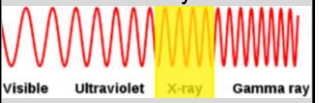
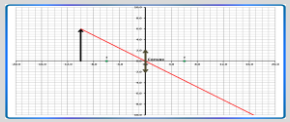
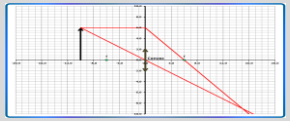
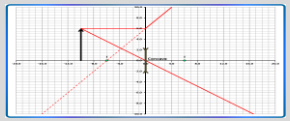
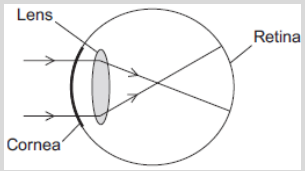
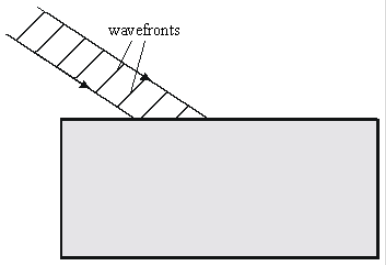
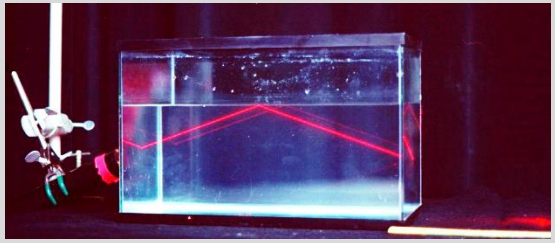
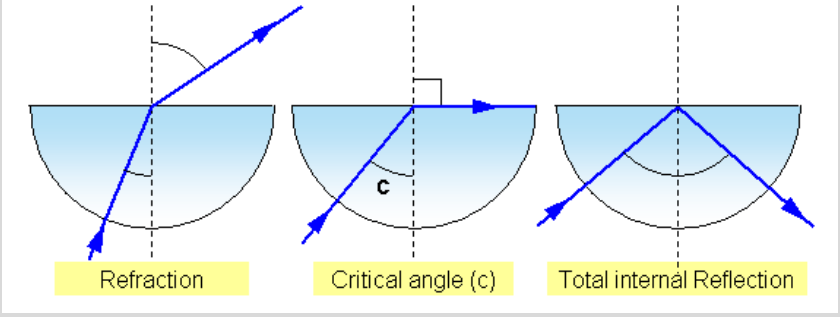
P3 Medical applications of physics: x-rays and ultrasound

What is an x-ray? 	X-rays are high frequency, high energy, short wavelength electromagnetic waves. They are transverse, ionising and their wavelength is similar to the diameter of an atom	What is ultrasound? 	A soundwave with a very high frequency, above 20,000 Hz which is above the upper limit of human hearing. Ultrasound waves are longitudinal.
Why are x-rays suitable for photographing bone structure?	Passes through flesh, absorbed by bone	What happens to ultrasound inside the body?	Ultrasound is partially reflected at the boundary between different media. Ultrasound waves travel at different speeds though different media.
Why are lead lined aprons used by x-ray operators?	X-rays are ionising and can be harmful but do not go through lead. This reduces the risk of x-rays damaging the operators cells.	Give uses of ultrasound as a medical treatment	Destruction of kidney stones, damaged tissue/muscle repair and removing plaque from teeth.
What happens to X-rays inside the body?	Oxygen reacted with ammonia to produce water and nitrogen.	Give medical uses of ultrasound scanning	Pre-natal scanning, imaging organs not surrounded by bone, e.g. stomach, bladder, testicles and Doppler scanning blood flow.
How do x-rays affect photographic film?	X-rays affect photographic film, the same way light does, turning it from white to black where the rays meet the film.	Give industrial uses of ultrasound	Cleaning, flaw detection or sonar.
Advantages of a CT scan	Images are higher resolution, scan produces a slice through the body and an image can be made of any part of the body. A CT scan also gives a 3D image this can be viewed from different directions making problems easier to diagnose.	What equipment is needed for an ultrasound image to be formed?	A coupling gel, an ultrasound transducer (transmitter and receiver) and a display device e.g. a computer or a CRO.
Disadvantages of a CT scan	The x-rays used are ionising which increase the chances of mutations and can turn cells cancerous. X-rays can also kill cells and therefore shielding is needed to carry out CT scans safely.	Why are people able to see different parts of the foetus in an ultrasound scan?	Different tissues have different densities and ultrasound wave travel at different speeds in different tissues until the bounce back from tissue boundaries and the time taken is measured which allows distance to be calculated.
Explain the medical uses, risks and operational precautions associated with x-rays 	X-rays can be used in the detection of bone fractures, dental problems and CT scanning as well as in the killing of cancer cells. X-rays are hazardous as they are ionising which can damage and mutate cells which can turn cells cancerous or kill them. X-ray operators should stand being a glass screen and wear a lead lined apron when making an x-ray.	What are the differences between the ultrasound waves emitted and those received by the transducer when measuring an object moving **away** from the source?	Frequency decreases, wavelength increases and the intensity decreases for the reflected waves in comparison to the emitted waves.
		Explain the medical uses, risks and operational precautions associated with ultrasound 	Ultrasound can be used in pre-natal scanning, removal of kidney stones, damaged tissue/muscle repair and removing plaque from teeth. There is no evidence that ultrasound damages human cells as it is not ionising and therefore poses no risk. There are no precautions necessary when making an ultrasound scan.

