**Physics: 2. Energy and Energy Conversions**

***Please remember to photocopy 4 pages onto one sheet by going A3→A4 and using back to back on the photocopier***

**Syllabus**

**OP16** Classify sources of energy as renewable or non-renewable

**OP17** State the principle of conservation of energy

**OP18** Explain why the sun is considered our primary source of energy and how this is important in food production and energy supply

**OP19** List the advantages and disadvantages of different energy sources, including nuclear sources of energy, as part of the solution to national energy needs

**OP20** Identify different forms of energy and carry out simple experiments to show the following energy conversions:

1. Chemical energy to electrical energy to heat energy
2. Electrical energy to magnetic energy to kinetic energy
3. Light energy to electrical energy to kinetic energy

**OP21** Give examples of energy conversions from everyday experience.

**Student Notes**

**The sun is our primary source of energy.**

This means that almost of our energy came about either directly or indirectly from the sun.

For example fossil fuels were formed from decaying plants and animals.

These plants and animals relied on the sun either directly (plants) or indirectly (animals eat plants or other animals that ate plants) for their survival. So essentially, fossil fuels contain the captured energy of the sun from millions of years ago.

**Conservation of energy**

**The principle of conservation of energy states that energy cannot be created or destroyed, but can only be converted from one form to another.**

**Question to make you think**

* + - 1. In the summer, why does leaving the fridge door open *not* cool the kitchen down?

**Sources of Energy: renewable and non-renewable**

Energy sources can be divided into two groups – renewable and non-renewable.

**A renewable source of energy can be replenished in a short period of time.**

**A non-renewable source cannot be replenished in a short period of time.**

Examples of renewable sources are solar energy, wind energy, wave energy etc (see table below)

Examples of non-renewable energy are fossil fuels (peat, coal, oil etc) which can take millions of years to form.

**Fossil fuels** are fuels that were formed from the remains of plants and animals that lived millions of years ago.

In Ireland 90% of electricity is generated by burning fossil fuels (compared to a European average of 50%).

We will study fossil fuels in detail in a Chemistry chapter later on.

**Nuclear energy** is energy stored in the nuclei of atoms.
It can cause a lot of problems if an accident occurs at a nuclear power station, but many people are in favour of it (including me) because our entire civilisation is in danger if we continue to use fossil fuels (because of Global Warming)

**Non-renewable energy sources**

|  |  |  |
| --- | --- | --- |
| **Original source** | **Advantages** | **Disadvantages** |
| Fossil fuels  | Fuel can be storedRelatively cheap | Increases Global Warming Limited supply of fuel available |
| Nuclear energy | Very little greenhouse gas emissionsYou can get a lot of energy from a very small amount of fuel | Possibility of nuclear accidentsNot easy to dispose of the waste |

**Renewable energy sources**

|  |  |  |
| --- | --- | --- |
| **Original source** | **Advantages** | **Disadvantages** |
| **Solar energy** | Costs little to run | Expensive to install first dayNot always available |
| **Wind energy** | Costs little to run | Expensive to install first dayNot always available |
| **Hydroelectric energy** | Costs little to run | Expensive to install first day |
| **Wave energy** | Costs little to run | Expensive to install first dayNot always available |
| **Tidal energy** | Costs little to run | Equipment can be damaged in storms |
| **Biomass energy** | Costs little to run | Requires a lot of land |
| **Geothermal energy** | Costs little to run | Expensive to install first day |

 **Energy Conversions**

The most useful form of energy is electrical energy. This is because it can be changed into other forms easily, e.g. electric to motor to move things, electric to heat, electric to sound, electric to light.

|  |  |
| --- | --- |
| **Appliance** | **Energy Conversion** |
| Electric heater | Electricity to Heat |
| Speaker | Electricity to Sound |
| Light-bulb | Electricity to Light |

**Potential Energy and Kinetic Energy**

Another way of understanding energy is to divide energy up into two separate categories: potential energy and kinetic energy.

