Combined Science: Trilogy Physics Paper 2 Higher

Knowledge Organisers

Physics Paper 2		
		1h 15min
Topics in the Paper:		
P8	Forces in Balance	
P9	Motion	
P10	Force and Motion	
P12	Wave Properties	
P13	Electromagnetic Waves	
P15	Electromagnetism	

P8: Forces in Balance: Trilogy Specification: Higher

Newtons First Law

If the resultant force acting on an object is zero and the object is stationary, the object will stay stationary. However, if the object is moving, the object continues to move at the same speed and in the same direction. This means the object continues to move at the same velocity. The velocity of an object will only change if there is a resultant force acting on the object. **The tendency of objects to continue in their state of rest or of uniform motion is called inertia.**

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 in which the objects are physically touching or non-contact forces in which the objects are physically separated. Examples of contact forces include friction, air resistance, tension and normal contact force. Examples of non-contact forces are gravitational force, electrostatic force and magnetic force. Force is a vector quantity as it acts in a direction.

Centre of Mass

The weight of an object acts at a single single point called the centre of mass. This idea is very important for designers and engineers to make sure that they design something that wont tip over. The centre of mass of an object is the point at which its mass can be concentrated. If you suspend any object it will come to rest with its centre of mass directly below the point of suspension.

Friction

A force that acts in the opposite direction of a moving object. Examples include air resistance and water resistance.

Scalar and Vector Quantities

Scalar quantities have magnitude only while vector quantities have magnitude and an associated direction. Scalars include time and speed while vectors include velocity. A vector quantity may be represented by an arrow. The length of the arrow represents the magnitude, and the direction of the arrow the direction of the vector.

Newtons Third Law

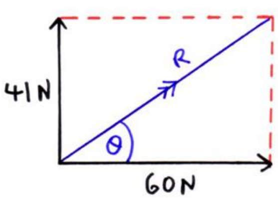
Whenever two objects interact, the forces they exert on each other are equal and opposite. For example a man pushes on a wall with 100N and experiences a force of 100N in the opposite direction from the wall.

Resultant Force

A single force that has the same effect as all the forces acting on the object. For example if there is a force of 100N to the right and 50N to the left then overall there will be a resultant force of 50N to the right. If forces are acting in the same direction add them together, if they are acting in opposite directions subtract them from each other.

Resolution of Forces

You need to be able to draw vector diagrams to illustrate resolution of forces and determine the magnitude and direction of this force. You will need a protractor and a ruler. Use a ruler to draw the the forces to scale and use a protractor to measure the accurately the angle between these forces. Draw the resolving force line to complete the diagram. This should make a triangle. Measure the size of this line to measure the magnitude of this force.



Distance

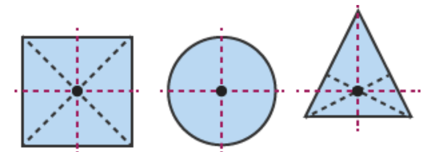
Distance is how far an object moves. Distance does not involve direction. Distance is a scalar quantity.

Displacement

Displacement includes both the distance an object moves, measured in a straight line from the start point to the finish point and the direction of that straight line. Displacement is a vector quantity.

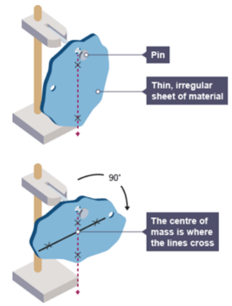
Determining Centre of Mass of a Symmetrical Object

For a flat object that is symmetrical its centre of mass is along the axis of symmetry. If the object has more than one axis of symmetry than its centre of mass is at the point that these axis meet.



Determining Centre of Mass of an Irregular Shaped Piece of Card

Put a hole in one corner of the card and suspend the card from a rod. Use a plumb line to draw a vertical line on the card from the rod. Repeat this again hanging the object from different corners. The point at which the lines meet is the centre of mass.



