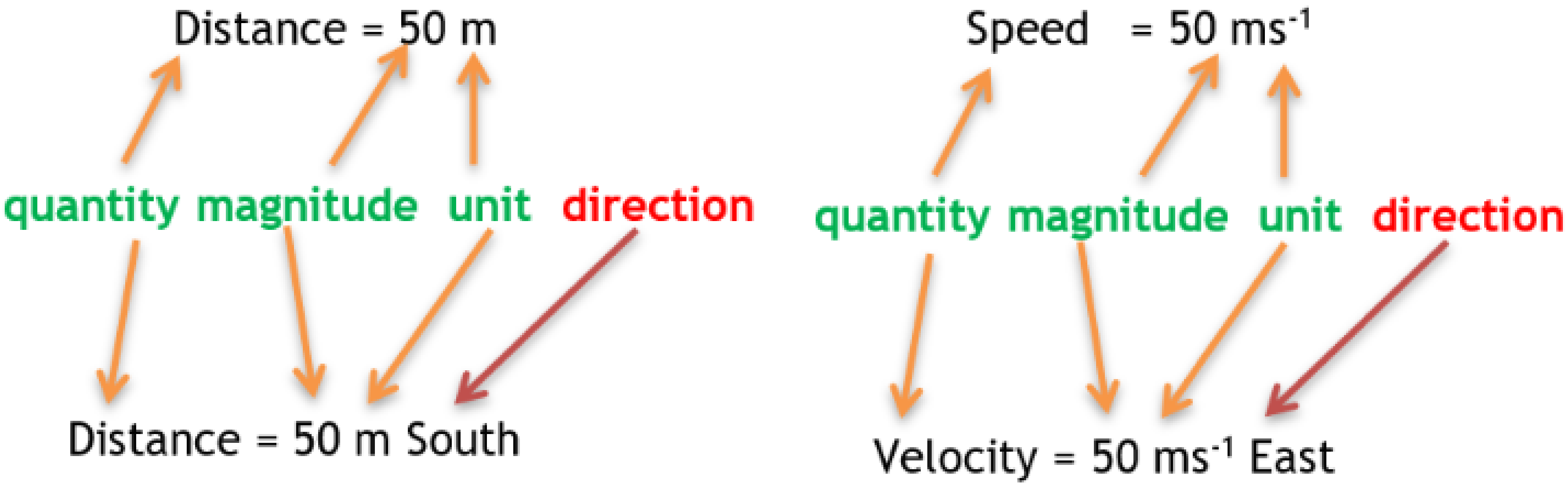
VELOCITY $s = vt$

- **Velocity** is the rate of change of displacement and is described by the equation below.

$$velocity = \frac{displacement}{time} \qquad v = \frac{s}{t}$$

- Velocity is a **vector** quantity.
- The direction of the velocity will be the same as the direction of the displacement.
- If the velocity is measured over the whole journey then it is known as **average velocity**, with the symbol $\bar{\mathbf{v}}$.

Scalars and Vectors, Distance and Displacement, Speed and Velocity

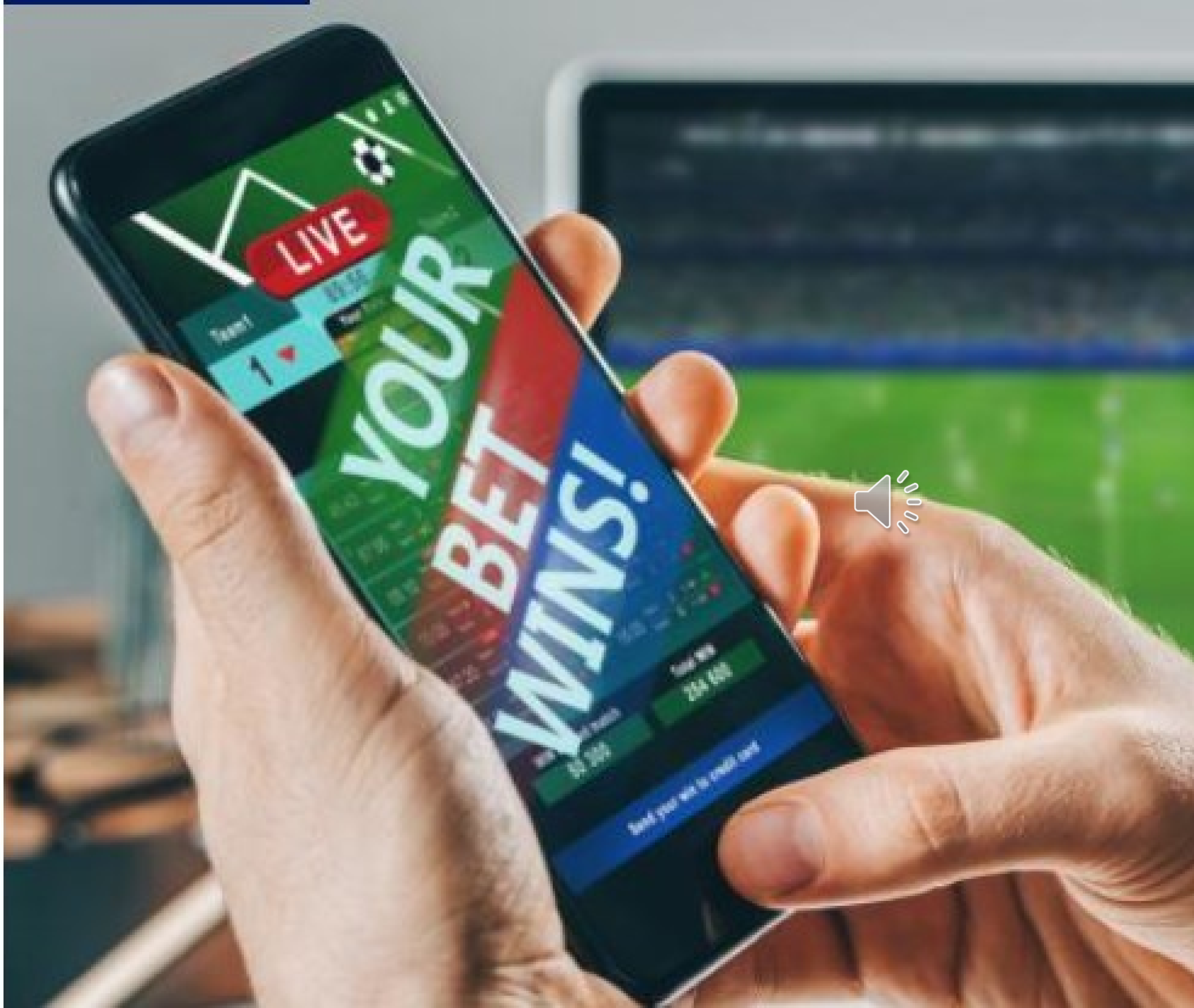


Acceleration

- What is acceleration?
- How to measure acceleration
- Using the equations to calculate acceleration

Acceleration

- TASK
- Write down what you think is the meaning of acceleration



My money is on......

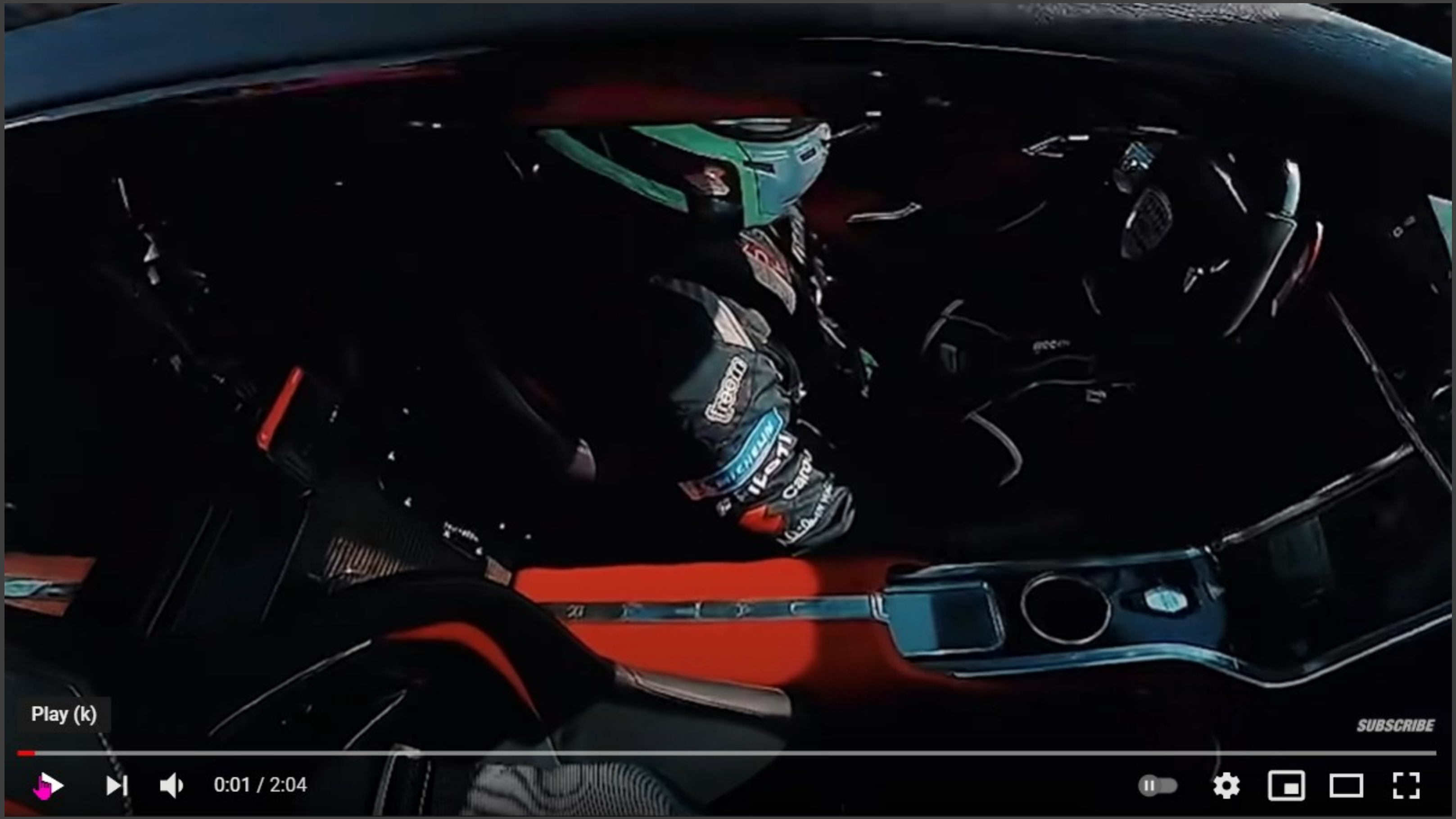
- I bet you nearly all said
- “speeding up”

