Year 11 –Energy

es and systems

What is a system?	An object or group of objects
What happens when a system changes?	The way energy is stored changes
System	Change in energy storage
An object projected upwards	Kinetic energy to gravitational potential energy
A moving object hitting a vehicle	Kinetic energy transferred to thermal and sound
An object accelerated by constant force	Increase in kinetic energy
A vehicle slowing down	Decrease in kinetic energy
Bringing water to boil in an electric kettle	Electrical energy being transferred to thermal energy (and sound)

2. Changes in Energy

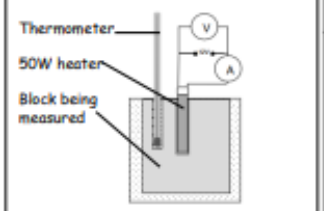
Energy	Definition	Word equation	Symbol equation	Units
Kinetic energy, E_k	Energy associated with moving objects	Kinetic energy = 0.5 x mass x (speed)^2	$E_k = \frac{1}{2}mv^2$	E_k - J m - kg v - m/s
Elastic potential energy, E_e	Energy associated with a compressed spring	Elastic potential energy = 0.5 x spring constant x(extension)^2	$E_e = \frac{1}{2}ke^2$	E_e - J k - N/m e - m
Gravitational potential energy, E_g	Energy associated with objects raised above ground level	Gravitational potential energy = mass x gravitational field strength x height	$E_g = mgh$	E_g - J M - kg g - N/kg h - m
Work done, W	Another way of saying "energy transferred"	Work done = force x distance	W = Fd	W - J F - N d - m

3. Specific Heat Capacity

Energy change	Word equation	Symbol equation	Units
Amount of energy stored or released in a system as its temperature changes	Change in thermal energy = mass x specific heat capacity x temperature change	$\Delta E = mc\Delta\theta$	E - J m - kg c - J/kg°C Θ - °C

Specific heat capacity:
Amount of energy required to raise the temperature of 1kg of a substance by 1°C

What is the setup for measuring the specific heat capacity of a metal block?



4. Power

Definition	Word equation	Symbol equation	Units
Rate at which energy is transferred	Power = $\frac{\text{energy transferred}}{\text{time}}$	$P = \frac{E}{t}$	P - W E - J t - s
Rate at which work is done	Power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$	P - W W - J t - s

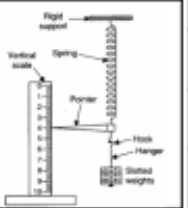
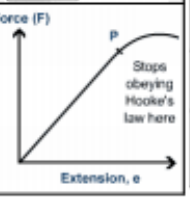
A power of one Watt is an energy transfer of one Joule per second

5. Efficiency

Efficiency	In term of energy transfer	= $\frac{\text{Useful output energy transfer}}{\text{Total input energy transfer}}$
	In terms of power	= $\frac{\text{Useful power output}}{\text{Total power input}}$

Measures how much energy or power is usefully transferred.
It is value between 0 and 1.
0 → no input energy or power is usefully transferred
1 → all the input energy or power is usefully transferred

6. Hooke's Law

What needs to be applied for an object to change shape?	A force
What is elastic deformation?	Once the force is removed from an object, it returns to its original shape
What is inelastic deformation?	Once the force is removed from an object, it does not return to its original shape
What is Hooke's Law?	The extension of a spring is directly proportional to the force applied to it
Does Hooke's Law hold for all applied forces?	No, after a large enough force, the spring will not be able to stretch anymore.
What s the experimental setup for testing Hooke's Law?	
What does a graph of force applied against extension of spring look like?	

7. Energy Conservation and Dissipation

What is a closed system?	A system with no external forces acting on it and no mass is transferred in or out of it. There is no net change to the total energy
What is an open system?	A system with external forces acting on it and mass can be transferred in or out of it
How is energy stored in a system?	Energy can be stored usefully and some energy is dissipated (wasted)
Example: energy stores in a hair dryer	Useful energy: thermal Dissipated/wasted: sound
Example: energy stores in a TV	Useful energy: light and sound Dissipated/wasted: thermal

8. Thermal Conductivity and Insulation

What is thermal conductivity?	A measure of how quickly energy can be transferred by conduction through a material
What does it mean if a material has high thermal conductivity?	Energy is transferred by conduction very quickly
What two factors affect how quickly a building cools down?	- Thickness of its walls - Thermal conductivity of its walls
How do these factors affect how quickly a building cools down?	If we slow the rate of conduction, the building will cool down slower. We need: - Thick walls→it takes for energy to be transferred by conduction - Walls made of material with low thermal conductivity→the longer it takes for energy to be transferred by conduction

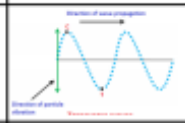
9. Renewable and Non-Renewable Energy sources