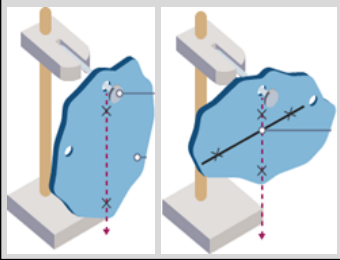
How could you change the focal length of a lens?	Change the material it is made from (refractive index) or the radius of curvature (how thick or thin it is)
What happens to parallel rays of light when the reach a convex lens?	They are refracted through the focal point on the other side of the lens
What happens to parallel rays of light when the reach a concave lens?	The are refracted outwards but appear to originate from the focal point on the side of the lens they were travelling from.
Images from a convex lens can be…	- inverted, real and diminished (camera) - inverted, real and magnified (Projector) -upright, virtual and magnified (Magnifying glass)
Images from a concave lens can be…	- upright, virtual and diminished
When drawing a ray diagram   	1. Draw a ray going from the top of your object through the point where the lens crosses the **principle axis** 2. Draw a second ray **parallel to the principle axis** until it reaches the lens then… a.) Convex: draw a ray from the point the ray touched the lens through the focal point on the **other side** of the lens. A real image is formed where this ray and ray 1. meet. If they diverge extrapolate the rays backward and where they meet a virtual image is formed. b.) Concave: from the point where the ray meets the lens draw a virtual ray backwards to the focal point on the **same side** of the lens. Where this ray and ray 1. cross a virtual image is produced.
What happens when an object is placed at the focal point F of a convex lens?	The 2 rays end up parallel and no image is formed.
What are the key situations involving lenses to be known?	The eye, a camera, a projector and a magnifying glass.

How do you calculate the power of a lens?	Power = 1 / focal length Dioptres metres
How do you calculate the magnification of a lens?	Magnification = image height / object height No units
What is the difference between a real and a virtual image?	Real images are formed when real rays cross and can be project onto a screen (film / CCDs) and captured. Virtual images cannot be put onto a screen and are formed where at least one of the rays used to produce the image is virtual.
What are the key components of the human eye?	Retina – where the image is formed changes light into electrical signals, lens – component that focuses light, cornea – main place for refraction, pupil – hole that allows light in, iris – controls the amount of light entering the eye, ciliary muscle – changes the shape of the lens and suspensory ligaments – attach the ciliary muscles to the lens.
State causes and corrections for long-sightedness 	The eyeball is too short or the lens being too weak. To correct this a convex lens can be used to focus the light rays on the retina. This is because rays of light from a near object spread a lot and therefore need to be bent a lot to focus on the retina.
State causes and corrections for short-sightedness	The eyeball is too long or the lens being too powerful. To correct this a concave lens can be used to focus the light rays on the retina. This is because rays of light from a distant object are roughly parallel and therefore do not need to be bent much to focus on the retina.