Warning!

- For all of our examples we will assume you are travelling in a **straight line** so the **value (magnitude)** of your **speed is the same** as the **magnitude of the velocity** so I might be a little careless in my language.
- *You should always try to use velocity with acceleration*

Buying a "fast" car

- Have you ever looked closely at advertisements for cars? Most of them will say something like this:
- **0 – 60 mph in 8 seconds**
- **What does this tell you?**
- It's not how fast the car can go – cars can manage more than 60 miles per hour.
- It's how quickly the car gains speed – the car's. The less time a car takes to gain speed, the greater its acceleration.



Time how long it takes this car to get from 3 mph to 63 mph, it isn’t long

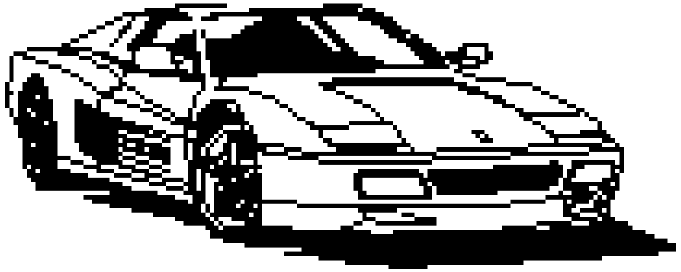
- I think this car was going for top speed rather than maximum acceleration. You could later work out the acceleration for different changes of velocity. Do you see how the road is long and straight so the
- magnitude of speed = size of velocity along the road.

Vauxhall Nippy:

Top speed: 115 mph

Engine size: 1.2 litres

0 – 60 mph: 10 seconds

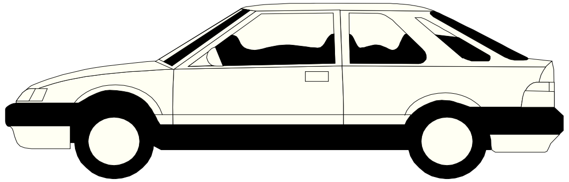


Ferrari Flyer:

Top speed: 130 mph

Engine size: 2.4 litres

0 – 60 mph: 5 seconds



Ford Speeda:

Top speed: 125 mph

Engine size: 1.6 litres

0 – 60 mph: 7.5 seconds

Mazda Vroom:

Top speed: 135 mph

Engine size: 2.0 litres

0 – 60 mph: 6 seconds

1. Which car has the highest top speed?
2. Which car has the greatest acceleration?
3. Which car would you prefer to drive? Why?

- Imagine two drivers side by side at a set of traffic lights, the lights are on red. Angus is in a boring saloon car, and Caitlin is sitting on her motorbike. The lights turn green and both vehicles set off. Both vehicles accelerate, the speed of both vehicles increases.
- After a while both vehicles reach the same speed; but we can tell that the motorbike will have a greater acceleration than the car.
- Acceleration is not just about the increase in your velocity it takes account of the time it takes to change your velocity.
- The **time it takes** your ~~speed~~ velocity to change must be in the equation

Acceleration

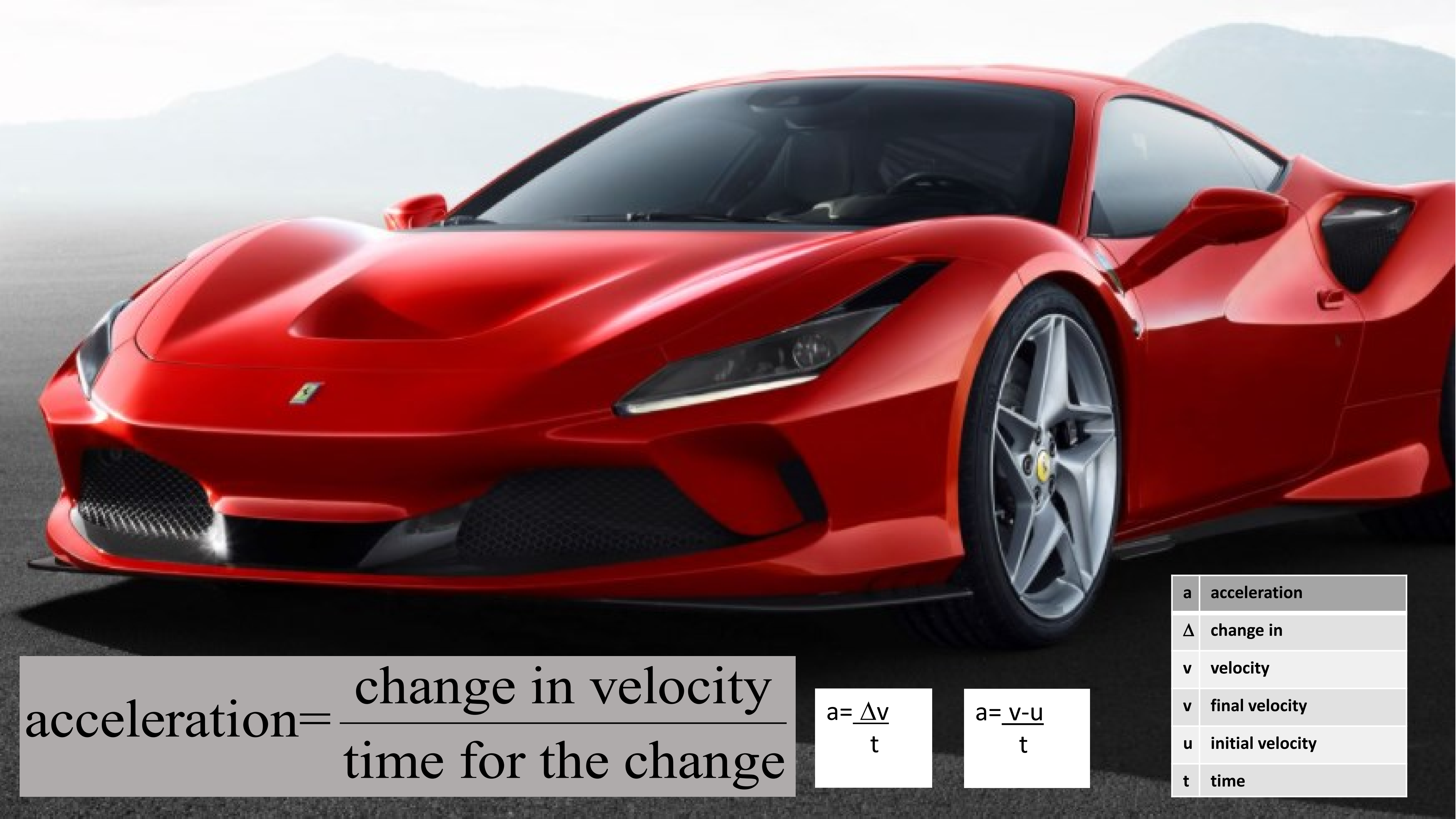
Acceleration is the rate of change of velocity.

(how quickly you change your velocity).

Or

change of velocity per second

If you change your velocity quickly you have a high acceleration.