**Potential energy is energy that is stored, i.e. the energy can do work if released.**

Examples of potential energy are a stretched string, water at the top of a dam and chemical energy in a battery.

**Kinetic energy is energy that is associated with movement, i.e. anything that is moving has kinetic energy.**



**Experiments**

1. **Chemical energy to electrical energy to heat energy**

An electric circuit consisting of a battery connected to a light-bulb or heater.

Switch on the circuit and note the temperature rising using a thermometer.

1. **Electrical energy to magnetic energy to kinetic energy**

Use an electromagnet (a coil of wire wrapped around a nail, connected to a battery) to pick up some nails.



1. **Light energy to electrical energy to kinetic energy**

Connect a solar panel to an electric motor which turns when light shines on the solar panel

**Did you know???**

Almost all the matter around us (and from which we are made) was originally produced in one or more exploding stars – you are, quite literally, star stuff.

Now within our sun millions of tonnes of matter are disappearing every second

This as a result produces energy which we call radiation (or just ‘sunlight’) and it is this energy which is used to grow food.

So it is entirely correct to assert that, when next you are eating an apple, you are, quite literally, eating part of the sun!

**Exam questions**

**Renewable and non-renewable energy**

1. [2011]

Give two examples showing that the sun is our primary source of energy.

1. [2001 OL][2008 OL][2012 OL]

Pick two forms of renewable energy from the list on the right.

|  |
| --- |
| Coal |
| Oil |
| Solar |
| Tidal |

1. [2009 OL] Pick two forms of non-renewable energy from the list on the right.
2. [2007 OL][2007]

Nuclear energy could be used to solve Ireland’s energy shortage.

Give one advantage and one disadvantage of using nuclear energy to generate electricity.

1. [2008]

Some equipment can convert the energy of waves in seas into electrical energy.

Give one advantage and one disadvantage of generating electrical power in this way.

1. [2009]

Give one advantage or one disadvantage of fitting solar panels to your home.

1. [2006]

Suggest two alternative sources of energy (instead of fossil fuels) for the generation of electricity in Ireland.

1. [2008]
2. Name the energy from the sun that the solar panel changes into electricity.
3. The electrical energy is then changed into a form of energy that can be stored in a battery Name the form of energy that can be stored in a battery.
4. In winter it may be dark when the pupils are going to or coming from school.

Give two energy conversions that occur to produce the flashes of light warning motorists approaching the school on dark mornings.

1. [2010]

Light, from the sun is a renewable source of energy.

Ireland only uses about 2% renewable sources to meet current energy needs.

1. Name two renewable energy sources, excluding sunlight, that are available in Ireland.
2. Give two benefits that Ireland would get from increasing the use of renewable energy sources to meet our energy requirements.
3. [2011]

Compact fluorescent lamps (**CFL**s), shown in the photograph, have a **Grade A** rating (efficiency rating).Electrical energy is converted into light and one other form of energy in bulbs.

1. Name this second form of energy.
2. Which form of energy does the more efficient bulb produce more of?
3. Name another electrical appliance where checking the energy efficiency rating would be important to save money on running costs.
4. [2012]

Renewable energies are shown in the picture.

1. Pick any two of the energies shown in the picture and name your selection.
2. Give one advantage associated with each energy you’ve selected.

Two different reasons must be given.

1. Give one disadvantage associated with each energy you’ve selected.
Two different reasons must be given.

**Energy Conversions**

1. [2006 OL]

Energy cannot be created or destroyed but it can be changed from one form to another e.g. chemical energy can be converted into heat energy.

Describe an experiment you could carry out to show the conversion of chemical energy to heat energy.

Draw a labelled diagram of any equipment used.

1. [2008 OL]

The diagram shows a common light bulb.

List the two main energy changes that take place when the bulb is in use.

