Energy Notes -

to be used together with website and textbook. Just the notes is not enough!

4.1.1.1 Energy stores and systems

Content

A system is an object or group of objects.

There are changes in the way energy is stored when a system changes.

Students should be able to describe all the changes involved in the way energy is stored when a system changes, for common situations. For example:

- an object projected upwards
- a moving object hitting an obstacle
- an object accelerated by a constant force
- a vehicle slowing down
- bringing water to a boil in an electric kettle.

Throughout this section on Energy students should be able to calculate the changes in energy involved when a system is changed by:

- heating
- work done by forces
- work done when a current flows

This is the tricky bit. The rest of this module is pretty straightforward, so don't get demoralized early on. There are two ways of describing the way energy moves between stores. They are shown below for the examples given. One comes from AQA and one from the Institute of Physics. Take your pick, I prefer the mechanical pathway language. Both are correct.

Alternatively the Institute of Physics uses this language.
Energy carriers (or pathways, or transfers)

mechanically (when a force moves through a distance)
electrically (when a charge moves through a potential difference)
by heating (because of a temperature difference)
by radiation (e.g. light, microwaves, sound)

- Examples:
- an object projected upwards
    - **Energy shifts from chemical energy store of the body to GPE store of the object via the mechanical pathway (OR work done by forces)**
- a moving object hitting an obstacle
    - **energy shifts from kinetic store of object to the thermal energy and elastic potential store of the obstacle via the mechanical pathway (OR work done by forces)**
- an object accelerated by a constant force e.g. car accelerating
    - **energy shifts from chemical store of the fuel to the kinetic store of the object via the mechanical pathway (OR work done by forces)**
- a vehicle slowing down
    - **energy shifts from the kinetic store of the vehicle to the thermal store of the brakes and surroundings via the mechanical pathway (OR work done by forces)**
- bringing water to a boil in an electric kettle.
    - **energy shifts from chemical store of the fuel (at power station) to the thermal store of the water via the electrical pathways (OR work done when a current flows).**

4.1.1.2 Changes in energy

Content	Key opportunities for skills development
Students should be able to calculate the amount of energy associated with a moving object, a stretched spring and an object raised above ground level.	
The kinetic energy of a moving object can be calculated using the equation: $kinetic\ energy = 0.5 \times mass \times (speed)^2$ $\left[E_k = \frac{1}{2} m v^2\right]$ kinetic energy, E_k, in joules, J mass, m, in kilograms, kg speed, v, in metres per second, m/s	Learn this equation and practice rearranging it i.e. making it say m= and v=
The amount of elastic potential energy stored in a stretched spring can be calculated using the equation: $elastic\ potential\ energy = 0.5 \times spring\ constant \times (extension)^2$ $\left[E_e = \frac{1}{2} k e^2\right]$ (assuming the limit of proportionality has not been exceeded) elastic potential energy, E_e, in joules, J spring constant, k, in newtons per metre, N/m extension, e, in metres, m	This equation is on the data sheet you are given in the exam. Again be sure you can rearrange it.
The amount of gravitational potential energy gained by an object raised above ground level can be calculated using the equation: $g.p.e. = mass \times gravitational\ field\ strength \times height$ $\left[E_p = m g h\right]$ gravitational potential energy, E_p, in joules, J mass, m, in kilograms, kg gravitational field strength, g, in newtons per kilogram, N/kg (In any calculation the value of the gravitational field strength (g) will be given.) height, h, in metres, m	Again, learn this equation

You need to recognize situations where these three types of energy shift from one store to another and be able to work it out mathematically.

e.g. Ball rolling down hill - GPE shifts to KE. Therefore mgh = $0.5mv^2$. You then substitute in numbers and find whatever you need.

e.g. arrow from bow up into air - EPE (stored in pulled back bow) shifts to GPE. i.e. $0.5ke^2$ = mgh

Thus you could, for example, given the spring constant of the bow, the extension and the mass of the arrow, work out how high the arrow went.

4.1.1.3 Energy changes in systems

Content	
The amount of energy stored in or released from a system as its temperature changes can be calculated using the equation:	
$change\ in\ thermal\ energy = mass \times specific\ heat\ capacity \times temperature\ change$ $[\Delta E = m\,c\,\Delta\theta]$ change in thermal energy, ΔE, in joules, J mass, m, in kilograms, kg specific heat capacity, c, in joules per kilogram per degree Celsius, J/kg °C temperature change, $\Delta\theta$, in degrees Celsius, °C The specific heat capacity of a substance is the amount of energy required to raise the temperature of one kilogram of the substance by one degree Celsius.	This equation is given on the data sheet. You need to know the units of things and how to rearrange it.