$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time for the change}}$$

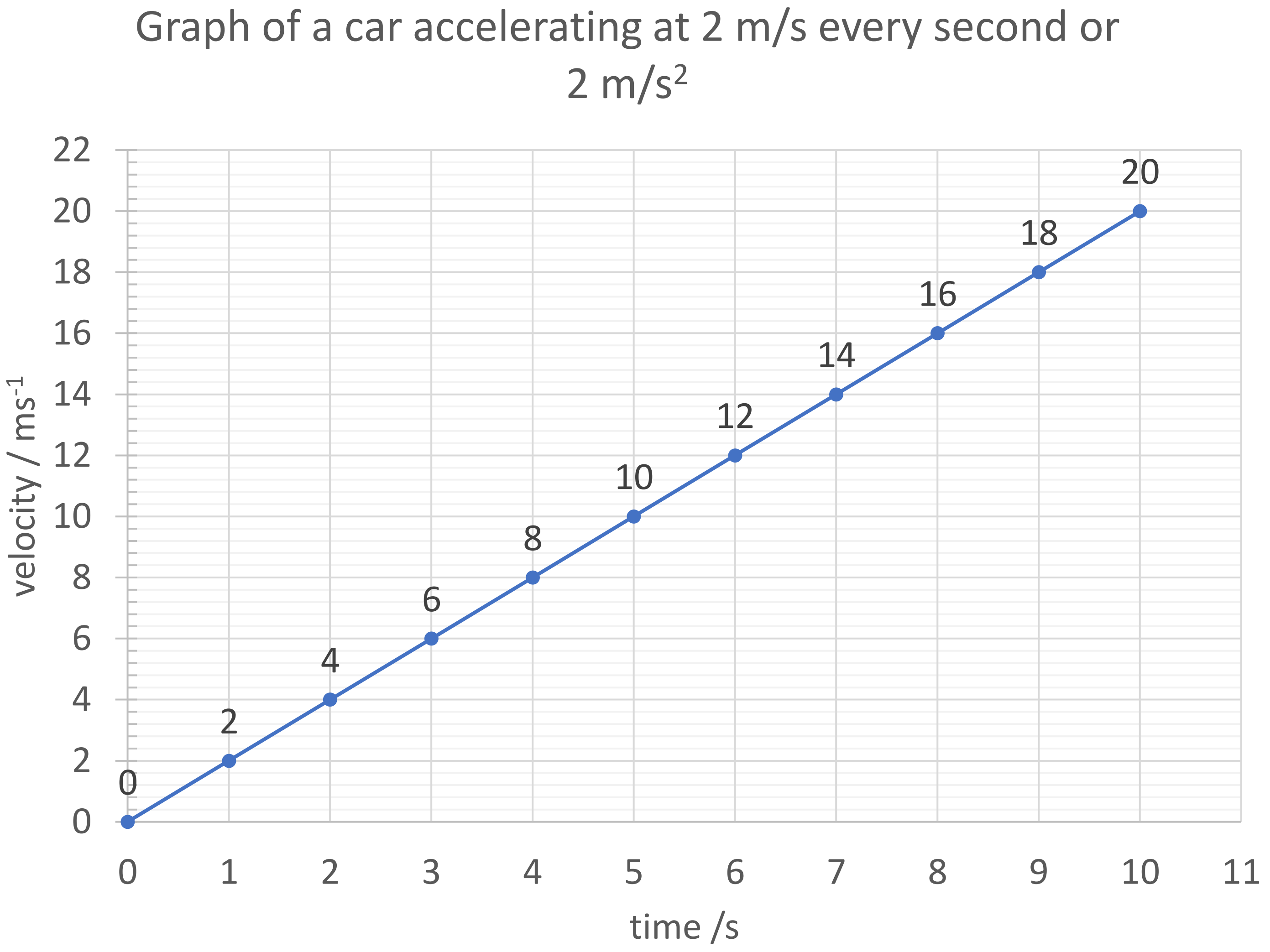
$$a = \frac{\Delta v}{t}$$

$$a = \frac{v - u}{t}$$

a	acceleration
Δ	change in
v	velocity
v	final velocity
u	initial velocity
t	time

Units of Acceleration

- If the change in velocity is measured in metres per second (m/s) and the time is measured in seconds, then the acceleration is measured in metres per second per second (m/s^2).
- For example, if a car accelerates at 2 m/s^2,then its speed increases by 2 metres per second every second.
- If it was stationary when the clock is started, then after the first second it will be going at 2 m/s, after the second second it will be travelling at 4 m/s, and after ten seconds the car will be travelling at 20 m/s. what will be the speed of the car after sixty seconds?



$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time for the change}}$$

The proper unit for acceleration is
metres per second per second,
metres per second squared.
(miles per hour per second).
m/s^2 or ms^{-2}
mph/s

.....and lastly

Do you think you are accelerating when you are slowing down?

Slowing down is accelerating

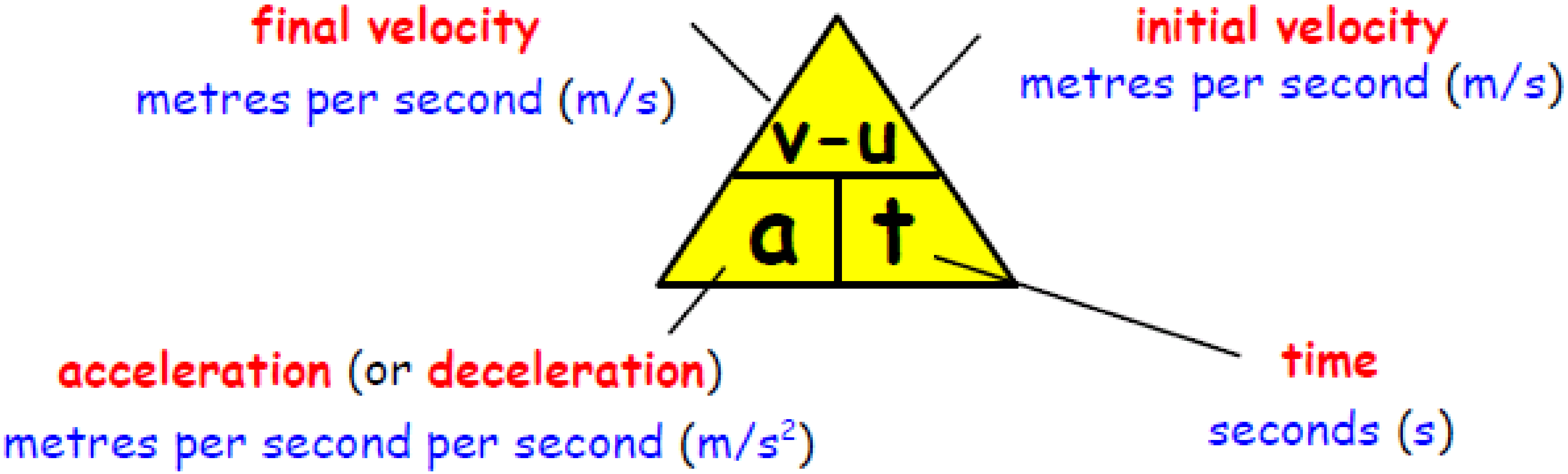
- If we look at the formula

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time for the change}}$$

$$a = \frac{\Delta v}{t} \qquad a = \frac{v-u}{t}$$

- If you are slowing down your velocity is changing
- So you are accelerating.
- We will find out that you will have a **negative acceleration** if you are slowing down which is also called a **deceleration**

Calculating Acceleration

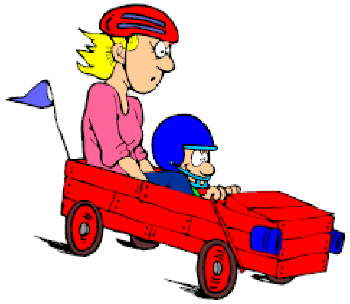


Acceleration

1. A Jaguar can reach 27 m/s from rest in 9.0 s, calculate its acceleration.
2. The space shuttle reaches 1000 m/s, 45 s after launch. Calculate the acceleration.
3. A car reach 30 m/s from a speed of 18 m/s in 6 s. calculate its acceleration.
4. A train moving at 10 m/s increases its speed to 45 m/s in 10 s. calculate its acceleration.
5. A bullet travelling at 240 m/s hits a wall and stops in 0.2 s. Calculate its acceleration.
6. A car travelling at 20 m/s brakes and slows to a halt in 8 s. Calculate its acceleration, it ought to be a negative value!

In each case, calculate the **acceleration** c
vehicle:

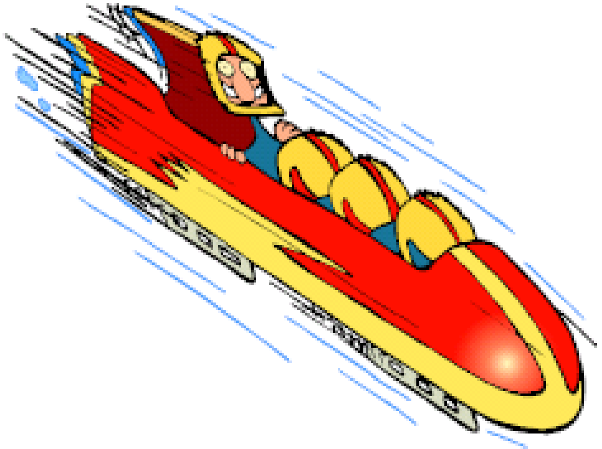
(a) Farmer Jones' tractor starts from rest and increases its velocity to 8 m/s to the right in 10 s.