P9: Motion: Trilogy Specification: Higher

Speed
Speed is a scalar quantity as it does not involve direction. The speed of a moving object is normally changing and so is rarely constant. The speed a person travels at can depend on their age, terrain (is it hilly or flat) fitness and distance travelled. Typically people travel at 1.5m/s when walking, 3m/s when running and 6m/s when cycling. The speed of sound and of the wind may change also. Sound typically travels at 330m/s. The formula to calculate the speed of an object is:

Distance Travelled = Speed x Time

Velocity
The velocity of an object is its speed in a particular direction. This means velocity is a vector quantity. **If you are travelling around a roundabout (in a circle) your speed may be constant, but the velocity will be changing as you are constantly changing direction.**

Quantity	Symbol	Unit
Speed	v	m/s
Distance	s	m
Time	t	s
Change in Velocity	Δv	m/s
Initial Velocity	u	m/s
Final Velocity	v	m/s
Acceleration	a	m/s^2

Acceleration
This is a measurement of the rate in which an objects velocity changes. If an object is slowing down than it is said to be decelerating. It can be calculated using the equation:

Acceleration = change in velocity / time taken.

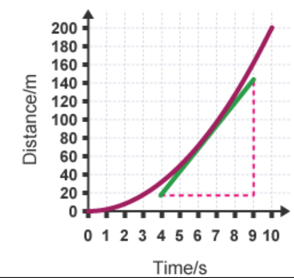
Be careful when calculating change in velocity. For example if you are told an object from standing accelerates to 12m/s then the change in velocity is 12m/s. However if you are told that the object was moving at 5m/s and accelerates to 12m/s the change in velocity is now 7m/s.

Uniform Acceleration
The following equation applies to uniform acceleration (you are given this one on your data sheet):

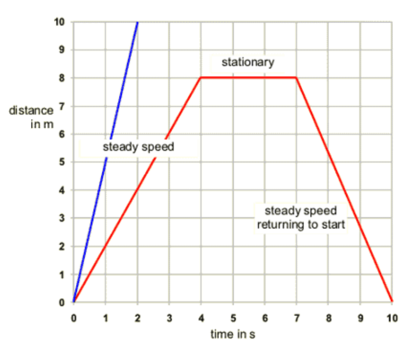
$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$

Near the Earth's surface any object falling freely under gravity has an acceleration of about $9.8 m/s^2$

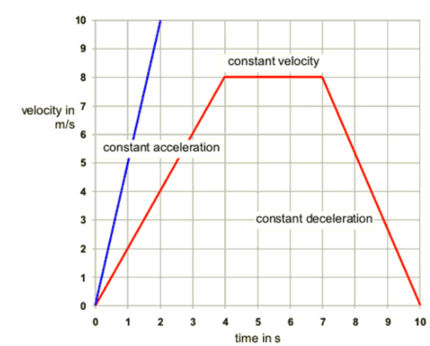
Drawing a Tangent on a Point of Acceleration of a Distance Time Graph



Distance Time Graphs
If an object moves along a straight line, the distance travelled can be represented by a distance–time graph. The speed of an object can be calculated from the gradient of its distance–time graph. **If an object is accelerating, its speed at any particular time can be determined by drawing a tangent and measuring the gradient of the distance–time graph at that time.**



Velocity Time Graphs
The acceleration of an object can be calculated from the gradient of a velocity–time graph. **The distance travelled by the object can be calculated by measuring the area underneath the line of a velocity time graph.**



P10: Force and Motion: Trilogy Specification: Higher

Newtons Second Law
This is the rule that the acceleration of an object is proportional to the resultant force acting on an object, and inversely proportional to the mass of the object. The equation for this is:

Resultant Force = Mass x Acceleration

Inertial mass is a measure of how difficult it is to change the velocity of an object and is defined as the ration of force over acceleration.

Changing Speed
The velocity of an object increases if the resultant force is in the same direction as the velocity while an object will slow down if the resultant force acts in the opposite direction to its velocity.

Terminal Velocity
An object falling through a fluid initially accelerates due to the force of gravity. Eventually the resultant force will be zero and the object will move at its terminal velocity.

