AQA GCSE Physics

Paper 2 (H) Revision

Topic 5: Forces

Name: ________________________________

Form: 11 ___

AQA GCSE Physics
Paper 2 Revision
Topic 5: Forces

Specification point	Notes ✓	☺		☹	Questions?
Describe the difference between scalars and vectors					
Be able to represent vectors with arrows					
Describe non and contact forces and give examples					
Describe the interaction between pairs of objects which produce a force on each object.					
Know the weight of an object depends on the gravitational field strength at the point where the object is. W = mg					
Know the weight of an object may be considered to act at a single point , the 'centre of mass'.					
The weight of an object and the mass of an object are directly proportional and measured using a Newtonmeter					
Define and calculate resultant force					
Use free body diagrams to describe forces					
Be able to resolve a force into two components acting at right angles to each other.					
Use vector diagrams to show resolution of forces, equilibrium situations and find the resultant of two forces					
Calculate work done when a force moves an object (W = F s) and work done against friction causes the object to heat up					
Convert between newton-metres and joules.(1 joule = 1 newton-metre)					
Describe the difference between elastic deformation and inelastic deformation caused by stretching forces.					

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Specification point	Notes ✓	☺		☹	Questions?
Know that the extension of an elastic object is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.					
Calculate Force on a spring (F = k e)					
Calculate Energy stored when work is done to stretch a spring (Elastic Potential = 0.5 k e^2)					
Calculate the Moment of a force (m = F d)					
Apply the principle of moments to a system in equilibrium					
State that a fluid can be either a liquid or a gas and the pressure in fluids causes a force normal (at right angles) to any surface.					
Calculate the pressure on a surface in a fluid (P = F/A)					
Calculate the pressure due to a column of liquid (P = h ρ g) at different depths					
Define Upthrust					
Describe the factors which influence floating and sinking.					
Describe how the pressure and density of the atmosphere change with height					
Explain the difference between distance and displacement and speed / velocity					
Recall typical values of speed for a person walking, running and cycling and speed of sound in air.					
Calculate the distance travelled by an object at constant speed (s = v t)					

Specification point	Notes ✓	☺		☹	Questions?
Explain qualitatively, that motion in a circle involves constant speed but changing velocity and hence acceleration.					
Calculate the speed of an object from the gradient or tangent of its distance–time graph.					
Calculate acceleration (a = change in velocity / time)					
Calculate the acceleration of an object from the gradient or tangent of a velocity–time graph.					
Calculate the distance travelled by an object from the area under a velocity–time graph.					
Calculate acceleration ($v^2 - u^2 = 2\,a\,s$)					
State and apply Newtons First Law					
Define Inertia and Inertial Mass					
State and apply Newtons Second Law (F = m a)					
Explain terminal velocity and inteprt v-t graphs showing objects reaching terminal velocity					
Estimate the speed, accelerations and forces involved in large accelerations for everyday road transport					
State and apply Newtons Third Law					
Explain the effect of force on breaking					
Calculate Momentum (p = m v)					
State and apply the principle of conservation of momentum					

Scalar, vectors and types of forces

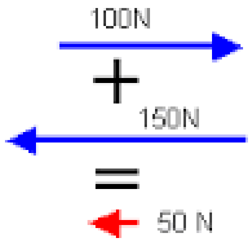
Scalars and vectors

Scalars have magnitude only. Examples include: Energy, distance, speed and pressure.

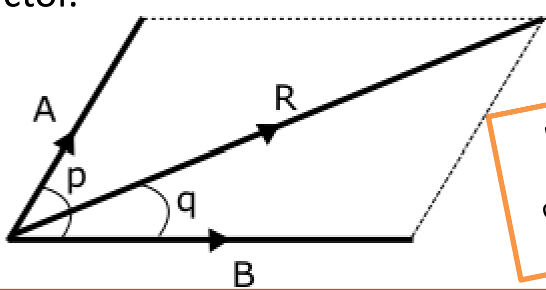
Vectors have magnitude and a direction. Examples include: Displacement, velocity and momentum.