(b) In their go-kart, Jill and her Mum increase their velocity from rest tc the right in 12 s.

(c) On her motor scooter, Dominique takes 5 s to increase her velocity from 3 m/s to 13 m/s to the right.

(d) Mike's motorbike takes 5 s to increase in velocity from 10 m/s to 30 m right.



20) As a bobsleigh reaches a steep part of track, its velocity increases from 24 m/s to 36 m/s down the slope. This happens in 0.4 s.

Calculate the acceleration of the bobsleigh during this time.

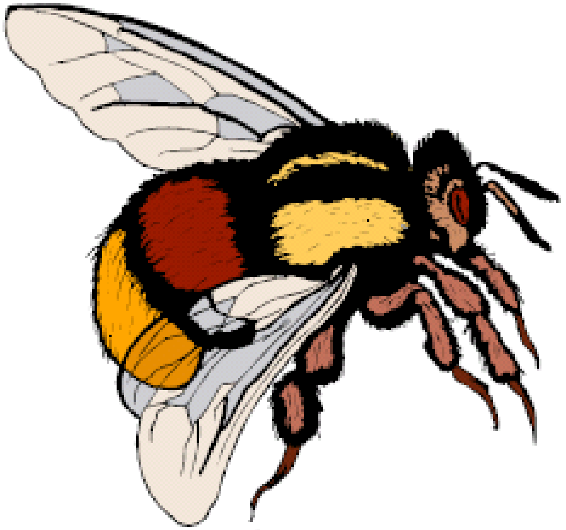
21) An arrow hits a stationary target with a velocity of 50 m/s to the right and comes to rest in 0.1 s.

Calculate the deceleration of the arrow once it hits the target.

22) Starting from rest, a fireman slides down a pole with an acceleration of 1.2 m/s^2 downwards. His velocity at the bottom of the pole is 3.6 m/s downwards.

Calculate the time taken to slide down the pole.

23) A bee, decelerating at 0.7 m/s^2 to the right, decreases its velocity from 6.7 m/s to 2.5 m/s to the right.

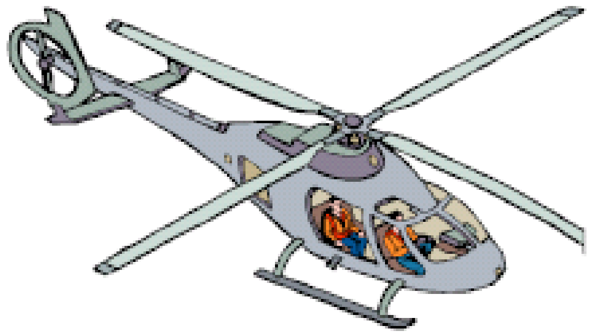


What time does this take?

24) When a stationary rugby ball is kicked, it is in contact with a player's boot for 0.05 s. During this short time, the ball accelerates at 600 m/s^2 at 45° above the horizontal ground.

Calculate the velocity with which the ball leaves the player's boot.

25) A helicopter is flying at 35 m/s to the right. It then decelerates at 2.5 m/s^2 to the right for 12 s.

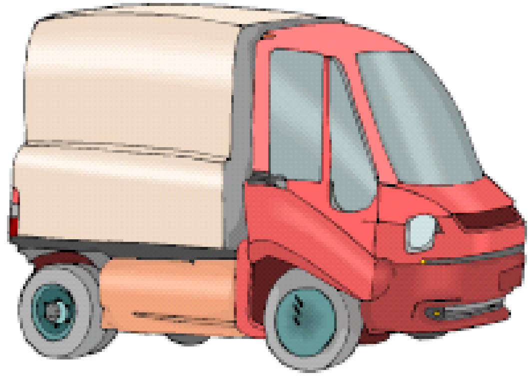


Calculate the velocity of the helicopter after the 12 s.

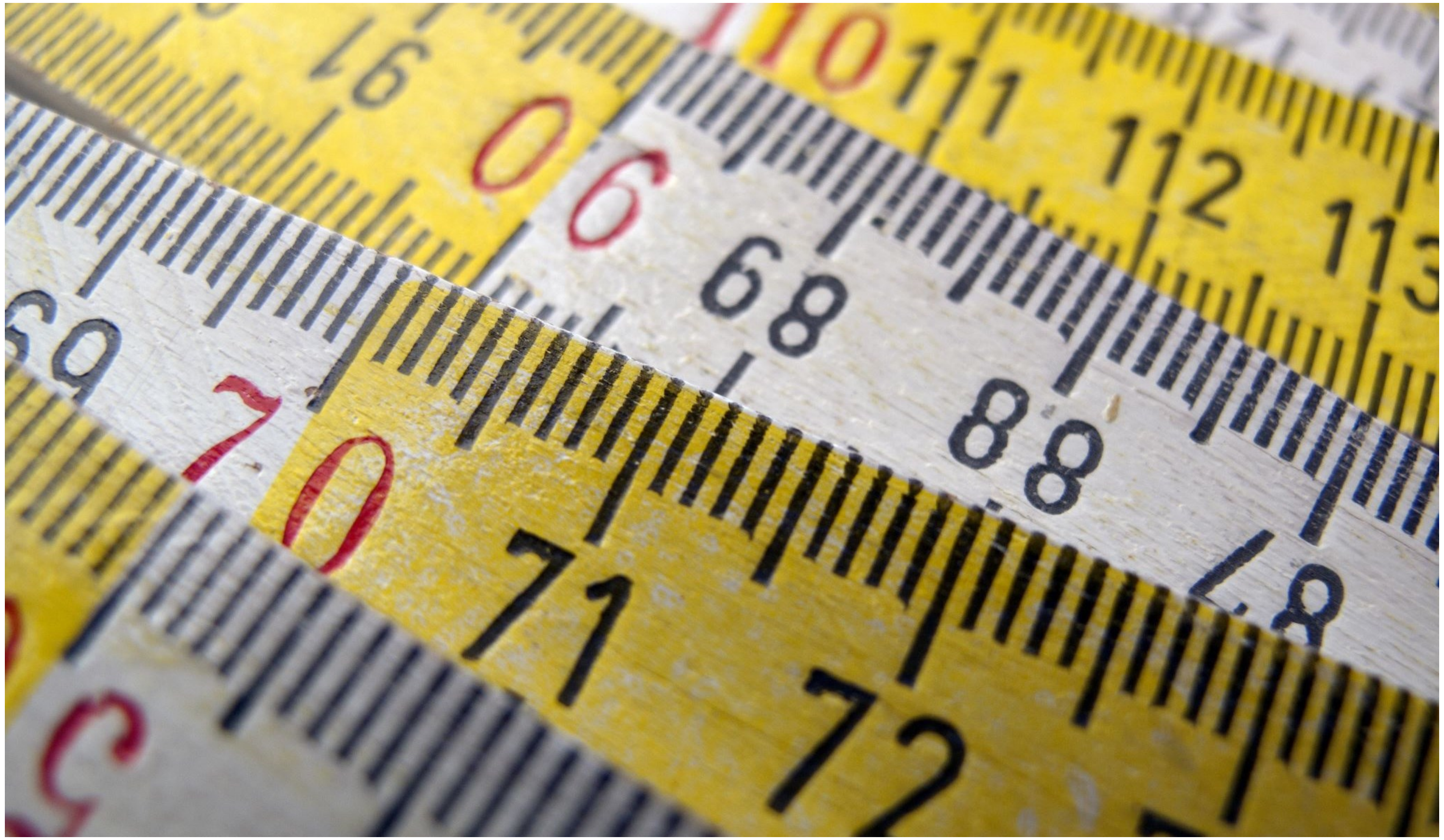
26) The velocity of a conveyor belt which is moving to the right is increased to 2.8 m/s by accelerating it at 0.3 m/s^2 to the right for 4 s.

Calculate the initial velocity of the conveyor belt.

27) A van decelerates at 1.4 m/s^2 to the right for 5 s. This reduces its velocity to 24 m/s to the right.



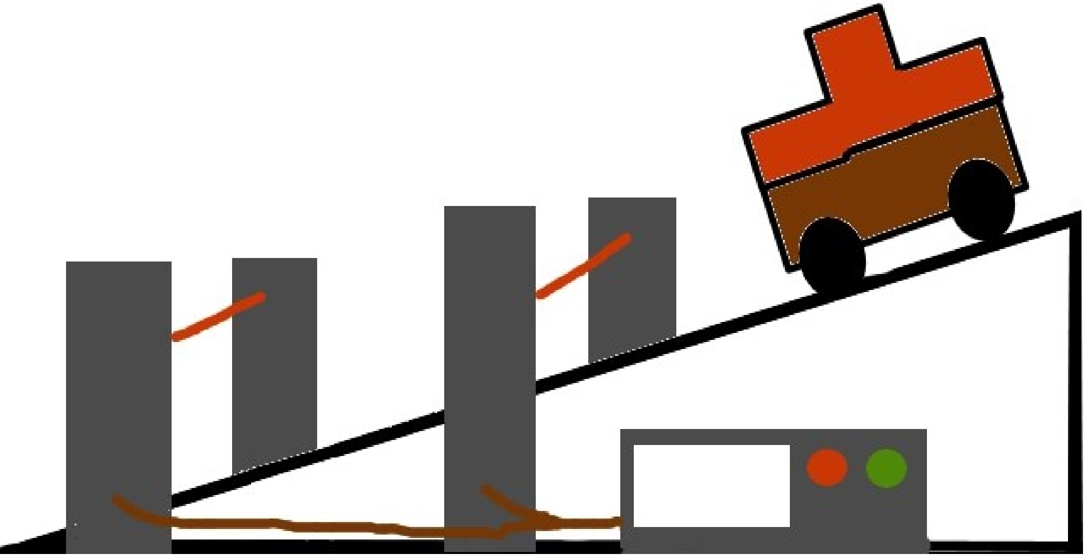
Calculate the van's initial velocity.

