Switch on STEM

ENGINEERING

Electricity & Magnetism

Background

- This activity is designed to allow the students to explore the forces of electrostatics and magnetism and learn about their practical application in the generation of electricity. There are a number of interactive devices that allow students to observe and manipulate objects using electrostatic and magnetic forces including: The Levitron, magic penny kit and the FunFlyStick. A demonstration of the generation of electricity is provided using a generator demo kit. Information and discussion on sources of renewable energy sources to generate electricity is also included as part of the activity.

Learning outcomes

- On completion of this task student will be able to:
  - Identify and explain electrostatic and magnetic forces
  - Hands-on experience of manipulating objects with electrostatic and magnetic forces
  - Identify the key components of an electrical generator
  - Identify sources of energy to produce electricity and distinguish between renewable and non-renewable sources

Equipment - Kit

- FunFlyStick
  - Cost for 5 total €116.83
  - Available from GrandIllusions.com
- Magic penny kit
  - Cost for 2 kits €47
  - Available from GrandIllusions.com
- Levitron Ultimate
  - Cost €59
  - Available from GrandIllusions.com
- Eisco hand cranked generator
  - Cost €98
  - Available from Amazon.com

FunFlyStick Kit

The FunFlyStick is a wand that produces an electric field to keep an object floating in the air based on electrostatic repulsion. The electrostatic charge is produced by a small Van der Graaf generator inside the wand when the button is pressed.

- It is used to demonstrate electrostatic forces

- To see what the kit does see the website: http://www.grand-illusions.com/acatalog/FunFlyStick.html
- The kit contains the items displayed in the picture. The objects that the stick keeps in the air (on the right) are in the booklet. The stick itself is stored in two pieces that can be easily connected. Each flystick requires 2 AA batteries. Further instructions are in the booklet.

Magic penny kit

- The kit contains an activity booklet, bag of pennies and 2 strong magnets
- The activities documented in the booklet are to demonstrate magnetic forces
- See what the magic penny kit does on the Grand Illusions website
  http://www.grand-illusions.com/acatalog/Magic-Penny-Kit-693.html
- NOTE the magnets in this kit are strong and care needs to be taken not to get fingers caught between the magnets when they are configured to attach to each other. Students must be informed of this when handling the kit.

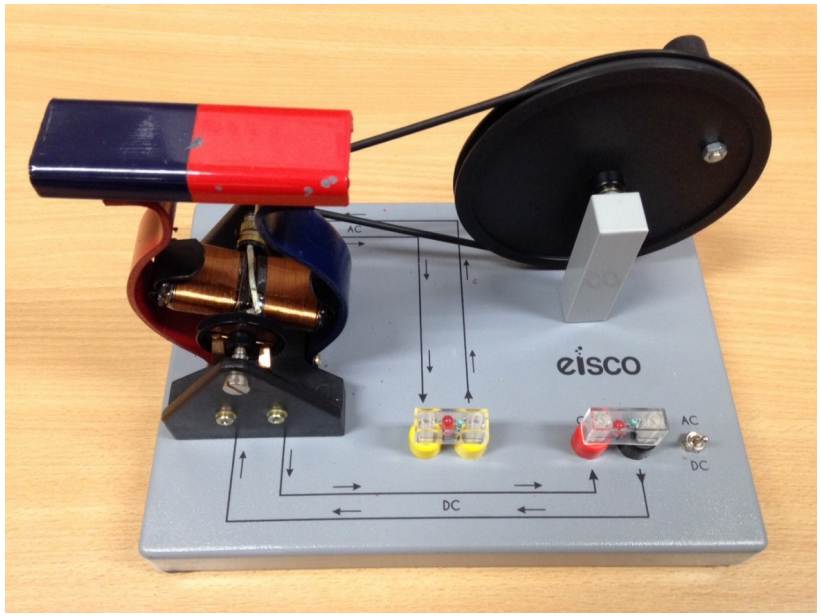
Levitron Ultimate Kit

- The Levitron demonstrates magnetic forces by balancing a spinning top in mid air
- What the Levitron does, by Grand Illusions: http://www.grand-illusions.com/acatalog/Levitron-Ultimate-692.html

- NOTE This kit takes practice to be able to use. There is a 'knack' to operating it which needs to be practiced to be acquired. The photo on the right depicts the starting point for setting the top spinning. After setting the top spinning, you raise the plastic stand slowly until the magnetic field lifts the top up. The base has adjustable legs that must be set so the magnetic field is vertical, if it is not set correctly the top will fall to one side when it lifts.
- Further instructions on the use of the Levitron are in the accompanying booklet.

Eisco generator demo model

- What is the Eisco generator demo?
  - The model is a hand cranked generator that produces electricity from the hand cranked wheel. This in turn lights the LED to show the flow of current.
  - Information and diagrams can be found in the booklet with the kit.
  - Further information can be found at http://www.eiscolabs.com/Store/Product/PH1245N8



Equipment Consumables/Stand

- Consumables
  - 2 AA batteries are required for each of the fun fly sticks
  - Fun fly stick refill packs are also available for when the objects that it floats are destroyed
- Stand
  - Table and chairs
  - Poster and poster stand

Preparation

- Review documentation on demonstration and background information
- View videos on each kit at the links provided
- Familiarise yourself with the contents of the demonstration and the equipment to be used
- Try using each piece of kit for familiarity and check the booklet is with each kit
- Practice using the Levitron

Demonstration

- Outline that in this activity you will be discussing and demonstrating electrostatic and magnetic forces and ultimately how electricity is generated.
- Ask the students if they know what electrostatic forces are and what they know about them?
  - If students can explain this let them proceed
  - If they are unsure provide the answer – a force exists between two electrically charged objects and is called an electrostatic force. Objects with the same charge repel each other and objects with opposite charge attract. Charged objects create an electric field which in turn produces a force.