Quantity	Symbol	Unit
Resultant Force	F	N
Mass	m	kg
Acceleration	a	m/s^2
Weight	W	N
Gravitational Field Strength	g	N/kg
Velocity	v	m/s
Momentum	p	Kg m/s
Spring Constant	k	N/m
Extension	e	m

Stopping Distance
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 under the braking force (braking distance). For a given braking force the greater the speed of the vehicle, the greater the stopping distance.

Momentum
Momentum can be calculated using the equation:
Momentum = Mass x Velocity

In a closed system, the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum.

Reaction Times
People have different reaction times. Typically people have a range between 0.2s and 0.9s. A persons reaction time can be affected by a persons tiredness and their use of drugs and alcohol. Distractions can also affect a drivers reaction time. To measure a persons reaction time in the science lab you could use a ruler. You would place the ruler just the finger and thumb of a friend and without warning drop the ruler. You would record the distance the ruler dropper before your friend caught it. You can then use this to find a reaction time.

Symbol for Proportionality

$\propto$

Hooke's Law
The extension of a spring is directly proportional to the force applied as long as the limit of proportionality is not exceeded.

Force Applied = Spring Constant x Extension

Braking
Braking distance of a vehicle can be affected by the road and weather conditions as well as the condition of the vehicle. Poor road conditions include wet or icy conditions while poor condition of the vehicle could include the brakes or tyres. of a vehicle, 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. The greater the speed of a vehicle the greater the braking force needed to stop the vehicle in a certain distance. The greater the braking force the greater the deceleration of the vehicle. Large decelerations may lead to brakes overheating and/or loss of control.

Forces and Elasticity
To change the shape of an object (by stretching, bending or compressing), more than one force has to be applied. If an object is elastic it will return to its original shape when the forces deforming it re removed.

Weight
The weight of an object can be calculated using the equation:

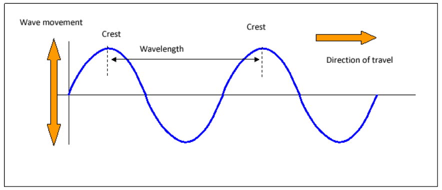
Weight = mass x gravitational field strength

The weight of an object and the mass o an object are directly proportional and weight is measured using a calibrated spring-balance otherwise known as a newtonmeter.

P12: Wave Properties: Trilogy Specification: Higher

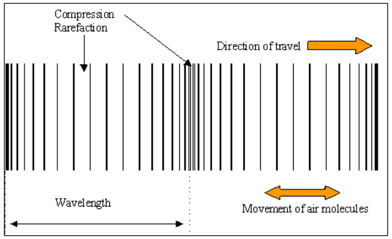
Transverse and Longitudinal Waves

Waves can be either Transverse or Longitudinal. Transverse Waves. All waves transfer energy.



In a transverse waves the particles oscillate perpendicular to the direction of energy transfer. Examples of transverse waves include water waves and electromagnetic waves.

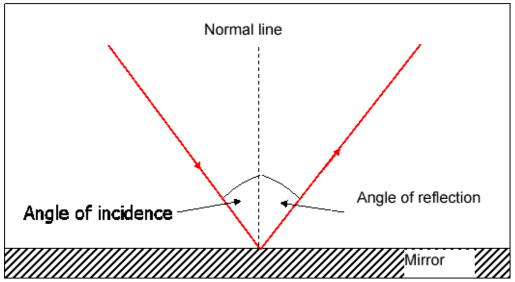
In a longitudinal wave the particles oscillate parallel to the direction of energy transfer. Examples of longitudinal waves include sound waves.



Reflection of waves

Waves can be reflected at a boundary between two different materials. They could also be transmitted or absorbed at a boundary between two different materials.

A ray diagram illustrates the reflection of a wave at a boundary. All ray diagrams should be drawn with a pencil and arrows clearly indicate the direction the light is travelling. These arrows must be included in all ray diagrams.



Sound Waves

Sound waves can travel through solids causing vibrations in the solid.

In the human ear, sound waves cause the ear drum to vibrate which allows us to detect sound. The conversion of sound waves to vibrations of solids only works over a limited frequency range. This restricts the range of human hearing. The range of human hearing is from 20Hz to 20kHz.

