



Highsted Knowledge Organiser Physics: Motion

What I need to know

To be able to describe the motion from the shape of the curve on a graph
 To calculate speed from Distance—Time Graphs
 To calculate instantaneous speed using a tangent on a Distance-Time Graph,
 To calculate acceleration and distance on a Velocity-Time graph

Key Vocabulary:

Displacement is a straight line from the start point to the finish point

Distance is how far an object has moved.

Velocity is speed in a particular direction

Typical speeds to remember

- walking - 1.5 m/s
- Running - 3 m/s
- Cycling - 6m/s

Equations

$$\text{Distance} = \text{speed} \times \text{time}$$

$$s = v \times t$$

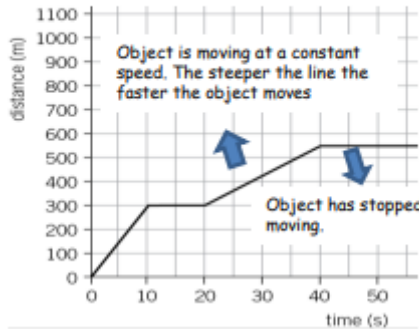
$$\text{Acceleration} = \text{Change in velocity}/\text{time}$$

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

Student reference point

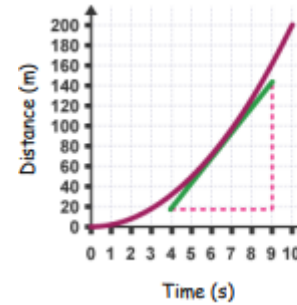
Distance-time graphs

Distance-time graphs show how far an object travels in a certain amount of time.



Calculate speed from a distance time graph by finding the gradient. Eg. Speed of object above in the first 10s

$$\text{gradient} = \text{rise}/\text{run} = (300 - 0)/(10-0) = 30\text{m/s}$$



We can only calculate the speed at a particular point (instantaneous speed.) E.g. calculate the speed at 7s.

Step 1: Draw a tangent at 7s (a straight line that just touches the curve at 7s.)

Speed, v , in meters per second, m/s.
 Time, t , in seconds, s.
 Distance, s , in metres, m.

Acceleration, a , in m/s^2 .
 Final speed, v , in metres per second, m/s.
 Initial speed, u , in metres per second, m/s.
 Distance, s , in metres, m.
 Time, t , in seconds, s.

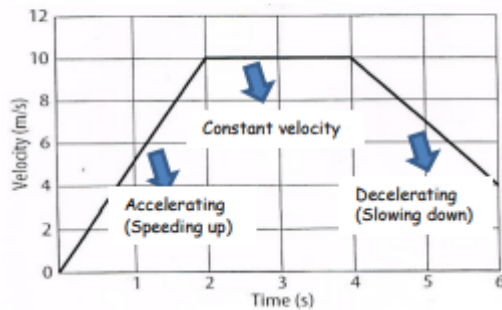
Step 2: Calculate the gradient of your tangent

$$\text{gradient} = \text{rise}/\text{run} = (140-20)/(9-4) = 24 \text{ m/s}$$

The instantaneous speed = 24 m/s

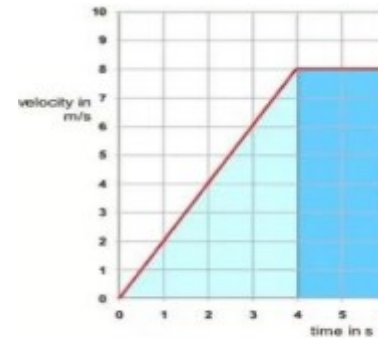
Velocity-time graphs

A velocity-time graph shows the velocity of an object at different times



Calculate acceleration from a velocity time graph by finding the gradient. Eg. acceleration of object above in the first 2s

$$\text{gradient} = \text{rise}/\text{run} = (10 - 0)/(2-0) = 5\text{m/s}^2$$

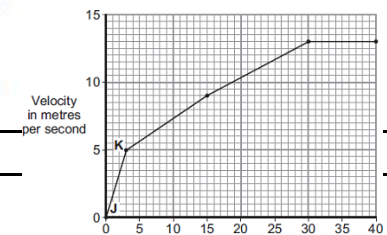


E.g. Calculate the distance travelled in the first 4s

Step 1: Shape under graph for first 4s is a triangle

Step 2: Area of a triangle = $\frac{1}{2} \times \text{base} \times \text{height}$

$$\text{Step 3: Distance travelled} = \frac{1}{2} \times 4 \times 8 = 16\text{m}$$



Challenge question: Use the graph on the far left to calculate the acceleration of the go-kart between points J and K.