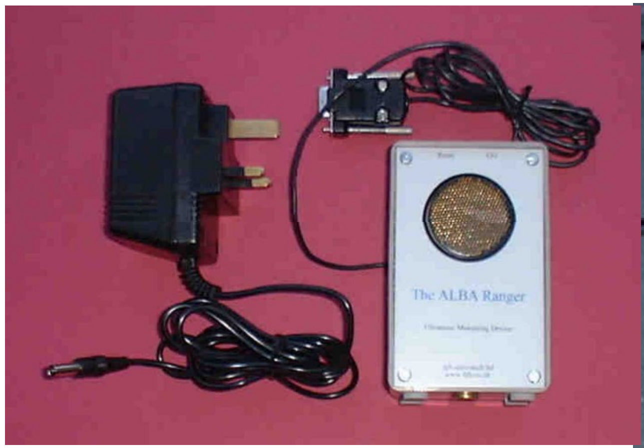


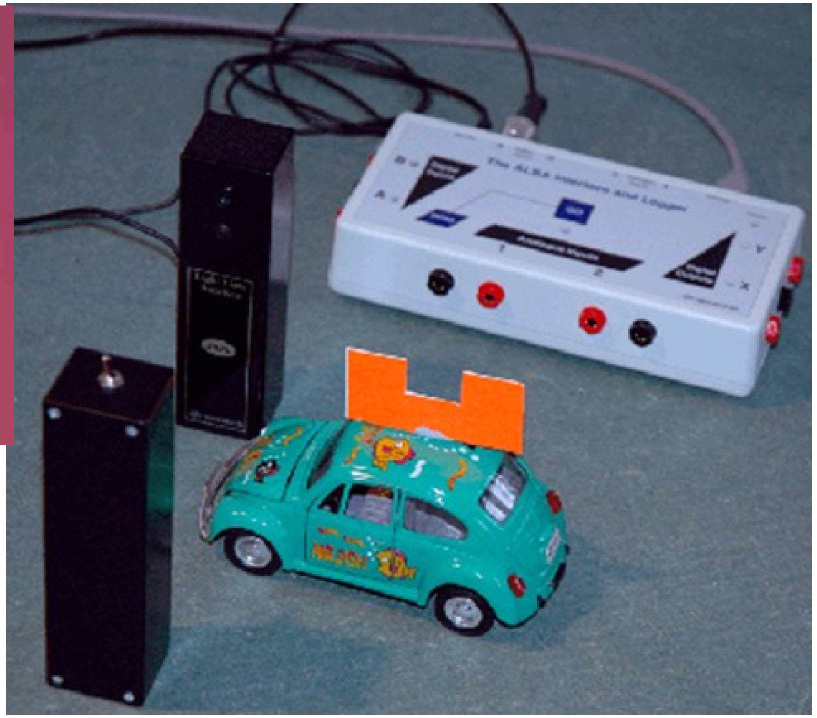
Measuring Acceleration

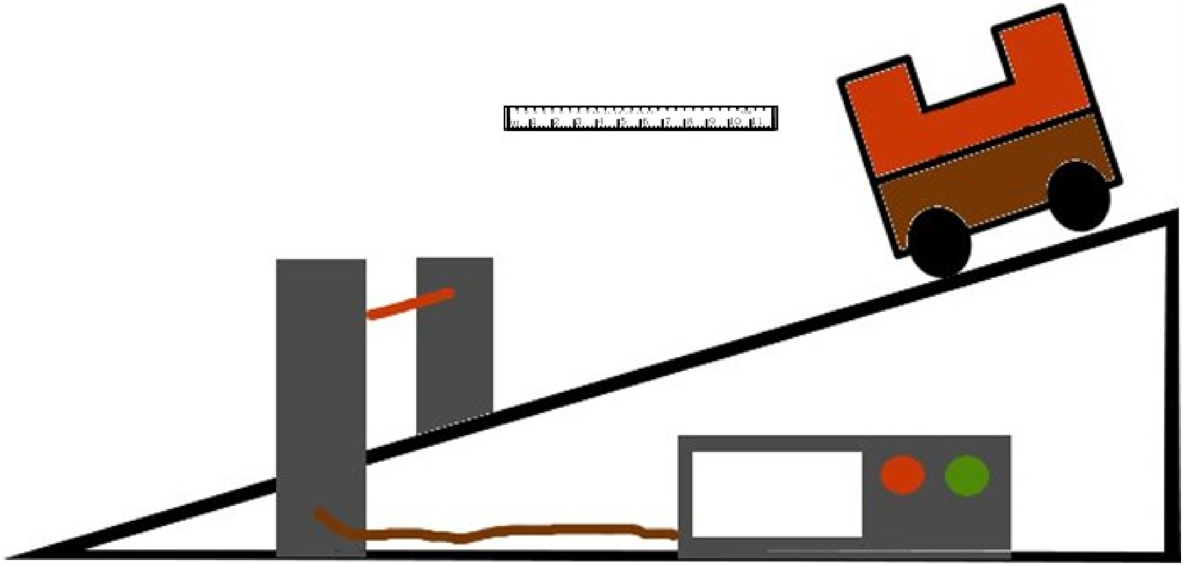
- Describe how you could measure the acceleration of a small vehicle as it runs down a slope in the laboratory.