Vector addition calculations

When vectors act in the same plane you can add them together:



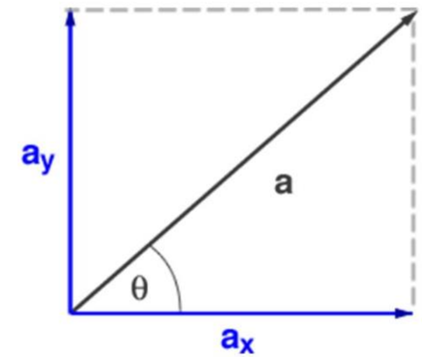
When vectors act in different planes we can draw a scale vector diagram and use the trapezium rule to calculate the resultant vector.



If 1cm is equal to 100m, what is the resultant displacement? Remember to give a direction too.

Vector resolution

A vector can also be resolved into his horizontal and vertical components:



Contact and non-contact forces

A force is a push or pull that acts on an object due to the interaction with another object. All forces between objects are either:

- contact forces – the objects are physically touching e.g. friction, normal reaction and air resistance.
- non-contact forces – the objects are physically separated e.g. gravitational, electrostatic and magnetic.

Force calculations

Weight

Weight is the force acting on an object due to gravity. The force of gravity close to the Earth is due to the gravitational field around the Earth. The weight of an object can be thought to act at an objects centre of mass. The weight of an object depends on the gravitational field strength at th point where the object is and can be c

Which piece of equipment do you use to measure an objects weight?

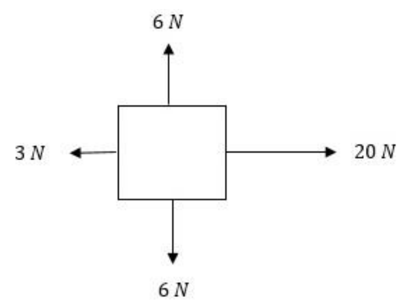
W = mg

Where W is weight (N), m is mass (kg) and g is gravitational field strength (N/kg or m/s^2). g on Earth is 9.8 N/kg. We can therefore say weight is *directly proportional* to an objects mass.

What does directly proportional mean?

Resultant forces

Below shows forces acting on an object. This is known as a free body diagram. The resultant force is 17 N to the right. The resultant force means the overall force. This objects motion will change (more on this later).



Work done

Energy has to be transferred if you wish to move an object. In this case, we say work is done on the object. We can calculate work done using:

W = Fs

Where W is work done (J), F is force (N) and s is distance/displacement (m). When work is done against friction is causes the temperature of the object to increase.

Key definitions:
One joule of work is done when a 1 N force causes a displacement of 1 m.

1 J = 1 Nm

Which energy transfers occur when a ball is rolled down a slope?

Force and elasticity

Stretching and squashing

You need to have at least two forces acting on an object to cause it to change shape, otherwise you just end up pulling it across the desk for example.

Objects can either stretch or compress elastically or inelastically. Elastically is where the object returns back to its original shape when the forces are removed, like a hair bobble. For an inelastic object, the object does not return back to its original shape once the forces are removed e.g. blue-tak.

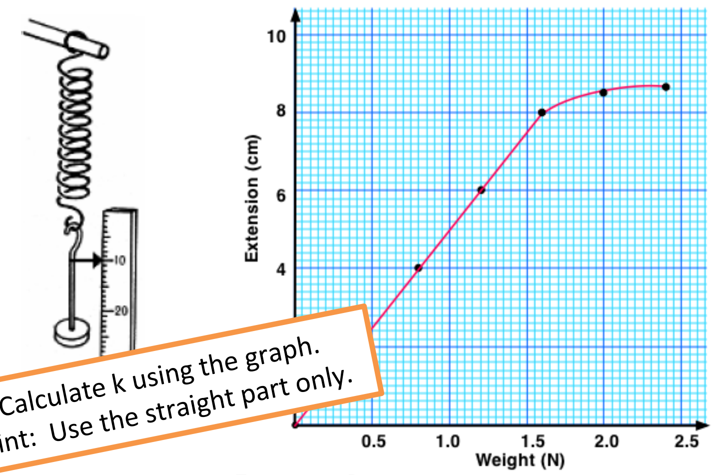
Hooke's law

The extension of an elastic object, such as a spring, is directly proportional to the force applied, provided that the limit of proportionality is not exceeded. This gives rise to the following equation:

$$F = ke$$

Where F is the force applied (N), k is the spring constant (N/m) and e is the extension/compression (m).

Required practical to verify Hooke's law



Calculate k using the graph.
Hint: Use the straight part only.

Providing the elastic limit is not exceeded the graph shows a linear and directly proportional relationship. The gradient gives the value of the spring constant.