Demo the FunFlyStick

- Identify the FunFlyStick and point out where the button is and how to arrange the object that you wish to manipulate/levitate with the flystick.
- Demonstrate it working.
- Allow the students to have a FunFlyStick and challenge them to keep the object levitated using the FunFlyStick.
- Ask them if they can explain the how the flystick works. Prompt them to consider electrostatic forces if they are unsure. Provide the answer of electrostatic repulsion between the wand and the object. The wand becomes electrically charged from a small generator powered by the battery.
- Ask the students if the electrostatic force between the wand and the floating object is stronger then the force of gravity on the object?
  - Answer – the electrostatic force is stronger then gravity when it is close enough to cause the object to rise.

Demo the magic penny kit

- Identify the magic penny kit and the items in the kit – identify the arrows on the end of the magnets which aid identifying the orientation of the magnetic poles.
- Mention that care should be taken not to get fingers caught between the magnets as the magnets are strong.
- Ask the students if they can explain what magnetic forces are?
  - If the students can provide an answer let them explain, otherwise provide the answer.
  - Answer – magnetic forces are produced by electrically charged objects that are moving and by magnetic objects. Magnets have north and south poles. Like poles repel and unlike poles attract.
  - Ask the students to identify everyday objects. Example answer – a compass. Ask if students can explain how a compass works.
- Challenge the students to demonstrate magnetic attraction and repulsion with the magnets
- Challenge the students to make a chain of swinging pennies as illustrated on page 37 of the magic penny kit booklet. See which team can get the longest chain of pennies.

Demo Levitron

- While students are working with the magic penny kit get the top balanced on the levitron
  - Please note that this takes time and practice and will not work on a first attempt
  - You should prepare this beforehand and ensure that the magnetic base of the levitron is appropriately balanced to allow it to work, if not the spinning top will keep falling to the side.
- When it's working invite students to observe it and place their hand between the top and the magnet to see that it is suspended in mid air
- Ask the students what force is keeping the spinning top in mid air
  - Answer magnetic force – although the configuration is unstable when the top is not spinning and it cannot sustain the top in mid air. When the top is spinning it is stable and the magnetic force is sufficient to keep the top suspended in mid air.

Demo the Eisco generator model

- Explain to the students that electricity can be generated by getting magnetic and electric fields to interact, which requires motion
  - This is more precisely stated in Faradays law. A simple summary: a changing magnetic field causes a current to flow in a wire. The motion in the generator causes the changing magnetic field that induces a current to flow.
- Show the students the generator model and identify key components the hand crank (to turn the wheel), the coiled wire and the magnets.
- Explain that when a coil of electrically conducting wire is rotated in the presence of a magnetic field it causes electrical current to flow
- Ask the students what electrically charged sub atomic particle flows when electricity is produced
  - Answer – the electron which has a negative charge. Also note that a flowing current produces a magnetic field.

Demo the Eisco generator model

- Explain the components of the model and explain that turning the hand crank will cause electricity to flow in the circuit as depicted on the base of the model (see model booklet for labelled diagram)
- Turn the hand crank and point out the LED lighting, which shows that current is flowing
- State that the generator can be configured to produce alternating current (AC) or direct current (DC) and show them the switch on the model
- Ask them if they can explain the difference between AC and DC current
  - Answer (brief version) – Direct current is held at a constant level whilst AC current varies in a waveform alternating between positive and negative. Demonstrate a sinusoidal type wave to explain how it varies. Note the diagrams in the generator model booklet may help to explain this.

Demo the Eisco generator model

- Ask which type of current you get from a battery AC or DC
  - Answer DC
- Ask which type of current you get from a power socket
  - Answer AC
- Explain that almost all electricity generated in the world today comes from generators consisting of the same basic components but on a much larger scale, so that the energy demands of a whole country or region can be met.
- Ask how the motion is provided to create the rotation when electrical power is being generated.
  - Answer - a number of sources exist including hydro electric power and steam generated power from burning fossil fuels. With steam powered generators the motion is generated from steam, which turns a steam turbine, which in turn causes the rotations within the generator and produces electricity. Steam created by burning fossil fuels is currently the primary source in Ireland, in 2013 it was created from the following fuel sources - 47.9% natural gas, 22% coal, 11% oil and 12.7% renewable (with a small remainder imported that particular year)

Sources of energy for electrical generators

- Ask the student what the issues are with burning such large amounts of fossil fuel to provide the electricity required by the country
  - Burning fossil fuels creates emission that are bad for the environment, notably CO_2 , in addition to this it is an expensive and non-renewable source of energy.
- Ask the students what is renewable energy and if they can provide some examples of renewable energy
  - Answer – Solar, wind energy, hydro-electric and wave energy are the main sources. Other power sources exist, see if the students can name them.
- Which renewable energy sources are most suited to Ireland?
  - Answer – wind and wave power as they are relatively abundant.

Take home task

- Challenge
  - Can students identify how much of the electricity generated in Ireland last year was produced from renewable sources? What are these renewable sources?
  - What is the target for Ireland in terms of renewable energy in the future?
  - Can students identify the benefit to the environment by switching to renewable energy sources instead of fossil fuels?

Links

- Excellent short video on Magnetisim:
- https://www.youtube.com/watch?v=GMnsZuEE_m8

- Excellent short video on the Electrostatic Force:
- https://www.youtube.com/watch?v=cy6kba3A8vY

- How to Make the World's Simplest Motor:
- https://www.youtube.com/watch?v=utJq81nB-3s