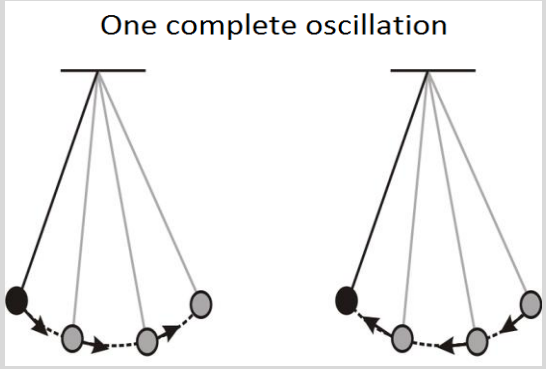
P3 Medical applications of light: other applications of light

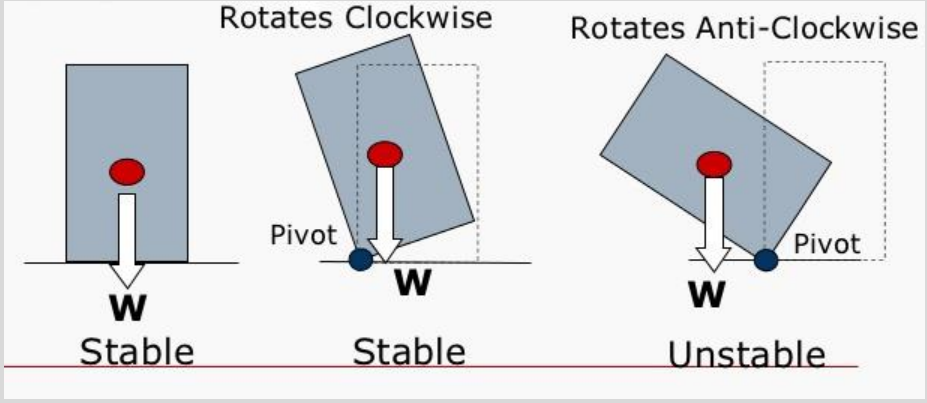
What is the name of the imaginary dashed line drawn perpendicular to where a ray hits a boundary?	The normal line. In reflection and refraction, calculation angles are **ALWAYS** measures between the rays and the normal.	Identify the condition necessary for refraction not to occur when meeting a boundary between media with different refractive indices.	The ray of light must be travelling along the normal line.
Explain what happens when a ray of light goes from a less dense medium into a more dense medium?	The light ray will bend towards the normal line because the side of the wave that come into contact with the new media slows down before the other side of the wave reaches the material.	Define refractive index	The ratio of the velocity of light in a vacuum to its velocity in a specified medium. $$n = \frac{\nu_1}{\nu_2} = \frac{\lambda_1}{\lambda_2} = \frac{\sin\theta_1}{\sin\theta_2}$$
Explain what happens when a ray of light goes from a more dense medium into a less dense medium?	The light ray will bend away from the normal line because the side of the wave that come into contact with the new media speeds up before the other side of the wave leaves the material.	Explain why the refractive index of glass is different for different colours of light.	Different colours of light travel at the same speed in a vacuum (or air) but different speeds in glass. This means the ratio of speed in a vacuum to speed in a medium will change for the different colours.
What is total internal reflection?	When a ray of light tries to move from a more dense medium to a less dense medium but its angle of incidence is greater than the critical angle.	Define the critical angle	When a light ray is shone from a more dense medium to a less dense medium and the angle of refraction is 90° the angle of incidence is known as the critical angle.
Light rays are sent down optical fibres using the process of total internal reflection. Give the uses of optical fibres.	Endoscopy, carrying laser light for surgery, telephone cables, fibre optic lamps and data transfer.		
State why, when using optical fibres in endoscopes, many thin fibres are used instead of a few think ones.	The cable can be bent more without loss of light, more flexible, more detailed image production and if some fibres are broken the system as a whole would still be usable.		
How are lasers used in medicine?	Laser eye surgery to alter the shape of the cornea		
How does an endoscope work?	Light passes though a bundle of optical fibres into the patients stomach. Inside the stomach some light is reflected, this light passes though a second bundle of fibres to an eyepiece for viewing.		

P3 Using physics to make things work: centre of mass, moments, hydraulics and circular motion

Centre of mass definition	The point at which the total mass of an object is thought to be concentrated.
Where is the centre of mass of a symmetrical object?	Where the lines of symmetry of the object cross. Even if the object is a hoop.
What equipment is needed to find the centre of mass of an irregular object?	The irregular object, strong pin, boss and stand, small weight, string and pen.
Explain how the centre of mass of an irregular object is found. 	Two small holes are made in the irregular object near its edge. The strong pin is placed through one of the holes and is then held up by the boss. The small weight is tied to the string and suspended from the same strong pin and, when stationary ,a line is drawn onto the object marking the position of the string. This is then repeated from the second hole in the object. The centre of mass is where the two lines cross.
Why should you wait until the object and plumb line are stationary before marking your line?	A freely suspended object will come to rest with its centre of mass directly below the point of suspension.
How can the centre of mass of an object be checked?	You can suspend your object from a new point and see if the plumb line passes through the current centre of mass.
State the two features of an object that make it difficult for it to topple	Wide base Low centre of mass
Why does the position of the centre of mass affect how likely an object is to topple?	The centre of mass is where the line of action points towards the ground from. If this is outside the base then a moment will be produced which will cause the object to topple.