The elastic potential stored by a spring is equal to the work done caused by adding the masses:

$E = \frac{1}{2}ke^2$ (Also in topic 1: Energy)

What is the energy stored in the spring used in the experiment when a force of 2.0 is placed onto it?

Moments, levers and gears

Moments

A force or a system of forces may cause an object to rotate such as a steering wheel or a see-saw. The turning effect can be called the moment of a force and can be calculated using:

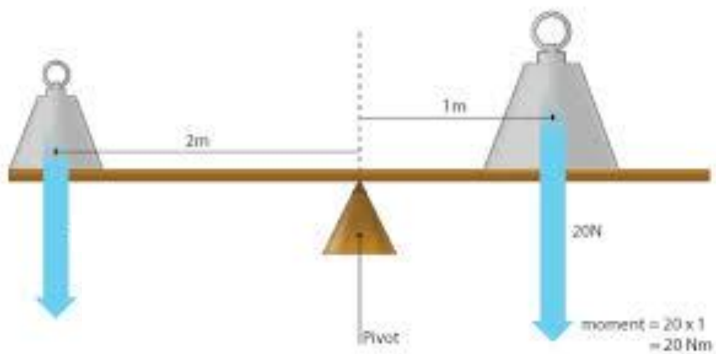
M= Fd

How is this equation different to the work done equation?

Where M is moment (Nm), F is force (N) and d is perpendicular distance from the force to the pivot (m).

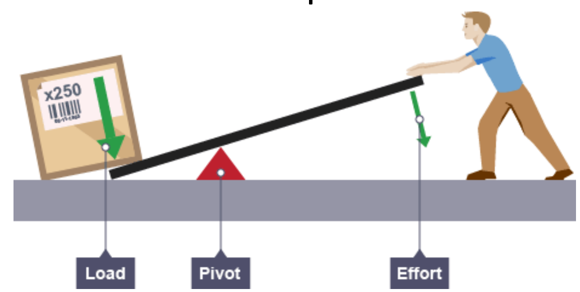
For an object to be in equilibrium (balanced), the total clockwise moment must be equal to the total anticlockwise moments:

What is the missing force?

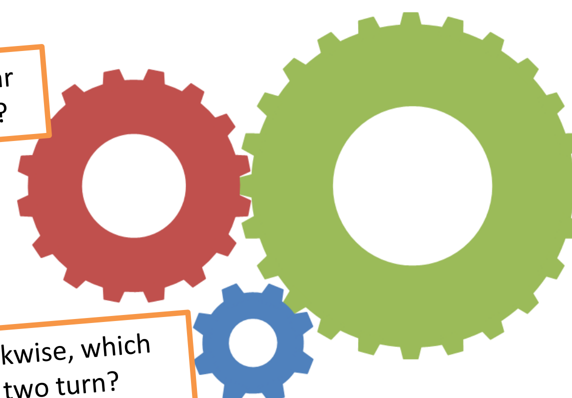


Levers and gears

Both levers and gears are used to transmit (and often multiply) an applied force. A **lever** is a simple machine that makes work easier to do. Examples of simple levers include cutting with scissors, or lifting the lid on a tin of paint with a screwdriver. Levers **reduce the force needed to** perform these tasks.



Which gear is fastest?



If the left gear rotates clockwise, which directions do the other two turn?

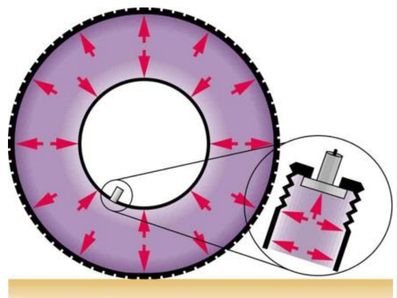
Pressure in fluids

Calculating pressure

Pressure can be calculated using:

P = F/A

Where P is pressure (Pa), F is force (N) and A is surface area (m^2). The force from the fluid acts at right angles (normal) to the surface. Note: A fluid is a liquid or a gas.



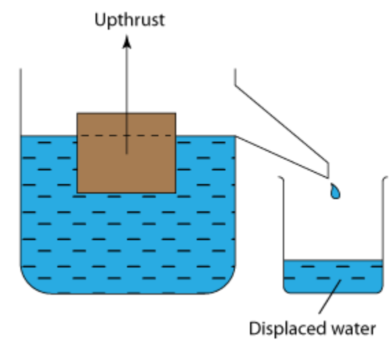
The pressure in a liquid increases with depth as there are more liquid particles above that point resulting in a larger weight of liquid pushing down on that point. This can be calculated using:

p = hρg

Where p is pressure (Pa), h is the height/depth (m), ρ is the density of the liquid and g is the gravitational field strength (N/kg).