Energy source	Uses	Advantages	Disadvantages
Coal	Electricity generation, heating	Found in many places Easy to transport to power stations Cheap	Non-renewable→will run out in 100 years Produces CO_2 → global warming Produces SO_2→ acid rain Miners get various lung-related illnesses
Oil and natural gas	Electricity generation, heating, transport	Found in many places Easy to transport	Non-renewable Produces CO_2 → global warming Produces SO_2→ acid rain Risk of environmental damage when oil spills
Nuclear fuel	Electricity generation	No greenhouse gas emissions Very little needed to generate lots of energy	Non-renewable- uranium supplies will run out Waste is radioactive and harmful Risk of terrorist attack
Biofuel	Electricity generation, heating, transport	Renewable Cheap Uses things that would otherwise be thrown away	Greenhouse gas emissions Biofuel crops are grown in place of food May run out of space
Wind	Electricity generation	Renewable No greenhouse gas emissions Wind is free→main cost in building wind turbine	Can only be used in areas with lots of wind Amount of wind varies daily Need many turbines to generate sufficient electricity Eye-sore
Hydro-electric	Electricity generation	Renewable No greenhouse gas emissions Water is free	Expensive to build dam (large wall in water) Building a dam requires flooding→affects local wildlife If insufficient rainfall→not enough water to turn turbines
Geothermal	Heating	Renewable Free No greenhouse has emissions	Limited number of places where power stations can be built Harmful gases and minerals can come up from ground
Tidal	Electricity generation	Renewable Tides are free→main cost in building power station No greenhouse gas emissions Know when tides happen→know when electricity will be generated	Need to build a dam→destroys habitats for plants and animals Tides happen twice a day→limited time for electricity generation
Solar	Electricity generation, heating	Renewable Energy from sun is free	Power stations are expensive to build If cloudy or dark→not enough light to generate electricity Eye-sore
Water waves	Electricity generation	Renewable No greenhouse gas emissions Waves is free→main cost is in building power station	Size of waves vary→electricity cannot always be generated Need to transport electricity from sea to land Technology is new→equipment is expensive

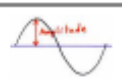
Year 11 –Energy (Triple content)

10. Waves in Air, Fluids and Solids

10a. Transverse and Longitudinal Waves

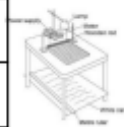
What is a wave?	Waves carry energy from one place to another.	
What else can a wave carry?	Information	
Are waves natural or man made?	Waves are common in natural and manmade systems	
	Transverse	**Longitudinal**
Diagram		
How do the oscillations relate to the direction of energy transfer?	Oscillations are perpendicular (right angles) to the direction of energy transfer	Oscillations are parallel to the direction of energy transfer
Can this type of wave travel through solids?	Yes	Yes
Can this type of wave travel through liquids?	Yes	Yes
Can this type of wave travel through air?	Yes	Yes
Can this type of wave travel through a vacuum?	Yes	No
Examples	Water waves, electromagnetic waves	Sound waves

10b. Properties of Waves

Property	Definition	How to work it out		Units
Amplitude	Maximum displacement of a point on a wave away from its undisturbed (equilibrium) position			m
Wavelength λ	Distance from a point on one wave to the equivalent point on an adjacent wave			m
Frequency F	Number of waves passing a point each second.	$\frac{1}{\text{Period}}$	$\frac{1}{T}$	Hz (or /s)
Period T	Time to complete one wavelength (one complete wave)	$\frac{1}{\text{Frequency}}$	$\frac{1}{f}$	S
Wave speed v	Speed at which energy is transferred (or wave moves) through the medium. The equation for wave speed is called the wave equation.	Frequency x wavelength	f x λ	m/s
		$\frac{\text{Wavelength}}{\text{period}}$	$\frac{\lambda}{T}$	

10d. RP: Measuring the Speed of Water Waves

Stage	Method
1) Find the wavelength	Use a ruler to measure as many waves as possible (dark lines show the peaks). Divide the number of waves by the total length of all the waves.
2) Find the frequency	Count the number of waves passing a fixed point for a given period of time (e.g. 10s). Divide the number of waves counted by the time.
3) Calculate the speed	speed = frequency x wavelength



10c. Measuring the Speed of Sound in Air

Method	How it works
Balloon and stop watch	- Person1 holds balloon and pin - Person2 stands fixed distance away with stopwatch - Person1 pops balloon - As soon as Person2 **sees** balloon pop → start stopwatch - As soon as person2 **hears** the balloon pop→stop stopwatch - Use speed = distance/time - Repeats for different distances and take the mean
Clap-echo method	- Stand a long distance from a wall - Clap at same time as starting timer - Stop timer when you hear echo - Distance travelled is double distance to wall - Use speed = distance/time
Microphone and data logger	- Set up two microphones a known distance apart - Connect to data logger - Ring a bell - Data logger records time taken to reach each microphone - Speed = distance between microphones/time on computer