Waves for detection and exploration

Ultrasound waves are waves that have a higher frequency than 20kHz. This is a wave with a frequency above the range of human hearing. Ultrasound waves are partially reflected when they meet a boundary between two different media. The time taken for an ultrasound detector to pick up these reflections can determine the distance of the boundary. This allows ultrasound waves to construct an image and they are used in medicine.

Seismic waves are produced by Earthquakes. P-waves are longitudinal seismic waves. S-waves are transverse seismic waves. S waves cannot travel through a liquid. P-waves and S-waves both provide evidence for the structure and size of the Earth's core.

Echo Sounding uses high frequency sound waves to detect objects deep underwater and can also measure the depth of water.

Wave Properties

The frequency of a wave is the number of waves passing through a fixed point each second.

The amplitude of a wave is the maximum displacement of a point on a wave from its undisturbed position.

The wavelength of a wave is the distance from a point on one wave to the equivalent point on the adjacent wave.

The wave speed is the speed at which the wave moves through the medium. This is also the speed at which the energy is transferred through the medium.

Wave Equation

Period = 1/frequency (you do not need to recall)

Wave speed = frequency x wavelength

Quantity	Symbol	Unit
Frequency	f	Hz
Wave Speed	v	m/s
Wavelength	λ	m
period	T	s

P13: Electromagnetic Waves: Trilogy Specification: Higher

Types of Electromagnetic Waves

Electromagnetic waves are transverse waves that transfer energy from the source to an absorber. All electromagnetic waves travel at the same speed, 3×10^8m/s. Electromagnetic waves form a continuous spectrum . The spectrum is grouped by order of their wavelength and frequency. Humans can only detect the visible light part of the spectrum with their eyes.

Long wavelength → Short wavelength

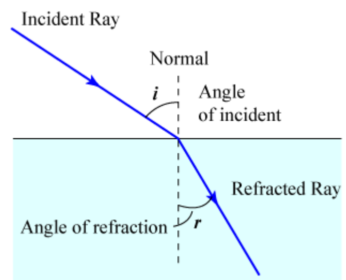
Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

Low frequency → High frequency

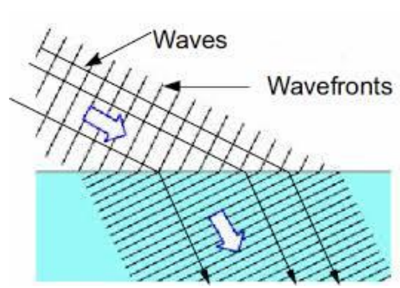
Component	Use
Radio Waves	Television and radio signal
Microwaves	Satellite communication, cooking food
Infrared	Electrical heaters, cooking food, infrared cameras
Visible Light	Fibre optic communication
Ultraviolet	Sun tanning, detecting forged notes
X-Rays	Medical imaging and treatment
Gamma Rays	Kill cancer cells, sterilization.

Properties of Electromagnetic Waves

Electromagnetic Waves can be absorbed, transmit, refract or reflect. Refraction is due to the difference in velocity that the waves travel in the different substances. A ray diagram can be used to illustrate refraction.



A wave front diagram can also be used to explain the change of speed that happens when the wave travels from one medium into another.



Properties of Electromagnetic Waves

Radio waves can be produced by oscillations in electric circuits. When radio waves are absorbed they can create an alternating current with the same frequency as the radio wave itself, so radio waves can themselves induce oscillations in an electrical circuit.

Changes in atoms and the nuclei of atoms can result in electromagnetic waves being generated or absorbed over a wide frequency range. Gamma rays originate from changes in the nucleus of an atom.

Ultraviolet waves, X-rays and gamma rays can have hazardous effects on human body tissue. The effects depend on the type of radiation and the size of the dose. Radiation dose is a measure of the risk of harm resulting from an exposure of the body to the radiation.

Ultraviolet waves can cause skin to age prematurely and increase the risk of skin cancer. X-rays and gamma rays are ionising radiation that can cause the mutation of genes and cancer.

