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| Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ( ) Class: \_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_   |  |  |  | | --- | --- | --- | | **Pirouetting Copper Coil**  *Student’s Handout* | | | | **Topic: Electricity and Magnetism** |  | **Estimated Duration: 2 hours** |  * **Aim**   This activity engages students through a phenomenon of electromagnetism to understand the underlying principles. The activity also develops students’ ability to do inquiry: asking questions, gathering evidence, formulating explanation based on evidence, evaluating explanation, and communicating the explanation.   * **Materials**   + Copper wire (approximately 0.5 mm diameter and 20 cm length)   + AA size battery (with battery holder)   + Neodymium magnets   + Connecting wires   + Switch   + Plotting compass   + Blu-tac * **Safety Precautions**   In this activity, you will handle very strong magnet which can damage watches, hard disks and other devices sensitive to magnetic field. The copper wire may become hot if setup is used for too long.   * **Procedures**  1. Consider the setup below:   copper coil  battery  magnets  plastic base    Predict, with reason, what will happen when the setup is completed.  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................   1. Proceed to complete the setup.   Safety: Remove the coil after observation to prevent the copper coil from getting hot.  Record your observation(s) and compare against your prediction.  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................   1. Write down possible questions that can be asked about the setup and observation.   ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................    **Key inquiry question:**   1. Dismantle your setup. Bring a compass near the magnets that were used in the setup.   Record and explain your observation.  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................   1. Setup the circuit below which will allow you to pass a current through a section of the copper coil used in the first setup. Place the compass on top of the copper coil as shown.   crocodile clip  compass placed on top of copper coil  battery in holder   1. Close the switch for a short time and open the switch again. Record your observation.   ..............................................................................................................................................  ..............................................................................................................................................   1. Compare this observation with the observation from step 4.   ..............................................................................................................................................  ..............................................................................................................................................   1. Using the observations from (4) and (5), explain the key inquiry question.   ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................   1. Read your textbook page \_\_\_\_ to \_\_\_\_. Use what you have read to modify your explanation from (6).   ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................   1. Present your answer (if you are asked to) and listen to the presentation of your classmates. Finalize your explanation from (7) based on the comments from your classmates and teacher.   ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................   1. Suggest a few possible applications of this effect.   ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  ..............................................................................................................................................  **Pirouetting Copper Coil**  *Teacher’s notes* | | | | |
| **Stream:** Express/ N(A) |  | **Topic:** Electricity and Magnetism |  | **Estimated Duration:** 2 hour |

* **Description of activity**

In this inquiry activity, students will predict the behaviour of an electromagnetic setup and formulate explanation based on evidence collected.

* **Key Idea**

A current-carrying conductor experiences a force in a magnetic field.

* **Aim**

This activity engages students through a phenomenon of electromagnetism (motor effect) to understand the underlying principles. The activity also develops students’ ability to do inquiry: asking questions, gathering evidence, formulating explanation based on evidence, evaluating explanation, and communicating the explanation.

* **Objectives** 
  + **Related Syllabus Learning Outcomes**
  + describe experiments to show the force on a current-carrying conductor in a magnetic field
  + explain how a current-carrying coil in a magnetic field experiences a turning effect
* **Skills and Processes**

This inquiry activity develops skills needed to perform inquiry as students make prediction about a setup, pose questions, use apparatus and equipment to collect evidence, draw conclusion from the evidence and communicate their conclusions.

* **Ethics and Attitudes**

In this activity, a visually captivating phenomenon (a simple motor made from commonly available items) is used to arouse the interest of students. This leverages on and fuels the spirit of curiosity of the students to get them to enjoy physics. As motors are used in many household appliances, students see the relevance and usefulness of physics in their daily lives.

The students also need to practice open-mindedness as their initial understanding is first challenged by new observations, then by established scientific knowledge and lastly by fellow classmates.

* + **21CC**

**CIT – Reflective Thinking:** One part of this lesson requires students to evaluate the explanation they have formulated about the electro-magnetic setup against established scientific knowledge. This essential feature of inquiry involves students to reflect on whether their explanation is supported or goes against established knowledge, and to make the necessary modifications. Through this, students develop the ability and willingness to think reflectively.

* **Prior knowledge**Students should be able to:
  + connect basic electrical circuits involving battery and switch
  + state the properties of magnets
  + state the presence of a magnetic field around a magnet.

In Lower Secondary Science, students learned about how interactions can lead to changes in a system. In this activity, their learning will be extended to include interactions of magnetic fields.

* **Materials**
  + Copper wire (approximately 0.5 mm diameter and 20 cm length)
  + AA size battery (with battery holder)
  + Neodymium magnets
  + Connecting wires
  + Switch
  + Plotting compass
  + Blu-tac
* **Suggested lesson guide**