Suggested reading: [gcse_section_12.pdf \(isaacphysics.org\)](https://www.isaacphysics.org/gcse_section_12.pdf)



Highsted Knowledge Organiser Physics: Forces in Balance

What I need to know

Examples of scalars and vectors
 Be able to draw free body diagrams
 Calculate resultant force with the use of parallelogram
 Resolve forces using horizontal or vertical components.

Key Vocabulary:

Physical quantities that have magnitude (size) and **NO** specific direction are called **SCALARS**

Physical quantities that have both magnitude (size) and direction **VECTORS**

Contact forces - These require the objects to be physically touching.

Non-contact forces - the objects are physically separated and do not need to touch each other.

Equations

Moment = force \times perpendicular distance from the line of action of the force to the pivot

$$M = F \times d$$

Student reference point

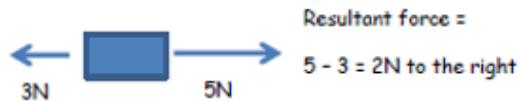
We can draw **free body diagrams** to show the forces acting on an object



Resultant Forces

When two or more forces act on an object, the resultant force is the overall effect of those forces

- When forces act in opposite directions, take the smaller force away from the bigger force to find the resultant
- When forces act in the same direction add the forces together to find the resultant force



Resultant forces cause objects to accelerate in the direction of the resultant force

Newton's First law states that if the forces acting on an object are balanced (the resultant force is 0), the object is either

- Stationary (not moving)
- Moving at a constant speed and in the same direction.

Newton's Third law states that when two objects interact with each other, they exert equal and opposite forces on each other



E.g The boy's weight pushes down on the chair which applies an upward support force on the boy.

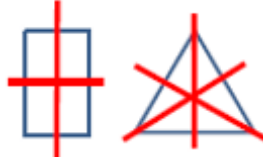
The weight and support force are equal in size but opposite in direction

Without this support force he would fall to the ground

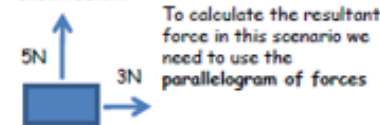
The **centre of mass** of an object is the point at which its mass can be thought of as being concentrated

The weight of the object may be considered to act at the centre of mass.

For a **symmetrical object** the centre of mass is located in the middle of the object where the axes of symmetry meet.

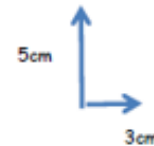


HIGHER ONLY: Sometimes we might have to calculate the resultant force when forces aren't acting along the same line (as shown below).



To calculate the resultant force in this scenario we need to use the **parallelogram of forces**

Step 1: Draw a scale diagram of the forces. This is a diagram that shows the direction of the forces and uses a scale to show the size of the forces using lengths. E.g if our scale is 1N = 1cm



Step 2: Complete the shape to form a parallelogram



Step 3: Draw a line connecting the bottom corner to the top corner. Measure the length of the line and convert it into a force using your scale.



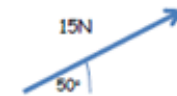
E.g line is measured to be 6cm

Using our scale 6cm = 6N
 Therefore the resultant force is 6N

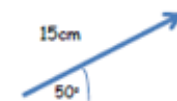
The direction is angle x.

HIGHER ONLY: Sometimes we might have the resultant force and we may need to calculate the forces which made it. This is called **resolving forces**

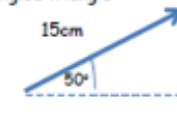
E.g Resolve the force below



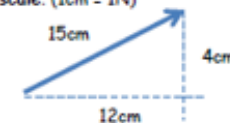
Step 1: Draw a scale diagram of the forces. This is a diagram that accurately shows the direction of the force and uses a scale to show the size of the forces using lengths. E.g if our scale is 1N = 1cm



Step 2: Complete the shape to form a right angled triangle



Step 3: Measure the length of the new lines and convert back into a force using your scale. (1cm = 1N)



Horizontal component = 12N

Vertical component = 4N

Challenge question: A force of 3N and 4N act on a point. Determine the magnitude and direction of the Resultant forces if the angle between their lines of action is 45 degrees.