1. [2011 OL][2010 OL]

When each of these appliances is used energy conversions take place.

|  |
| --- |
| Electrical to heat |
| Electrical to sound |
| Chemical to electrical |
| Chemical to heat |
| Heat to light |
| Potential to kinetic |



Copy the table into your copy and correctly match an appliance with an energy conversion that takes place when it is used. [Note: An appliance may be used more than once.]

1. [2006 OL]
Give an example from everyday life where electrical energy is converted to kinetic energy.
2. [2009]
Give two useful energy conversions that occur when a drill is being used.
3. [2008]

Fill in the missing words in both sentences.

1. The stretched rubber chord has \_\_\_\_\_\_\_\_\_\_\_\_\_\_ energy.
2. If the stone is released it will have \_\_\_\_\_\_\_\_\_\_\_\_ energy.
3. [2007]

When work is done energy is converted from one form to another.

Identify one energy conversion that occurred when a car brakes.

1. [2012]
The conversions of chemical energy to kinetic energy to potential energy occurs when you walk up a stairs.
Give two more everyday examples of energy conversions and the contexts in which they occur.

**Exam Solutions**

1. Light/ heat/ photosynthesis / food/ bio fuels/ wind/ waves/ fossil fuels/ light to electricity/ rain for hydropower…
2. Renewable: Any two of: Wind / solar / wave
3. Coal and oil
4. Advantage: no ‘greenhouse gas ‘emissions/ no carbon dioxide (CO2) emissions/ can produce large amounts of energy/ cleaner supply of electricity.

Disadvantage: devastation if a reactor erupts/ very long term storage of wastes/ wastes are radioactive (dangerous).

1. Advantage: renewable/ no pollution/ does not increase global warming/ secure energy source.

Disadvantage: energy of waves can vary/ storms could damage the device.

1. Advantage: to reduce fuel bills/ reduce CO2 emissions/ renewable/ ...

Disadvantage**:** expensive/ less heat absorbed in winter (on cloudy days)...

1. Biomass/ nuclear/ geothermal/ solar/ tidal/ wave/ wind/ hydroelectric.
2. Light or solar energy
3. Chemical
4. Chemical to electrical, Electrical to light
5. Hydropower/ wind/ tidal/ geothermal/ biomass/ infra red (IR) from the sun/ wave
6. Lower CO2 emissions/ less carbon tax/ energy security/ lower energy costs/ sell surplus electricity/ sustainable/ cleaner/ kinder to the environment…
7. Heat
8. Light
9. Fridge/ cooker/ TV/ computer…

Advantages

* Wind turbines emit no carbon dioxide (CO2) produced/ carbon dioxide (CO2) removed absorbed)/ carbon neutral/.
* Hydroelectric plants are long-lived
* Solar heating can provide hot water/ solar power panels supply electricity
* Tidal generators are submerged (their rotors turn slowly) (sea life is safe)/ wave generators are moored off-shore (just ‘bob up and down’)…

Disadvantages

* Wind turbines, in some areas, are objected to as unsightly (noise) (kill birds)
* Large solar power plants use a lot of water (need huge area) the rest of this list also applies to solar heating (direction of the sun changes) (changes in seasons) (day to night) (cloud cover )
* The construction of hydroelectric plants can cause dislocation of people (release of large amounts of carbon dioxide due cement production required)
* Biomass uses land that could be used for food production (uses food crops to make biofuels)…

do not accept: ‘expensive’ or ‘not expensive’ for (i) or (ii), a definition of renewable energy for (i) e.g. ‘will not run out’. Look for: items (i) & (ii) specific to candidate-selected energies.