More on pressure in liquids

It is the pressure difference that causes the force we call upthrust. There is a higher pressure on the bottom of the block in the image below compared to the higher parts. If this upthrust is smaller than the weight then it will sink. The weight of the submerged part of the block is equal to that of the water displaced.



Atmospheric pressure

The air particles around Earth is referred to as the atmosphere. Air particles colliding with surfaces causes air pressure. The atmosphere becomes less dense with altitude so air pressure decreases.

Objects in motion

Speed and velocity

Speed is a scalar and velocity is the speed in a given direction i.e. a vector.

A car going around a roundabout at 10 mph has a constant speed but a changing velocity (and therefore is accelerating)

You must learn some typical values for the speeds of certain activities:

Walking~ 1.5 m/s, running~ 3 m/s, cycling~ 6 m/s and the speed of sound = 330 m/s. These are average speeds as it is very rare something travels at a constant speed.

To calculate speed you can use the following equation:

$$s = vt$$

In KS3 you would have learnt this as distance = speed x time (d=st)

Where s is displacement/distance (m), v is speed/velocity (m/s) and t is time (s). To calculate the average speed it is the total distance divided by the total time.

Acceleration

Acceleration is defined as the rate of change of velocity. It can be calculated using the following equation:

$$a = \Delta v/t$$

Where a is acceleration (m/s^2), Δv is the change in velocity (m/s) and t is time (s). The same equation applies if the object is decelerating.

Linking acceleration, distance and velocity

The following equation links the terms introduced previously:

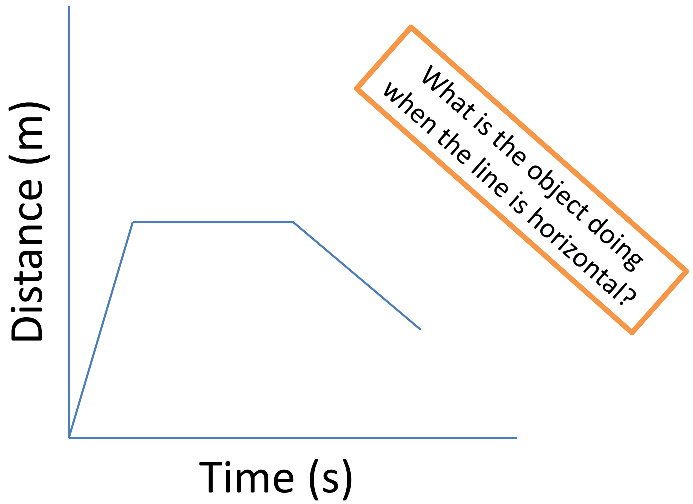
Check you can rearrange this as it can be tricky

$$v^2 - u^2 = 2as$$

Where v is the final speed/velocity (m/s), u is the initial speed/velocity (m/s), a is acceleration (m/s^2) and s is distance/displacement (m)

Motion graphs

Distance-Time Graphs

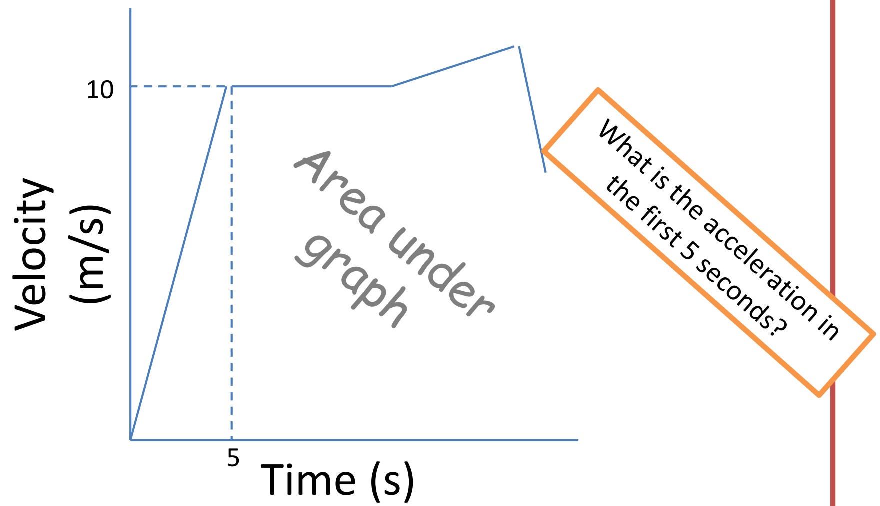


The gradient gives you the speed/velocity of the object

Straight lines means the object is travelling at a constant speed.