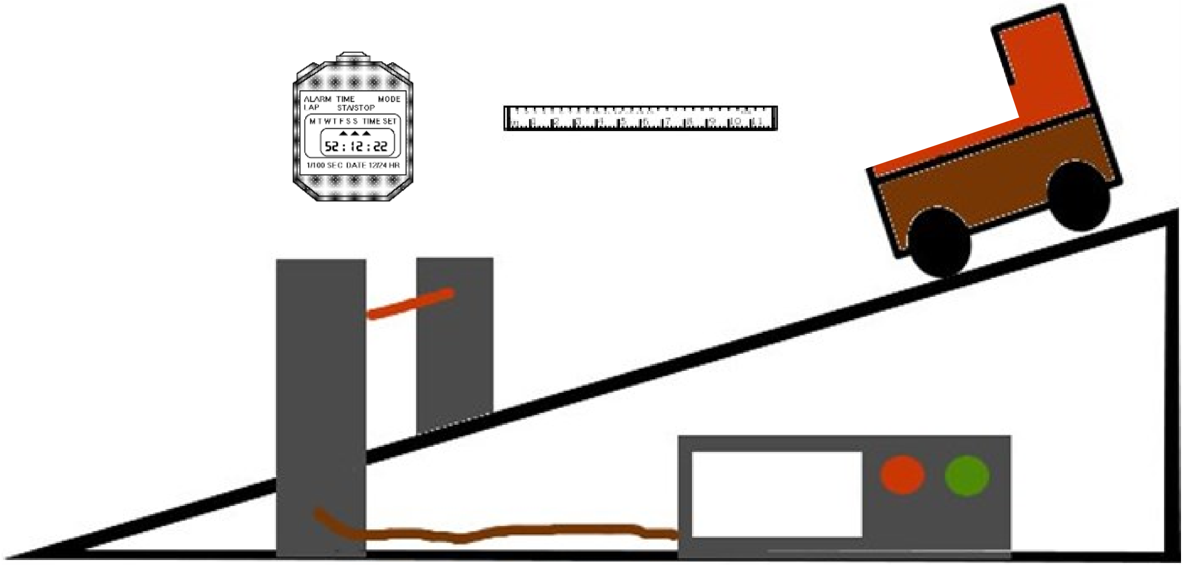
Many different ways





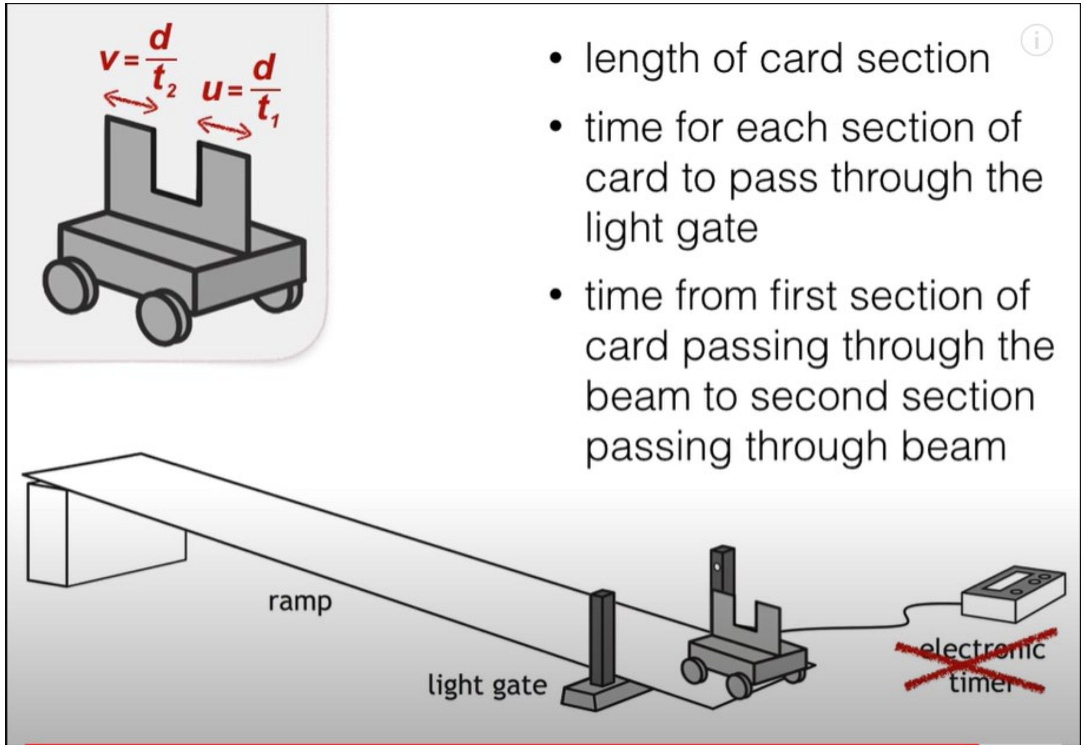


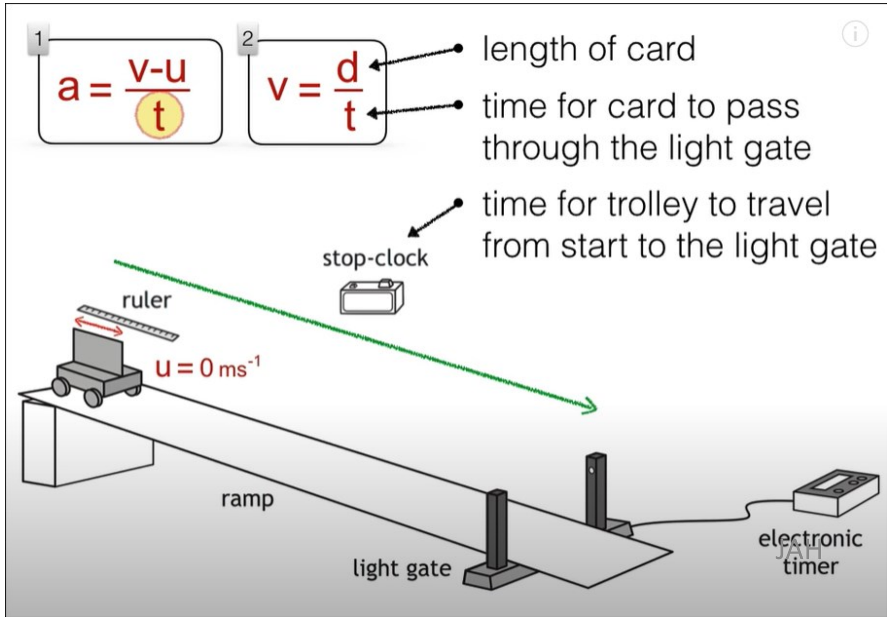


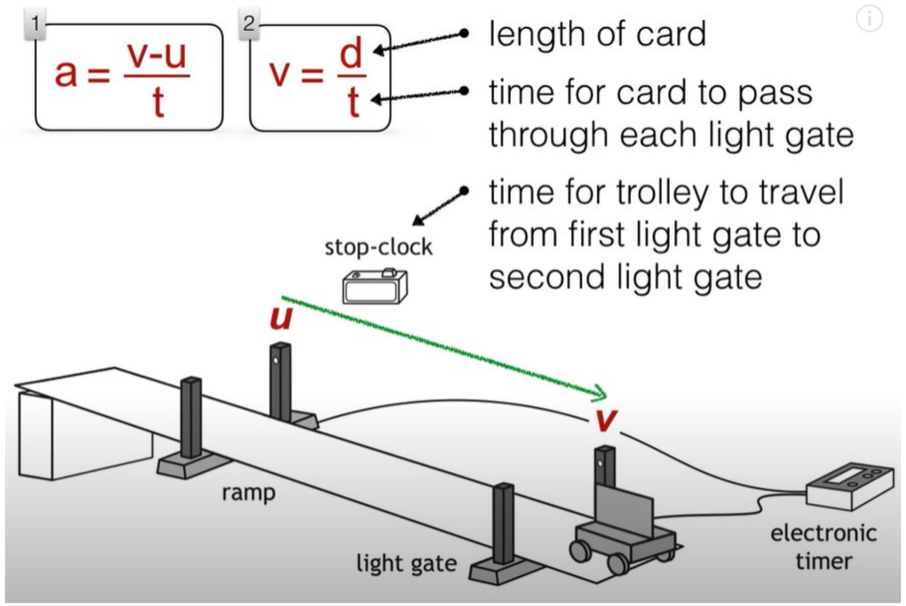


https://www.youtube.com/watch?v=YUqwdD73610

- There are different ways to measure acceleration here are a few.







Don’t measure acceleration we calculate it!

We don’t measure *v* and *u* we calculate them from

- *u=s/t*
  - Where
    - s = length of the card
    - t= time for the vehicle to pass through the top light gates.
- *v=s/t*
  - Where
    - s = length of the card
    - t= time for the vehicle to pass through the bottom light gates.

We also need to know the time it took the car to go between the light gates.

- Or v=s/t where s= length of second piece of card, and t is the time for the vehicle to pass through the light gate.

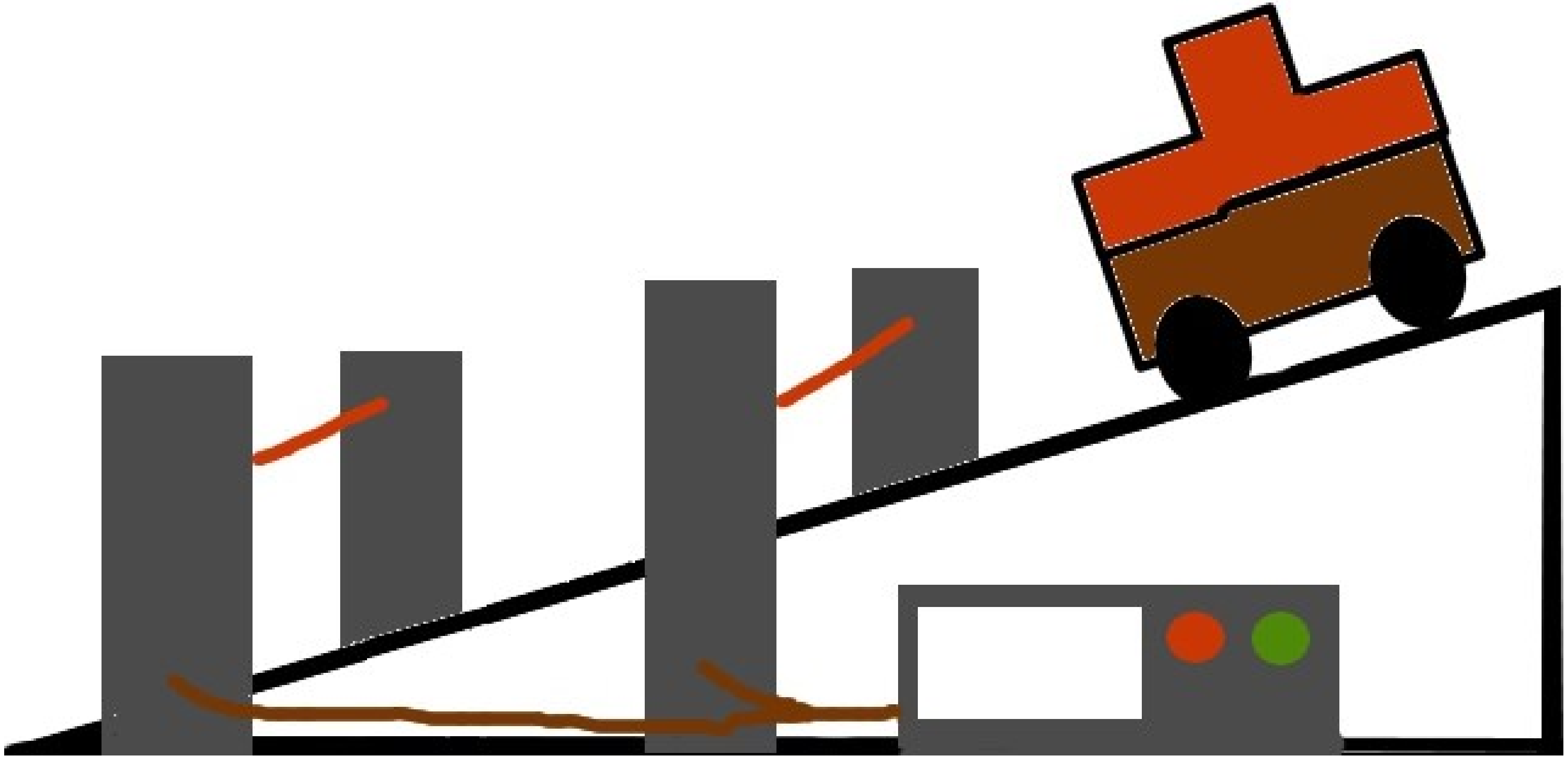
Measuring acceleration with the ALBA RANGER

Here the Ranger sends out pulses of sound / ultrasound. The sound waves reflect off the object and the reflected waves return to the ranger.