1. Nut (some combustible material) ignited / lighting Bunsen burner

Heating something (e.g. beaker of water)

Method of detecting (proving that it is) heating e.g. thermometer

OR

Circuit containing battery and heating coil (bulb)

Heating something e.g. container of water

Method of detecting (proving that it is) heating e.g. thermometer (bulb feels hot)

1. B: Electrical to light / electrical to heat / heat to light
2. Electrical to heat: Kettle [accept radio]

Electrical to sound: Battery powered radio

Chemical to electrical: Battery powered radio

Chemical to heat: Bunsen burner

1. Electric car / Drill/ Device containing electric motor
2. Electrical (electric) to magnetic
3. Magnetic to kinetic
4. Potential/ stored
5. Kinetic
6. Kinetic to heat/ kinetic to sound.
7. Falling down the stairs: potential energy to kinetic energy and sound energy/

Car: chemical energy to kinetic and heat energy/

Photosynthesis: nuclear energy to light energy to chemical energy/

Washing machine: electrical energy to heat, kinetic and sound energy/

Respiration: chemical energy to heat energy and kinetic energy…

**Energy: General Questions**

1. Why is electricity a convenient form of energy?
2. State the principle of conservation of energy.
3. What is meant by non-renewable energy?
4. Name a source of non-renewable energy?
5. What type of energy generates lightning?
6. Write down two *useful* changes that occur when a hairdryer is in use.
7. What is kinetic energy?
8. Give an example of electrical energy being converted to kinetic energy.
9. Name one renewable energy source that can be used in Ireland.
10. Why is this source considered to be renewable?
11. Give two ways of increasing the energy efficiency of a house.
12. Draw a diagram of an experiment to demonstrate electrical energy being converted to magnetic energy and in turn to kinetic energy.
13. Describe how to make a electromagnet.
14. Give two ways of increasing the strength of an electromagnet.
15. Complete the table.

|  |  |
| --- | --- |
| **Energy Conversion** | **Example** |
| Kinetic to Heat | Rubbing your hand along a desk |
| Chemical to Heat |  |
| Potential to Sound  |  |
| Light to Electric |  |

|  |  |
| --- | --- |
| **Instrument** | **List *two* Energy conversions** |
| Electric drill |  |
| Solar panel |  |
| Battery-powered torch |  |

**Teaching *Energy and Energy Conversions***

**Syllabus:**

**OP16**

Classify sources of energy as renewable or non-renewable

**OP17**

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**OP18**

Explain why the sun is considered our primary source of energy and how this is important in food production and energy supply

**OP19**

List the advantages and disadvantages of different energy sources, including nuclear sources of energy, as part of the solution to national energy needs

**OP20**

Identify different forms of energy and carry out simple experiments to show the following energy conversions:

a. chemical energy to electrical energy to heat energy

b. electrical energy to magnetic energy to kinetic energy

c. light energy to electrical energy to kinetic energy

**OP21**

Give examples of energy conversion from everyday experience.

**Introduction**

*Anyone who gives the impression that energy concepts are straightforward is either arrogant or ignorant or both.*

Energy must be one of the most difficult concepts to grasp in all of physics – probably because it lies at the heart of physics itself.

It doesn’t help that the legacy of many of the old ways of looking at energy are still with us.

This is caused in part by the separate sub-divisions of science/physics having their own interpretations of energy, and therefore their own terminologies.

This was back before scientists realised that all energy is inter-connected, which led to the principle of conservation of energy.

1. **Syllabus: Classify sources of energy as renewable or non-renewable**

This is relatively straightforward, although it could be argued that power from the sun will eventually ‘run out’, but I think for the purposes of this syllabus we can consider that it’s not going to run out before we do. Nuclear energy is a little trickier. Technically the fuel for nuclear *fission* is non-renewable, while fuel for nuclear *fusion* can be considered to be renewable. For exam purposes I think we can assume nuclear energy to be renewable.

Start with what do we mean by renewable /non-renewable energy.
Get the pupils to decide which of the following are renewable and which are non-renewable.