Curved lines means the object is accelerating or decelerating and you may be asked to calculate the instantaneous speed by drawing a tangent and finding its gradient.

Velocity-Time Graphs



The gradient gives you the acceleration of the object. The steeper the line the greater the acceleration.

If the lines gradient is negative then deceleration is occurring.

The area below the graph gives the distance travelled by the object – you will have to divide the graph into triangles and squares.

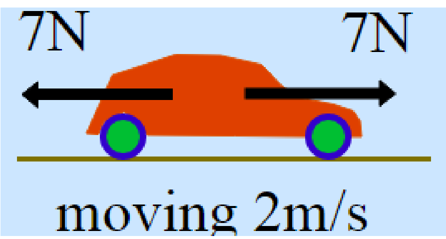
Newton's laws

Newton's 1st law

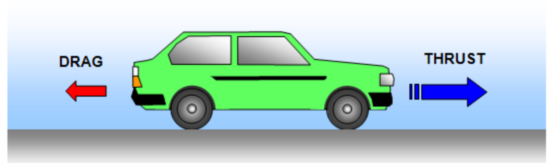
If the resultant force acting on an object is zero and:

- the object is stationary, the object remains stationary
- the object is moving, the object continues to move at the same speed and in the same direction. So the object continues to move at the same velocity.

What will each car do?



Speed: 10 m/s backwards



Note: The tendency of objects to continue in their state of rest or of uniform motion is called inertia.

Newton's 2nd law

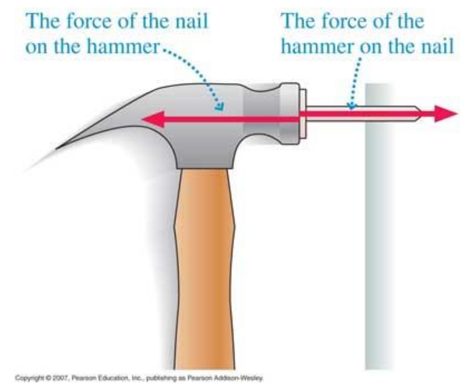
The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.

$$F = ma$$

Where F is force (N), m is inertial mass (kg) and a is acceleration (m/s^2)

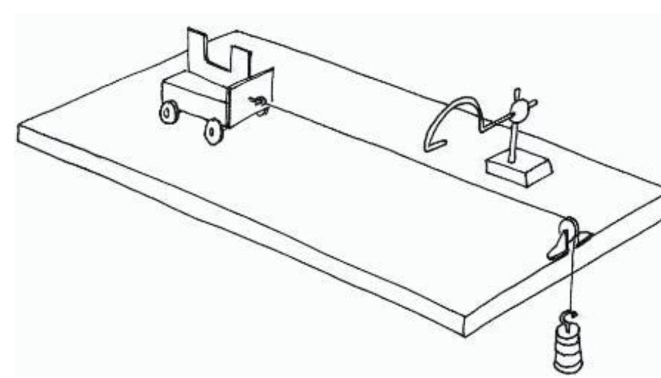
Newton's 3rd law

Whenever two objects interact, the forces they exert on each other are equal and opposite.