11. Electromagnetic Waves

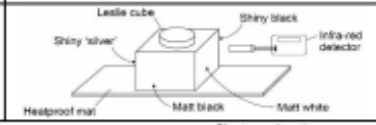
11a. Types of Electromagnetic Wave

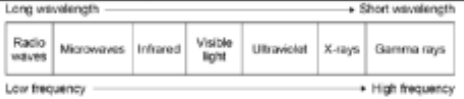
What are electromagnetic waves?	Transverse waves that transfer energy from the source of the waves to an absorber. They all travel at the same velocity through a vacuum and through air.
What is unique about electromagnetic waves compared to other transverse waves?	They can travel through a vacuum. They all travel at the same velocity through a vacuum and through air.
How many types of electromagnet waves are there?	7
How do we group the electromagnetic waves?	In terms of their wavelength and frequency
What are the 7 groups?	Radio Microwaves Infra-red Light Ultra-violet X-rays Gamma rays
Which is the only electromagnetic wave that humans can detect/see?	Visible light

11b. Applications of Electromagnetic Waves

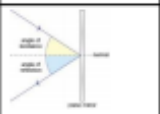
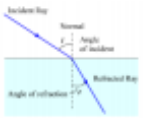
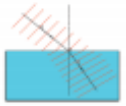
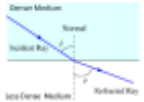
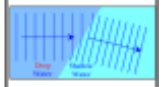
EM Wave	Use	Additional Information
Radio	Television Radio	-produced by oscillations in electrical circuits - when absorbed they create an alternating current with same frequency as itself
Microwave	Satellite communications Cooking food	Wavelength is approximately 1cm
Infrared	Electrical heaters Cooking food Infrared cameras	All hot things emit infrared (including humans!)
Light	Fibre optic communications	The only electromagnetic wave detectable by human eye
Ultraviolet	Energy efficient lamps Sun tanning	-Can cause skin to age prematurely -Increases risk of skin cancer
X-rays Gamma rays	Medical Imaging Medical treatments	-emitted from unstable nuclei -Ionising radiation→causes mutation of genes and cancer

11c. RP – Absorption and Emission of Infrared

What apparatus do you need?	- Leslie cube - Infrared detector - Heatproof mat - kettle
What is a leslie cube?	A hollow cube with four different surfaces on each side
What are the four surfaces of a ledlie cube?	- Matt white - Shiny black - Matte black - Shiny 'silver' (metal)
What is the method?	- Boil the kettle - Pour water into the leslie cube and put stopper in - Measure the temperature emitted from each surface using the infrared detector - Ensure you always measure from the same distance away from a side
What does a high temperature mean?	Lots of infrared is being emitted from that surface (therefore the surface material does not absorb infrared radiation)
What does a low temperature reading mean?	Very little infrared is being emitted (therefore the infrared is being strongly absorbed by the surface material)
Draw a diagram of the apparatus	



11d. Refraction – Ray Diagrams and Wave Fronts

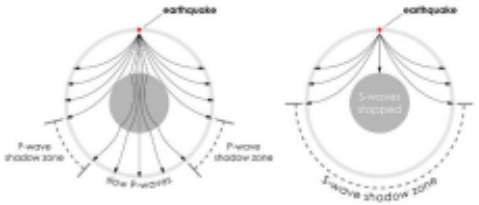
Property	What happens to the electromagnetic wave?	Ray diagram	Using wave fronts
Reflection	Angle of incidence = angle of reflection $\theta_i = \theta_r$		N/A
Refraction →Change in direction of a wave at a boundary due to a change in velocity when entering a different material	**Less dense to more dense** → waves slows down → angle of refraction is smaller then angle of incidence → bend towards the normal		
	More dense to less dense → wave speeds up → angle of refraction is larger than angle of incidence → bend away from normal		

Year 11 –Energy (Triple content)

12. Waves for detection and exploration

Ultrasound	
Why are ultrasound waves?	Sounds waves with a frequency higher than the upper limit of hearing for humans (>29kHz)
What happens when an ultrasound wave meets a boundary between two media?	They are partially reflected (some is reflected and some is transmitted)
How do you find out how far away a boundary is?	The time taken for the reflections to reach a detector is recorded. Knowing the speed of wave in the media means the distance can be found from: Distance = speed / time
What are ultrasound waves used for?	Medical and industrial imaging

Seismic waves	
Why are seismic waves?	Waves produced by earthquakes
What are the two types of seismic wave?	S and P
What are S waves?	Transverse seismic waves
What are P waves?	Longitudinal seismic waves
Can S waves travel through solids?	Yes
Can S waves travel through liquids?	No
Can P waves travel through liquids?	Yes
Can P waves travel through solids	Yes
What have P and S waves to used to as evidence for?	The size and structure of the Earth - S waves can not travel through core - P waves travel different speeds through core and mantel