Suggested reading: [AQA GCSE Physics Topic 5: Forces Revision - PMT \(physicsandmathstutor.com\)](https://www.physicsandmathstutor.com)

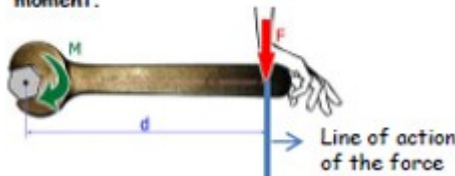


Highsted Knowledge Organiser Physics : Forces in Balance

<p>What I need to know Be able to calculate moments for a given situation Apply the principle of moments. Levers act as force multipliers Gears multiply the turning effect of a force.</p>	<p>Key Vocabulary: <i>Inertia is the tendency for objects to continue in their state of rest or of uniform motion</i></p>	<p>Equations Moment = force x perpendicular distance from the line of action of the force to the pivot $M = F \times d$</p>
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Student reference point

The turning effect of a force is called a **moment**.

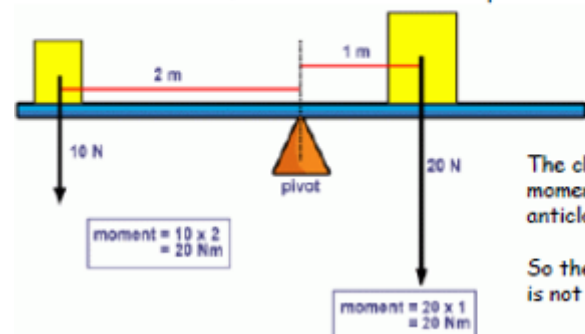


Note: The line of action of a force is a line along which a force may be considered to act.

Moment = force x perpendicular distance from the line of action of the force to the pivot
 $M = F \times d$

The principle of moments

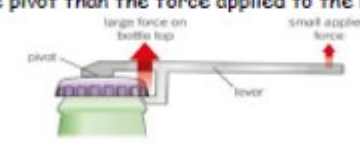
The principle of moments states that for an object that is not turning, the sum of all the clockwise moments about any point = the sum of the anti-clockwise moments about that point



The clockwise moments = the anticlockwise
 So the see saw is not turning


Gears and levers

Levers act as force multipliers. They can increase the size of a force acting on an object because the force applied by the lever is closer to the pivot than the force applied to the lever



Gears can also multiply the turning effect of a force

Low gear: A force applied to a small gear creates a large moment in the bigger gear. This gives a low speed but high turning effect



High gear: A force applied to a large gear creates a smaller moment in the smaller gear. Since the smaller gear rotates faster this gives a high speed but low turning effect.

Challenge question: The driving wheel or cog connected to the pedals has a radius of 45mm. If the cyclist pedals with a force of 360N what is the turning moment?

Suggested reading: [AQA GCSE Physics Topic 5: Forces Revision - PMT \(physicsandmathstutor.com\)](http://www.physicsandmathstutor.com)



Highsted Knowledge Organiser Physics: Forces and Motion

What I need to know

To investigate the relationship between force and extension.
Be able to apply Newton's Second Law.
To explain how an object reaches terminal velocity
To apply the law of conservation of momentum.

Key Vocabulary: Newton's 2nd Law

Newton's second law of motion says that the acceleration of an object is:

- Proportional to the resultant force on the object
- Inversely proportional to the mass of the object

Inertia is the tendency for objects to continue in their state of rest or of uniform motion

The law of conservation of momentum states that in a closed system the total momentum before an event is equal to the total momentum after the event. We can use this to solve collision problems

Equations

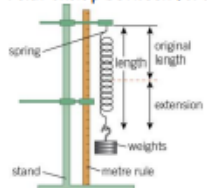
$$F = m \times a \quad W = m \times g$$

$$F = k \times e \quad p = m \times v$$

Stopping distance = thinking distance + braking distance

Student reference point

Hooke's Law Required practical: Investigate the relationship between force and extension for a spring

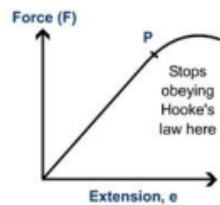


Independent variable: Force
Dependent variable: Extension
Control variable: Spring used