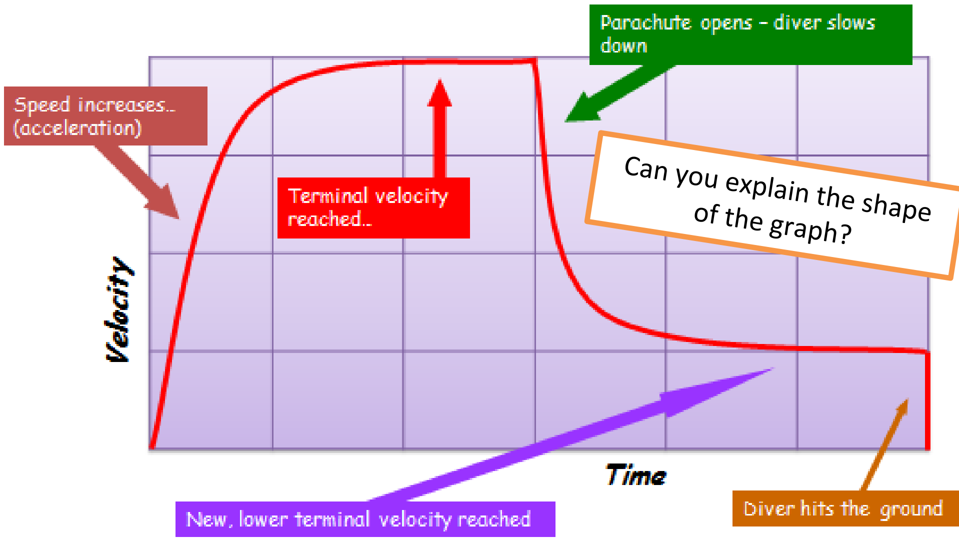
Required practical (Newton's 2nd law)

You change the mass and measure the acceleration to verify Newton's 2nd law.

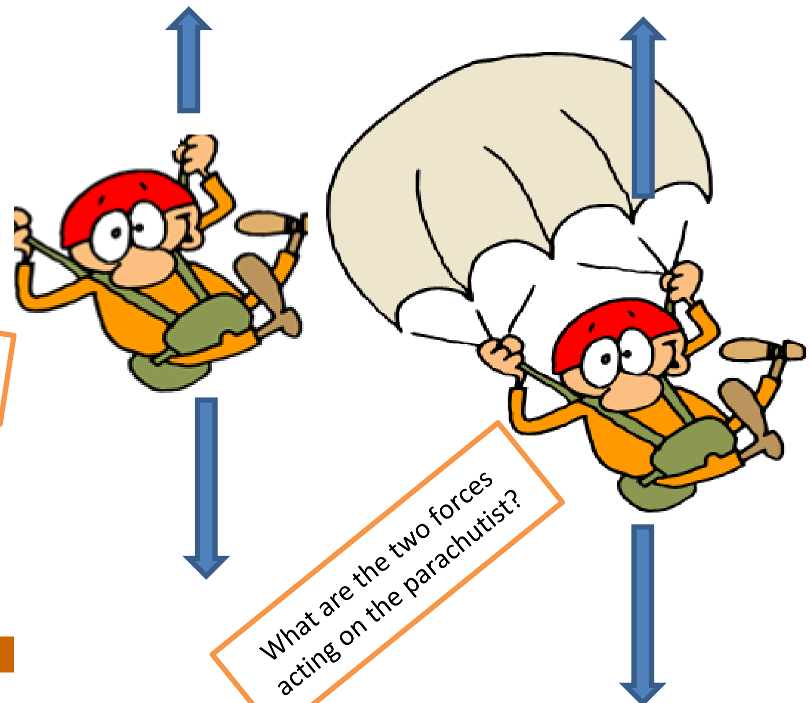


Terminal velocity

Velocity-Time graph for a parachutist



Can you explain the shape of the graph?



What are the two forces acting on the parachutist?

When an object starts to fall, the resultant force is in the downwards direction due to the weight causing the object to accelerate. As the object accelerates the resistive force increases. Eventually the two become equal but opposite (there is no resultant force) so the object starts to travel at a constant velocity, this is known as the objects terminal velocity.

Why does a van that has the same sized engine and that is the same mass have a lower terminal velocity than a car?

What would the weight of the parachutist be if he weighed 70kg? Take $g=9.8m/s^2$

At terminal velocity, what would the value of the resistance forces be? How is this force different to the parachutists weight

Forces and braking

Motion of the car

The car has kinetic energy when it is moving. There is friction between the tyres and roads generates heat energy.

Braking

The faster the car is travelling, the greater the braking force needed to stop in a certain distance. When the car brakes, work is done against the kinetic energy and hence it decreases.

Energy can only be transferred, What type(s) of energy is the kinetic energy transferred to?

Thinking Distance

This is the distance travelled by the car before the driver reacts and presses the brakes.

Drugs, alcohol, speed of car etc. can affect the thinking distance.