P15: Electromagnetism: Trilogy Specification: Higher

Poles of a Magnet

The poles of a magnet are the places where the magnetic forces are strongest. When two magnets are brought close together they exert a force on each other. Two like poles repel each other. Two unlike poles attract each other. Attraction and repulsion between two magnetic poles are examples of non-contact force.

Permanent Magnets

A permanent magnet produces its own magnetic field.

Induced Magnets

An induced magnet is a material that becomes a magnet when it is placed in a magnetic field. Induced magnetism always causes a force of attraction. When removed from the magnetic field an induced magnet loses most/all of its magnetism quickly.

Electromagnetism

When a current flows through a conducting wire a magnetic field is produced around the wire. The strength of the magnetic field depends on the current through the wire and the distance from the wire. Shaping a wire to form a solenoid increases the strength of the magnetic field created by a current through the wire. The magnetic field inside a solenoid is strong and uniform. The magnetic field around a solenoid has a similar shape to that of a bar magnet. Adding an iron core increases the strength of the magnetic field of a solenoid. An electromagnet is a solenoid with an iron core.

Motors

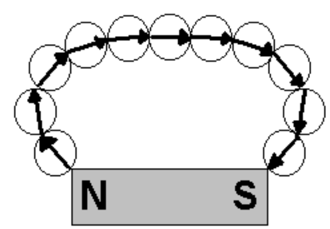
A coil of wire carrying a current in a magnetic field tends to rotate. This is the basis of an electric motor. The size of the force can be increased by increasing the current or using a stronger magnet. The size of the force depends on the angle between the wire and the magnetic field. The force is greatest when the wire is perpendicular to the magnetic field and zero when the wire is parallel.

Magnetic Fields

The region around a magnet where a force acts on another magnet or on a magnetic material (iron, steel, cobalt and nickel) is called the magnetic field. The force between a magnet and a magnetic material is always one of attraction. The strength of the magnetic field depends on the distance from the magnet. The field is strongest at the poles of the magnet. The direction of the magnetic field at any point is given by the direction of the force that would act on another north pole placed at that point. The direction of a magnetic field line is from the north (seeking) pole of a magnet to the south(seeking) pole of the magnet.

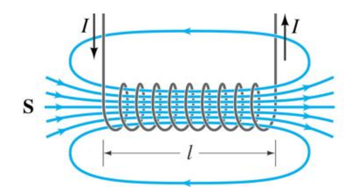
Plotting a Magnetic Field

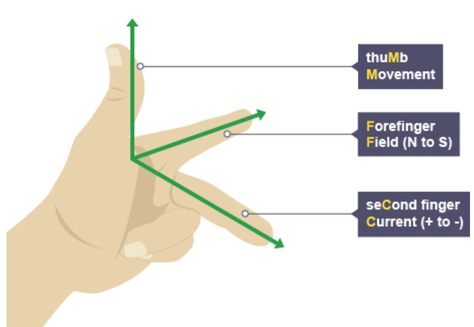
Mark a dot near the north pole of a bar magnet and place the tail of the compass needle above the dot and mark a second dot at the tip of the needle. Repeat this with the tail of the next compass over the new dot until you reach the south pole. Repeat this with further lines.



Solenoids

A solenoid is a long coil of insulating wire and they are used in lots of electrical devices where a strong magnetic field is needed. When a current is passed through the wire the magnetic field increases in strength if the current is increased and reverses in direction if the current is reversed.





Flemings Left Hand Rule

When a conductor carrying a current is placed in a magnetic field the magnet producing the field and the conductor exert a force on each other. This is called the motor effect. You need to be d be able to show that Fleming's left-hand rule represents the relative orientation of the force, the current in the conductor and the magnetic field.

Magnetic Flux Density

For a conductor at right angles to a magnetic field and carrying a current:

Force = Magnetic Flux Density x Current x Length

Quantity	Symbol	Unit
Force	*F*	N
Magnetic Flux Density	*B*	T
Current	*I*	A
Length	*l*	m