* In a dish, burn some ethanol / hexane or similar
* Blow into a fan & light a bulb
* Cover / uncover a light cell
* Suspend a magnet by a spring within a coil of wire attached to a galvanometer
* Try a fruit battery
1. **Syllabus: State the principle of conservation of energy**

While this may seem straightforward, and can indeed be ‘learned off’, it would mean passing over the opportunity to discuss one of the foundation stones of science itself. What this means is that at the moment of ‘the Big Bang’ a certain amount of energy was created and this amount has not increased or decreased one iota in the last 13.6 billion years between then and now. Now the textbooks don’t mention this (at Junior Cert or Leaving Cert) but we really have no idea why this is, but depending on your point of view this can be simply incredulous, unbelievably confusing or unbelievably wonderful (or, I suppose, all three).

So every time you lift your hand you are using energy which originated 13.6 billion years ago.

It’s also interesting to note that due to the the Conservation of Energy, you can’t actually ‘waste’ energy; it just gets converted into less useful forms, and usually ends up heating the air around us by a tiny amount.

1. **Syllabus: Explain why the sun is considered our primary source of energy and how this is important in food production and energy supply**

Most of our energy can be traced to the sun (the sun provides heat and light which allow food to grow, some of which gets eaten directly, more decays to peat, coal, oil, etc).

1. **Syllabus: List the advantages and disadvantages of different energy sources, including nuclear sources of energy, as part of the solution to national energy needs**

This is a wonderful opportunity to introduce global warming, but for reasons outside my ‘kin the concept itself does not need to be understood. It would be nice to blame others for this, but I suspect a large portion of responsibility lies with us as professional teachers; if we can’t be bothered to make any noise about it, why should anyone else?

1. **Syllabus: Identify different forms of energy and carry out simple experiments to show the following energy conversions:**
2. **chemical energy to electrical energy to heat energy**
3. **electrical energy to magnetic energy to kinetic energy**
4. **light energy to electrical energy to kinetic energy**

The best approach is to put all the resources out on the benches and let the students move between them, taking down diagrams and noting the energy conversions involved with each demonstration, along with answering any relevant questions from the work-book.

* 1. **chemical to electrical to heat**

There is a tray of calorimeters available in the Resource Room.

* 1. **electrical to magnetic to kinetic**
* There is a tray of electromagnets available in the Resource Room.
* Note that you could repeat this activity when covering the chapter on Magnetism
* If you are making electromagnets remember that you must use enamelled wire which is insulated and prevents the current simply running along the top of all the wires. The sections should be sanded however to remove this insulation material for connection.
* The textbook suggests using batteries but these run down very quickly so I would use power-packs instead.

**Precautions when using power-supplies**

1. It must be direct current (d.c.).
2. Keep the voltage fairly low.
3. Notice that the electromagnet gets stronger (and the wire heats up) as the voltage is increased. This is because the power supply is producing a larger current which in turn has a larger magnetic field associated with it.
4. These power-packs are fairly robust and the greatest danger with them here is that they will heat up the wire which may cause burning.
5. The fuse in the power-supply will ‘trip’ if the voltage is too high so try to ensure the voltage is kept below this value.
	1. **light to electrical to kinetic**

Solar panel connected to an Electric Motor

There should be one or two of these available in the Energy Resource Box, and I have another one in my lab.

1. **Syllabus: Give examples of energy conversion from everyday experience.**
* Stress the idea that electrical energy is the most useful because it can be converted relatively easily to all other forms.
* Ask students to learn examples of electric to sound (a speaker), electric to heat (a kettle), electric to light (light-bulb), electric to kinetic (a motor) etc.
* Ask each student to bring in something which contains energy / demonstrates an energy conversion and have a prize for the best/most origianl idea.

**Confusion with the terms “Potential” and “Kinetic” energy**

It’s not surprising that this causes confusion. The tendency in many text-books (and indeed exam papers) is to divide energy into categories like *potential*, *kinetic*, *sound*, *heat* etc., when in fact *potential energy* and *kinetic energy* are more like umbrella terms, i.e. you could say that all energy is either potential or kinetic.

Examples of Kinetic energy are sound and heat because they involve the movement of molecules.

Examples of Potential energy would be a stretched string, or perhaps an electrical battery.