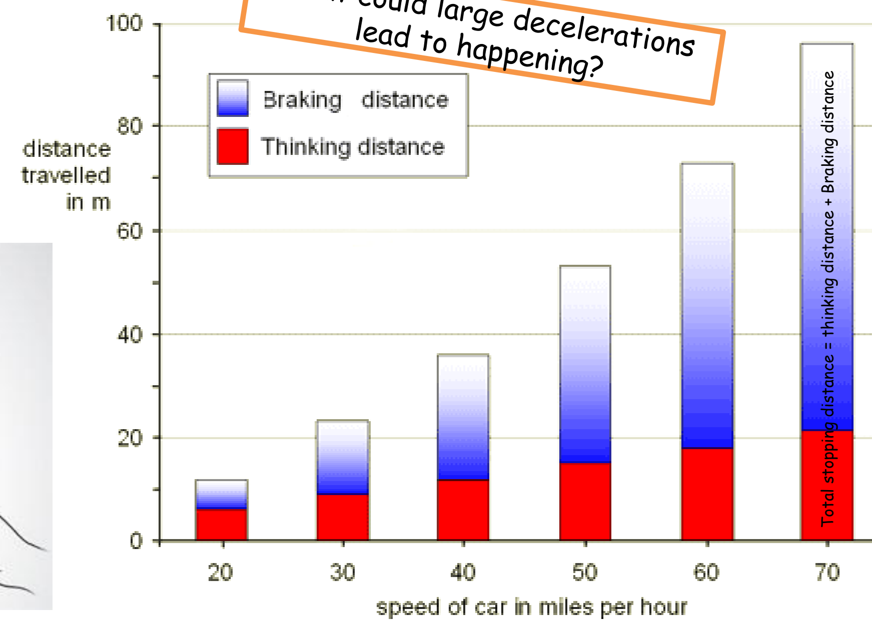
What factors could affect the braking distance?

Braking distance

This is the distance travelled once the cars brakes are applied.

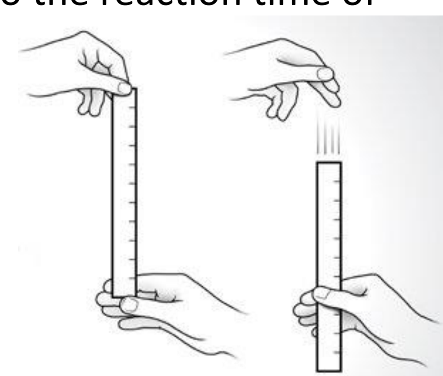
Stopping distance is the thinking distance + braking distance

What could large decelerations lead to happening?



Reaction time

The thinking distance is related to the reaction time of the driver. Reaction times vary from 0.2 to 0.9 s (you must learn these values). Can you explain how you could find someone's reaction time?



Momentum and impacts

Explain why a skateboard moves backwards when the skateboarded jumps forwards. Which one will move fastest, why?

Momentum

Momentum is a property all moving objects have.

Momentum = Mass x Velocity
(kg m/s) (kg) (m/s)

$$p = m \times v$$

The Conservation of Momentum

In a closed system, the momentum before an event must be equal to that of the momentum after the event.

$$m_{before} \times v_{before} = m_{after} \times v_{after}$$

A 1500 kg car is moving at 10 m/s and collides with a stationary car of 2000 kg. After the crash the 2000 kg car moves off at 6 m/s. What speed and direction (relative to the 2000 kg car) does the 1500 kg move off at?

Impacts

Air bags and crumple zones increase the amount of time an impact takes place in. The longer the impact time, the more the impact force is reduced. This can also be used to explain why playgrounds use rubber tiles.

Why is this the case?

We know acceleration = velocity/time. If we increase the time the acceleration therefore decreases.

We also know that force = mass x acceleration. As the acceleration has decreased this therefore means that the force decreases.

In terms of momentum there is another equation:

$$F = m\Delta v/t$$

Where m is the mass (kg), Δv is the change of velocity (m/s) and t is time (s). Again, a the impact time increases, the rate of change of momentum decreases and so does the force.

Key Equations

On the Data Sheet

$v^2 = u^2 + 2as$

$P = \rho h g$

$F = m \Delta v / t$

$E_e = \frac{1}{2} k e^2$

Not on the Data Sheet

$W = m g$

$s = v t$

$F = m a$

$a = \Delta v / t$

$P = F / A$

$p = m v$

$M = F d$

Work done $= F s$

$F = k e$