Required practical activity 1: investigation to determine the specific heat capacity of one or more materials. The investigation will involve linking the decrease of one energy store (or work done) to the increase in temperature and subsequent increase in thermal energy stored.
Check textbook or website for details of this practical.

4.1.1.4 Power

Content	
Power is defined as the rate at which energy is transferred or the rate at which work is done. $power = \frac{energy\ transferred}{time}$ $\left[P = \frac{E}{t}\right]$ $power = \frac{work\ done}{time}$ $\left[P = \frac{W}{t}\right]$	**Learn both of these.**
power, P, in watts, W energy transferred, E, in joules, J time, t, in seconds, s work done, W, in joules, J An energy transfer of 1 joule per second is equal to a power of 1 watt.	This is an important statement. Remember it.
Students should be able to give examples that illustrate the definition of power eg comparing two electric motors that both lift the same weight through the same height but one does it faster than the other.	Power is how quickly energy is shifted from one store to another. A more powerful torch shifts energy from the chemical store into other forms more quickly than a less powerful torch.

4.1.2 Conservation and dissipation of energy

Content	Additional notes
Energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed. Students should be able to describe with examples where there are energy transfers in a closed system, that there is no net change to the total energy. Students should be able to describe, with examples, how in all system changes energy is dissipated, so that it is stored in less useful ways. This energy is often described as being 'wasted'.	This is the most important statement in Physics and is always true. However, energy does tend to spread out and become less useful. Dissipated is a very useful word. Use it.

Students should be able to explain ways of reducing unwanted energy transfers, for example through lubrication and the use of thermal insulation.

The higher the thermal conductivity of a material the higher the rate of energy transfer by conduction across the material.

Students should be able to describe how the rate of cooling of a building is affected by the thickness and thermal conductivity of its walls.

Students do not need to know the definition of thermal conductivity.

If anything is moving, then friction is shifting energy from wherever it was to the thermal store of the surroundings via the mechanical pathway. To stop this happening use lube!

Something with a high thermal conductivity lets lots of heat flow through it quickly. Thus if you want something to stay warm you surround it with a material with a low thermal conductivity.

Required practical activity 2 (physics only): investigate the effectiveness of different materials as thermal insulators and the factors that may affect the thermal insulation properties of a material.

This the the thrilling practical involving wrapping increasing numbers of layers of newspaper around beakers and noting that the more layers the warmer the water stays. Instruction sheet available on the website (probably).

4.1.2.2 Efficiency

Content	Key opportunities for skills development
The energy efficiency for any energy transfer can be calculated using the equation: $efficiency = \frac{useful\ output\ energy\ transfer}{total\ input\ energy\ transfer}$ Efficiency may also be calculated using the equation: $efficiency = \frac{useful\ power\ output}{total\ power\ input}$	Learn this equation. Efficiencies can be given as a decimal or a percentage (multiply decimal answer by 100). Efficiency must always be less that 1 (or 100%)
(HT only) Students should be able to describe ways to increase the efficiency of an intended energy transfer.	The way to increase efficiency is to reduce the amount of energy shifted to thermal store of surroundings (i.e. wasted as heat). This is either the lube again or insulation.

4.1.3 National and global energy resources

<table>
<tr><th>Content</th><th>Key opportunities for skills development</th></tr>
<tr><td>The main energy resources available for use on Earth include: fossil fuels (coal, oil and gas), nuclear fuel, bio-fuel, wind, hydro-electricity, geothermal, the tides, the Sun and water waves.

A renewable energy resource is one that is being (or can be) replenished as it is used.

The uses of energy resources include: transport, electricity generation and heating.

Students should be able to:
• describe the main energy sources available
• distinguish between energy resources that are renewable and energy resources that are non-renewable
• compare ways that different energy resources are used, the uses to include transport, electricity generation and heating
• understand why some energy resources are more reliable than others</td><td>Key words here are reliable and renewable. They get you a long way.
You need to be able to describe the energy shifts involved in each type.

You need to know advantages and disadvantages of each one. You don't need to learn these, just think about it a it.</td></tr>
<tr><td>• describe the environmental impact arising from the use of different energy resources</td><td rowspan="3">NEVER say "because it is good for the environment" or "its eco-friendly". You must say e.g. fossil fuels release CO2 which contributes to global warming".</td></tr>
<tr><td>• explain patterns and trends in the use of energy resources.</td></tr>
<tr><td>Descriptions of how energy resources are used to generate electricity are not required.</td></tr>
<tr><td>Students should be able to:
• consider the environmental issues that may arise from the use of different energy resources
• show that science has the ability to identify environmental issues arising from the use of energy resources but not always the power to deal with the issues because of political, social, ethical or economic considerations.</td><td>Good luck with any questions on this bit. Just say things that are sensible and you will get marks.</td></tr>
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