If the pulses are returning after a longer time what does this tell you about the vehicle?

What about the pulses reflecting in a shorter time?

Measuring acceleration with two light gates and a single mask

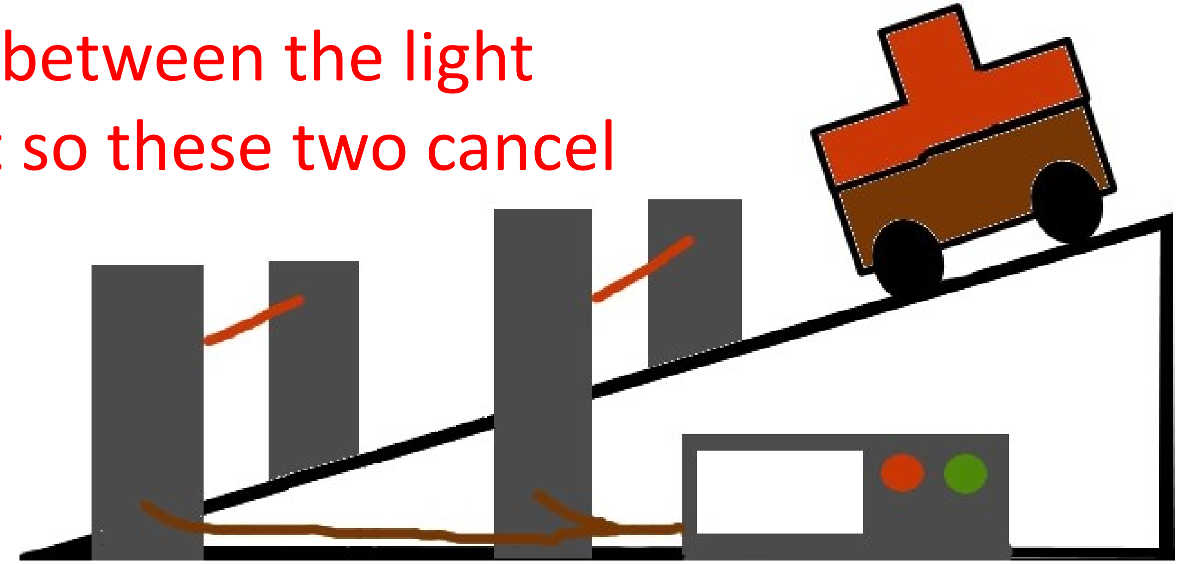


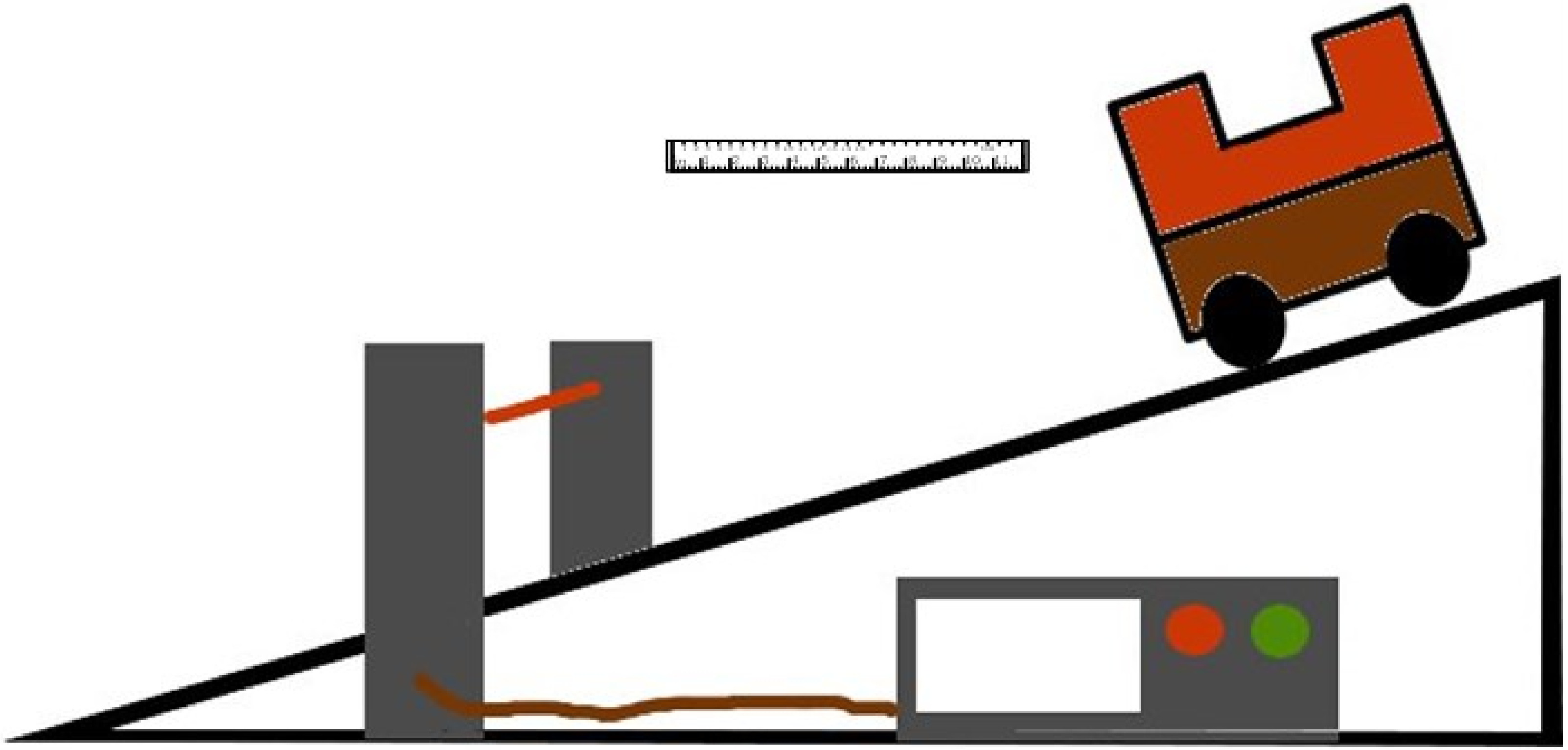
Does it matter how far apart the light gates are?

Surely the further apart the light gates the greater the value of v.

No it doesn't matter how far apart the light gates are if the acceleration down the slope is constant

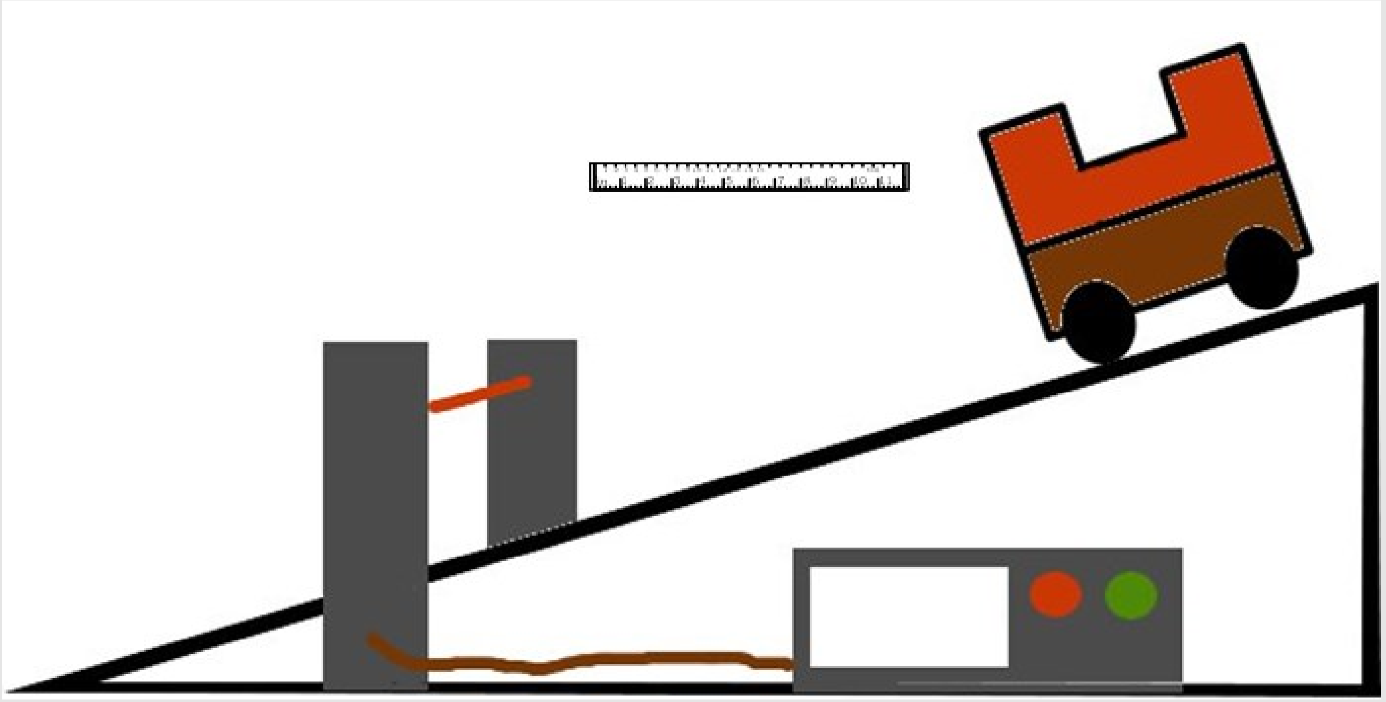
Yes the further apart the light gates the greater the value of v but the longer it takes to go between the light gates. If a=v-u/t then v is greater but also t so these two cancel and a remains constant.