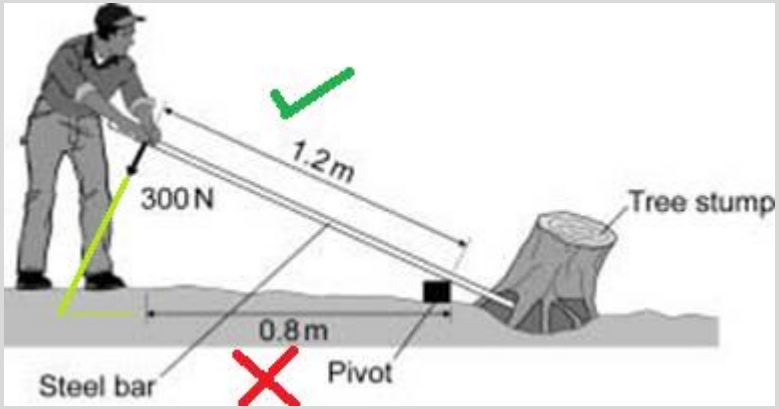
What is a pendulum?	A mass hanging from a rod or string that swings back and forth. The equilibrium position of the pendulum is the position when the mass is hanging directly downward.
What affects the time period of a pendulum?	ONLY its length.
When measuring the time period of a pendulum why should you measure the time taken for many swings instead of a single swing?	Increases **reliability** because the reading error will be the same but because you are taking a longer time this will reduce the percentage error in the timings.
How could you increase the accuracy of an experiment designed to find the time period of a pendulum?	Use many different lengths, take repeat readings use oscillations with small amplitudes, discard anomalous results and use a fiducial marker.



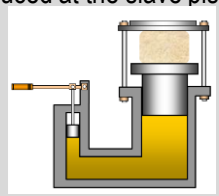


P3 Using physics to make things work: moments, hydraulics and circular motion

What is a moment?	The turning effect of a force measured in Nm.
How can you increase the effect of a moment?	Increase the distance between the force and the pivot or increase the force applied.
How do you calculate the moment exerted by a force?	moment = force × **perpendicular distance** from the line of action of the force to the axis of rotation Nm N m



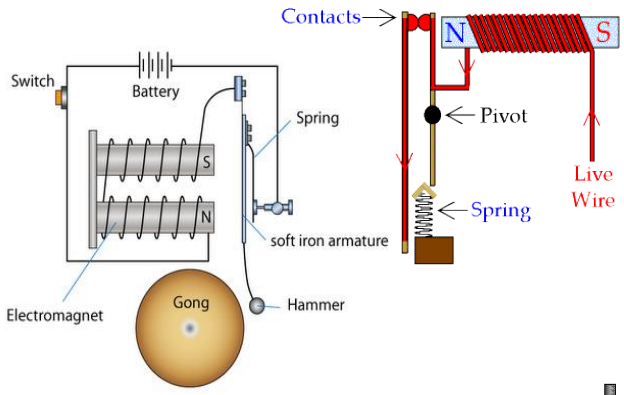
What does the word stable mean in terms of moments?	When an object will not fall over because the centre of mass (line of action of the weight) is over the base even if the object was given a small push.
What condition is necessary for an object to be in equilibrium?	No resultant moment. Total clockwise moment = Total anticlockwise moment