Method

1. Set up a clamp stand, ruler and spring as shown in the diagram
2. Measure the length of the spring with no force acting on it using the ruler
3. Add 100g (1N) mass. Measure the new length of the spring using the ruler
4. Calculate the extension (extension = new length - original length)
5. Repeat steps 3-4 until a maximum of 600g
6. Plot a graph of force vs extension
7. A straight line through the origin indicates a directly proportional relationship

Hooke's Law



An elastic object is one which will return to its original shape after it's shape is changed

Hooke's law states that the extension of an elastic object is directly proportional to the force applied, provided its limit of proportionality (P) is not exceeded

After point, P, the object is said to have undergone inelastic deformation. This means that it does not return to its original shape.

The velocity of an object increases if the resultant force is in the same direction as the velocity
The velocity of an object decreases if the resultant force is in the opposite direction to its velocity

The weight of an object is the force acting on it due to gravity. It is directly proportional to the mass of the object.

The mass of an object depends on the quantity of matter in it.

The weight of an object depends on the gravitational field strength at the place where the object is. Thus if an object is taken to a different planet its weight would change (as the gravitational field strength would be different) but its mass would remain the same.

The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels when the brakes are being applied (braking distance)

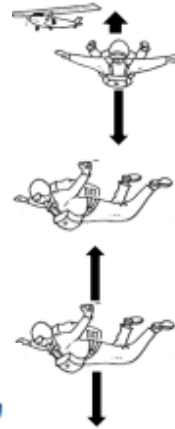
A driver's reaction time (and thus the thinking distance) can be affected by tiredness drugs and alcohol. Distractions and speed may also affect the driver's ability to react

The braking distance of a vehicle can be affected by adverse road and weather conditions (such as wet or icy conditions) poor conditions of the vehicle (such as poorly maintained brakes or tyres) and the speed of the vehicle

When the brakes are applied, work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases

Terminal velocity

A falling object has two forces acting on it. Weight acts downwards and air resistance acts in the opposite direction as it drags on the object.



When any object starts to fall its weight is larger than the air resistance acting on it. Therefore the resultant force is downwards and the object accelerates downwards

As the object accelerates, the air resistance acting on it increases (while its weight remains constant). This reduces the resultant force acting on it and therefore the acceleration decreases.

At some point the object will have gained enough speed that the air resistance acting on it will be equal and opposite to the objects weight. At this point the resultant force is 0 and so is the acceleration. The object has therefore reached a constant velocity which is called terminal velocity.

The law of conservation of momentum

Example: A red ball with a mass of 5kg moving at 2 m/s collides with a stationary ball with a mass of 8kg. After the collision the blue ball moves away while the red ball stops. Calculate the velocity of the blue ball.

$$(5 \times 2) + (8 \times 0) = 10 \text{ kg m/s}$$

$$(5 \times 0) + (8 \times v) = 8v$$

$$10 = 8v$$

$$v = 10/8 = 1.25 \text{ m/s}$$

Force, F, in Newtons, N.
Mass, m, in kilograms, kg.
Acceleration, a, m/s².
Weight, W, in Newtons, N.
Spring constant, k, in Newtons per metre N/m
Extension, e, in metres, m.
Velocity, v, in metres per second, m/s.
Momentum, p, in kilogram metres per second, kg m/s.
Gravitational field strength on Earth is 9.8 N/kg. This will be given to you in questions

A change in momentum occurs when an impact force acts on an object. Combining

$$F = m \times a \quad \text{and} \quad a = \frac{v - u}{t}$$

We get

$$F = \frac{m \Delta v}{\Delta t}$$

Where $m\Delta v$ = change in momentum.

• The bigger the change in momentum the larger the impact force required

• The longer the impact time (Δt) the more the impact force is reduced.

The 2nd point above is used in situations where a lower impact force during a collision is desirable. E.g

• Crumple zones and seat belts

• Cyclist helmets

• Cushioned play ground surfaces

Challenge question: If a skateboarder has a mass of 75Kg. After jumping off the skateboard he moves backwards at 2m/s. The skateboard has a mass of 4 Kg. Calculate the forward velocity of the skateboard.

Suggested reading: gcse_section_14.pdf (isaacphysics.org)