Measuring acceleration with only one light gate

Notice we now have a double mask!

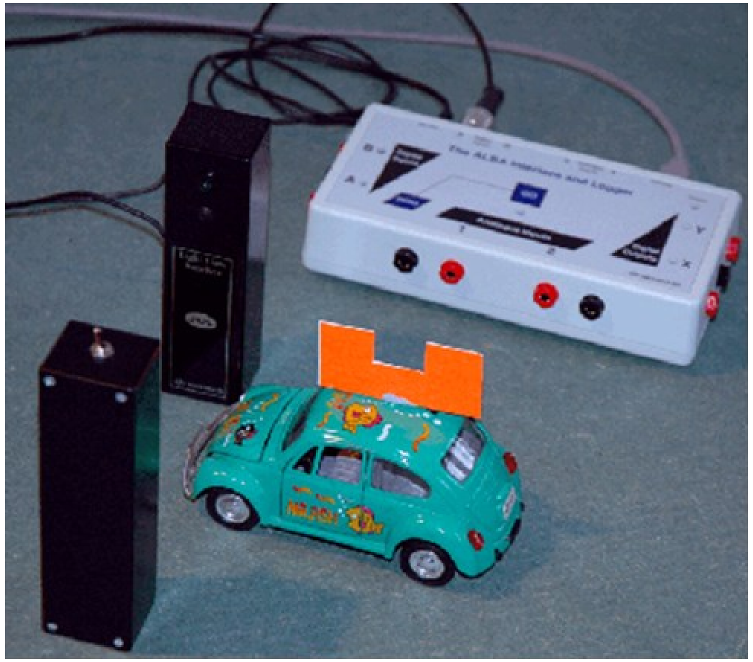


How can we only use 1 light gate to find acceleration?

- Yes the vehicle has a double MASK. *u* and *v* are still taken from the time it takes the mask to pass through the light gate and we need to measure the length of the mask.

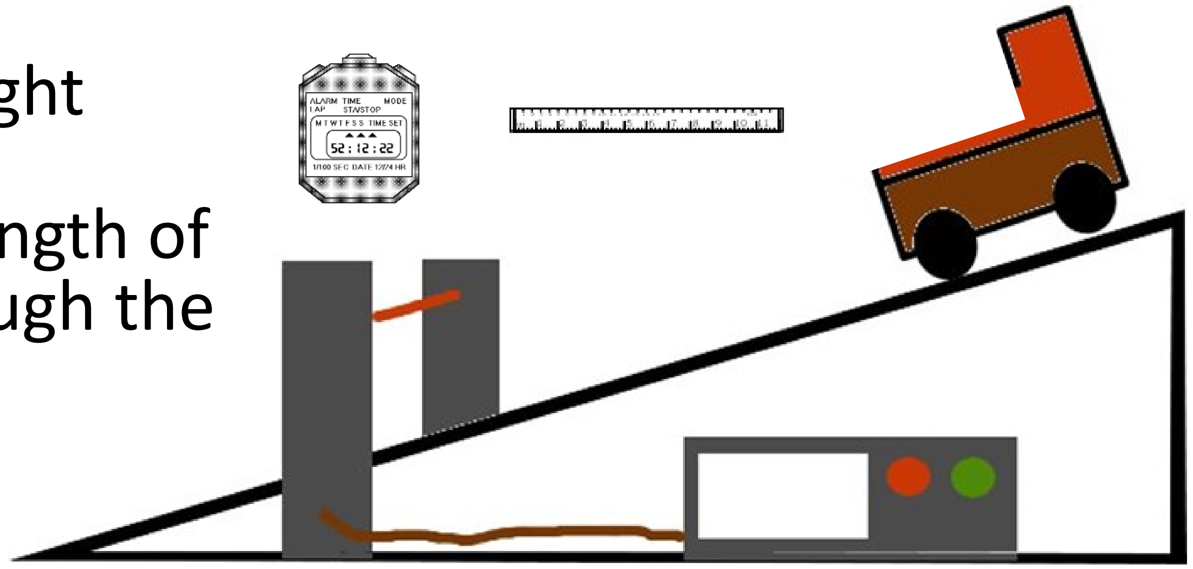
Measuring Acceleration

- You can measure acceleration in the lab with EITHER one single mask and two light gates or a double mask and one light gate.
- Whichever way the experiment is conducted the measurements that need to be made are:
  - Width of the mask or masks.
  - Time for first light beam to be broken.
  - Time for second light beam to be broken.
  - Time between the breaks in the light beam to be measured.



Measuring acceleration from rest

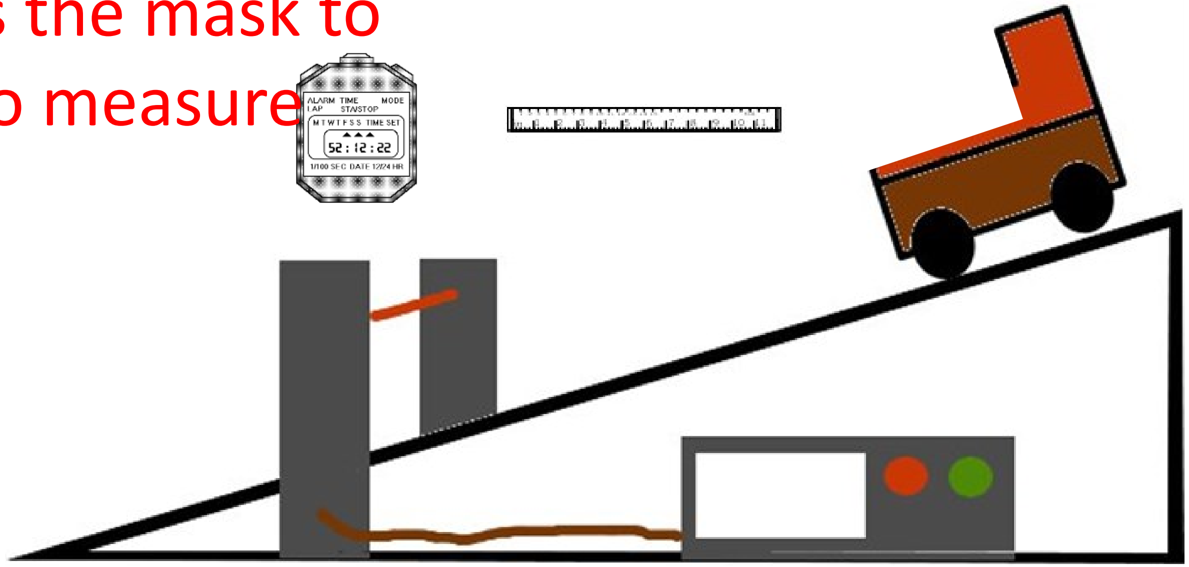
- If the vehicle is starting from rest then u does not need to be physically measured.
- A stopwatch can be used to time the vehicle from the time of release until the mask cuts the light gate
- The time for the mask to break the light beam allows the final velocity to be calculate from v=s/t where s is the length of the mask and t the time to pass through the light gate.



How can we only use 1 light gate and a single mask to find acceleration?

Here we take *u*, the starting velocity as zero, so we don’t need to measure that.

We time how long the vehicle takes to travel to the light gate. *v* is found from the time it takes the mask to pass through the light gate and we need to measure the length of the mask.



Measurements	Calculations
t_1 time to pass first light gate	$u = \frac{l}{t_1}$
t_2 time to pass second light gate	$v = \frac{l}{t_2}$
t_3 time between light gate	$a = \frac{v - u}{t_3}$
Length of mask	l

Now we need to try it and see what works and what doesn't

- Set up each method and find the value of the acceleration down the slope three times by each method.

- Record **all** of your measurements

- **Evaluate** each method, discussing what is easy or hard to set up, which measurements are easy or hard to take and which measurements do you think are reliable. How confident do you feel that your answer tells you the exact value for the acceleration of your vehicle down the slope?