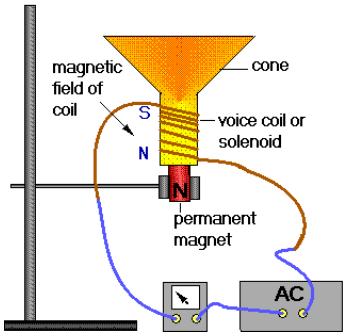
What is a hydraulic system?	A force multiplier that uses liquid to transmit a force
What property of a liquid is essential for a hydraulic system to work?	Liquids are virtually incompressible.
When a force is applied to a master piston why does the slave piston move?	The force creates a pressure in the liquid which is transmitted equally in all directions and the slave piston is the only point that can move.
What is the equation essential to hydraulic systems?	Pressure = Force / Area Pa N m^2
When a force is applied to a master piston, why is a greater force produced at the slave piston? 	**Provided that master piston has a smaller surface area than the master piston…** The force applied creates a pressure in the liquid which will be the same at all points in the liquid which produces a force on the slave piston. As the surface area of the slave piston is bigger the force must increase as the pressure must be constant.
Force x distance = work done. As energy cannot be created or destroyed how does a force multiplier work?	The force acting on the master piston moves a further distance than the force at the slave piston.
Why doesn't centripetal force appear on free body force diagrams?	Centripetal force is not a force in its own right it is the centre seeking resultant force caused when a object travels around a bend (in a circle)
State the factors that can increase the size of a centripetal force	Mass, velocity, radius of the bend.
Explain how an object can travel at a constant speed but still be accelerating	If an object travels around a bend with a constant speed then it will constantly be changing direction which means its velocity will be changing causing a constant acceleration towards the centre.
Give examples of forces that can provide the centripetal force	Weight, gravity, tension, friction, electrostatic, etc.

P3 keeping things moving: the motor effect

What is an electromagnet?	A charge carrying wire that causes an induced magnetic field.
How do you increase the strength of an electromagnet?	Core – soft iron Coils – many in the same direction and not overlapping Current – high.
State the key uses of electromagnets.	Electric bell, circuit breaker, crane and relay switch.
Outline how an electromagnetic use.	There is a change in the flow of current e.g. a switch is pressed or more current flows. This flow of current magnetises the metal core producing a magnetic field. A piece of metal is then attracted towards the electromagnet. This completes/breaks the circuit as needed. The circuit is then either reset automatically or manually.
What is an electromagnet?	A charge carrying wire that causes an induced magnetic field.
What is the basic principle of a motor?	Passing a current through an electrical conductor while it is in a magnetic field will cause it to feel a force.
State key uses of the motor effect	Electrical motors and the loudspeaker.
Why does the electrical conductor feel a force?	The current passing through it creates a magnetic field. This interacts with the permanent magnetic field of the magnets producing a force.
How could the direction a motor is turning be changed?	Reversing the direction of the current or reversing the direction of the magnetic field.
What are the key components of a simple motor?	Power supply, wires, metal brush contacts, split-ring commutator, rotating coil of wire, permanent magnets and an axle.

What is the basic principle of a generator?	Electromagnetic induction. Moving a magnet into a coil of wire causes a potential difference to be induced across the ends of the wire.
What does Flemings left hand rule tell you?	That the direction of Movement (force), the direction of the magnetic Field and the direction of conventional Current (positive to negative) are all perpendicular to each other.
What is the condition needed for no force to be felt by a charge carrying wire in a magnetic field?	If the conductor and field are parallel then the conductor will not experience a force.





P3 Keeping things moving: transformers

Why does a current flow through a wire that passes a magnet?	The wire 'cuts' through the magnetic field produced by a magnet which induces a potential difference across the ends of the wire
Describe the basic structure of a transformer	An insulated coil of wire, the primary coil, on one side of the core and another coil of insulated wire, the secondary coil, on the other side of the core. The core is made of two; soft, laminated iron C-cores that are joined to form a ring. **[ ] = []**
Why do the wires need to be insulated?	So the current doesn't flow through the core which could cause the system to short circuit.
Why is the core made of iron?	Iron is easily magnetised.
What is meant by the iron core being laminated?	Constructed in thin layers.
What type of power supply is needed for a transformer to work?	Alternating current, otherwise the transformer would not work.
What affect does passing an alternating current though the primary current have?	This produces an alternating magnetic field in the soft iron core. The core links this magnetic field to the secondary coils inducing a voltage. The induced alternating voltage causes an alternating current to be produced in the secondary coils. If there are more coils in the primary coil than the secondary then it is a step down transformer.
What is a step-up transformer used to do?	Increase the potential difference which reduces the current to keep the power the same. This reduces the energy lost as heat through the power cables.
What is a step-down transformer used to do?	Decrease the potential difference to a safe domestic level.

What is the relationship between the potential difference and the number of coils in a transformer?	$\frac{\text{output voltage}}{\text{input voltage}} = \frac{\text{number of turns on output coil}}{\text{number of turns on input coil}}$
Transformers are assumed to be 100% efficient what formula does this lead to?	Power in = Power out P.D. in x Current in = P.D. out x Current out
What type of transformer is found in a mobile phone charger?	A switch mode transformer
What are the key properties of a switch mode transformer?	They are smaller and lighter than traditional transformers and they only use a small amount of energy when left switched on but no appliance is connected.