Echo Sounding	
What is echo sounding?	Using high frequency sound waves to detect objects in deep water and to measure the depth of water
How does echo sounding work?	1. Ultrasound pulse is sent into water 2. Pulse will reflect back when it hits a surface boundary 3. The time between pulse being sent and reflection being detected is recorded. 4. Speed of ultrasound in water is known. 5. Use distance = speed x time. 6. Divide this number by two because the pulse travelled there and back (twice the actual distance of object)

13. Visible Light

What colours make up visible light?	Red, orange, yellow, green, blue, indigo, violet
What is specular reflection?	When light reflects from a smooth surface such that all the light is reflected in a single direction
What is diffuse reflection?	When light reflects from a rough surface, light is scattered (reflected in lots of different directions)
How do colour filters work?	By absorbing certain wavelengths (i.e. certain colours) and transmitting other wavelengths
What does transparent mean?	All light is can pass through it (is transmitted) and is not scattered
What does translucent mean?	Light can pass through but is scattered in different directions so object behind cannot be seen clearly
What does opaque mean?	Light cannot travel through the object
Why are opaque objects different colours?	The colour is determined by which wavelengths (and therefore colours) of light are more strongly reflected.
What happens to wavelengths that are not reflected from an opaque object?	They are absorbed by the object
What colour is an opaque object if all colours are reflected equally?	White
What colour is an opaque object if all colours are absorbed?	Black

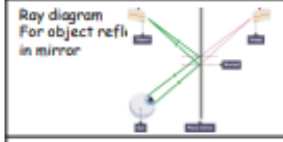
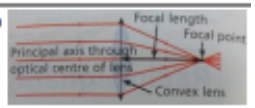
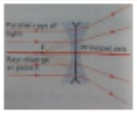
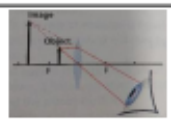
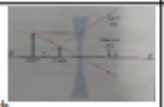
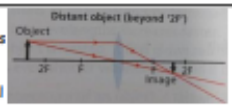
14. Sound waves

How do sound wave travel through a solid?	By causing particles in the solid to vibrate. These vibrations cause neighbouring particles to also vibrate.
How do humans hear?	Sounds wave cause the ear drum and other parts to vibrate, causing the sensation of sound
Why are their restrictions on human hearing?	The conversion of sound waves to vibrations in solids works over a limited frequency range
What is the range of normal human hearing?	20Hz - 20kHz

15. Lenses

How does a lens form an image?	By refracting light
What are the two types of lens?	Convex and concave
Draw a convex lens	
Draw a concave lens	
What two types of image can be formed by a lens?	Real and Virtual
What is a real image?	Image formed where light rays are focussed (meet at a focal point)
What is a virtual image?	Light rays appear to come from the image but don't actually (e.g. a mirror)
What type of image can be formed by a convex lens?	Real or virtual
What type of image can be formed by a concave lens?	Always virtual

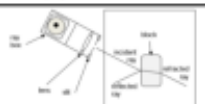
16. Ray diagrams

What is a ray diagram?	Diagram that traces the path that light takes
What are the rules for constructing a ray diagram?	1. A mirror is drawn as a straight line with hatches on one side 2. A concave lens is drawn as 3. Light rays (path of light) are drawn as solid straight lines with arrows on to show the direction the light is travelling 4. Light rays that appear to come from behind the mirror are drawn as dashed lines
Ray diagram For object refl in mirror	
Ray diagram for parallel rays incident on convex lens	
Ray diagram for parallel rays incident on concave lens	
Ray diagram for convex lens for object between lens and focal length	
Ray diagram for concave lens for object between focal length and twice focal length	
Ray diagram for convex lens for object further than twice the focal length	

17. Magnification

What is the magnification?	How large the image is compared to the object
What is the equation for magnification?	Magnification = image height / object height
What are the units for magnification?	No units
What do we measure image height and object height in?	Either cm or mm (both must be measured in the same units!)
If magnification is larger than 1 what does this mean?	Image is bigger than object
If magnification is smaller tan 1 what does this mean?	Image is smaller than object

18. RP - Reflection and Refraction

What apparatus do you need?	- Ray box and power supply - Collimating slit and lens - Rectangular transparaent blocks - 30 cm ruler - Protractor - Plain A3 paper
Draw the experimental setup	
What will you draw on the A3 paper and what you can measure from it?	-Shape and position of glass block -Path that the light has taken: incident, refracted and reflected rays 
What will happen to the angle of refraction as you change the type of material that block is made of?	The angle of refraction will change because the light will be slowed down a different amount by different materials.