| Assessment indicators | **LESSON ACTIVITY** | Pedagogical Considerations |
| --- | --- | --- |
| *Evidence of learning is shown when students are able to….*  Students are able to use their existing knowledge to make prediction.  Students are able to follow instructions and diagram to complete the setup. | **Engaging Students / Predict & Observe .**     * Given a diagram of an electromagnetic setup, students make prediction about what they will happen when the setup is completed. Teacher should encourage students to use what they have learned so far in physics to make prediction. * If the teacher feels that it is necessary, a sample setup can be used to supplement the diagram in the worksheet. The setup can be projected on the screen using a visualizer. * Students proceed to build the setup. The copper coil in the setup requires fine motor skills to make and can be quite difficult for some students. The teacher can prepare a few coils for students who face difficulties. However, perseverance is a science attitude that we want our students to have and they should only be provided with the pre-prepared coil after some attempts. * The students will then record their observations and compare their observations against their prediction. Remind students to remove the coil after observation to prevent the copper coil from getting hot. | Skills: Students exercise their prediction skill based on their existing understanding on moments, electricity and magnetism.  Ethics and Attitudes: Building the motor engages the students through an activity that is hands-on and visually captivating. This taps into the curiosity of the learners to want to understand what cause the wire to turn. |
| *Evidence of learning is shown when students are able to….*  Students are able to pose questions that can help them gain a deeper understanding of the phenomenon, e.g. ‘what cause the copper coil to turn?’. There are questions which are still worth asking and answering but do not offer much opportunity to probe deeper, e.g. ‘will the coil still turn if there is no magnet?’. | **Beginning Inquiry with scientific question..**   * Students write down possible questions about the setup and their observation from the previous step. Some questions that students may ask are:   + What cause the copper coil to turn?   + What is the purpose for having magnet?   + Will the coil still turn if there is no magnet?   + Is the circuit close? * For students who are more used to providing answers to questions rather than coming out with questions, this section can be challenging. To help them, the teacher can first explain that good scientific questions are questions that can be investigated and explained using evidence. Students can then use this as a guide to come out with questions. * Teacher provides key inquiry question: “what cause the copper coil to turn?” Teacher should affirm the efforts by students to come out with possible questions to inquire. However, the focus of the lesson will be this key inquiry question. | EF1: Students are engaged in scientifically oriented questions. Having students pose questions at the start highlight to students that scientific inquiry usually begins with a question to be answered.  (EF: Essential Feature of Inquiry)  Skills: Students may not be able to come out with good questions but they should be allowed to make attempts. For students to develop ability to ask questions, they must be given opportunities to do so.  21CC**:** Students learn to define problems as they attempt to identify questions that need to be answered;  The key inquiry question provides the focus of the rest of the activities. Providing the question makes the inquiry more teacher-directed but simplifies the logistic preparation. |
| *Evidence of learning is shown when students are able to….*  Students are able to use the correct science terms such as ‘deflection’ and ‘magnetic field’ to describe and explain the observations. They are able to make a good comparison by highlighting the similar effect. | **Gathering Evidence .**   * Students observe and record the effect of the magnets and current on a compass. The students will then compare the effects. Teacher may need to help the students see that the current carrying conductor produces a similar effect on the compass. Teacher can then ask if it is possible that the current carrying conductor produces a magnetic field.   Teacher should take this opportunity to highlight the significance of this step. Scientific explanations are based on evidence; explanations which are based personal beliefs or myths are not scientific. | EF2: Students give priority to evidence that will allow them to formulate scientific explanations. In the most student-directed inquiry, students need to decide the evidence that need to be collected. In this exercise, a more guided approach is used. Students are directed to collect certain evidence.  (EF: Essential Feature of Inquiry)  21CC**:** Students practice openness as they obtain and respond to new information that may not match their existing understanding. |
| *Evidence of learning is shown when students are able to….*  Students are able to formulate a logical explanation of the inquiry question based on the evidence collected. If a student explains that the coil turns because of electricity through it, the student has not made use of the evidence on magnetic field. | **Formulating Explanations .**   * Students construct an explanation based on the observations made. The explanation is the link between the evidence and the effect – this requires students to describe how the evidence (both magnet and current have magnetic field) lead to the effect (the coil turning). The explanations must be consistent with experimental and observational evidence. An example of explanation: “Because the magnet has magnetic field and the current produces another magnetic field, a force is produced to turn the copper coil. This is the same as two magnets which have magnetic field repelling each other”.   This part requires students and teachers to tolerate ambiguities as the students’ explanations may vary from the standard and scientifically accepted explanation. It is not uncommon for scientists to formulate an initial explanation based on the evidence and knowledge they have at hand and make modifications as new evidence emerges. | EF3: Students formulate explanation(s) based on evidence. As students formulate explanation, they need to use logical reasoning and tap into their existing knowledge. This process involves constructing new knowledge about what is unfamiliar from what is observed and what is known. This process is often bypassed in traditional science lessons.  (EF: Essential Feature of Inquiry)  21CC**:** Students practice sound reasoning as they construct explanations based on evidence. |
| *Evidence of learning is shown when students are able to….*  Students are able to use the knowledge in the textbook to improve their explanations. | **Evaluating Explanations .**   * Students consult their textbooks (section on force on current carrying conductor in a magnetic field; about 3 pages) to evaluate their explanations for correctness and completeness. By doing so, they connect their explanations to established scientific knowledge. They will then make the necessary addition or modification to their initial explanation. * Teacher can explain that evaluation and possible revision of explanations is a common feature of scientific inquiry. After scientists make an initial explanation, they have to check if this explanation contradicts existing scientific knowledge. | EF4: Students evaluate their explanations. Asking students to read the textbook after they have formulated an explanation for the phenomenon makes the effort more focused and meaningful.  (EF: Essential Feature of Inquiry)  21CC:Students practice reflective thinking as they evaluate their explanations against existing scientific knowledge. |
| *Evidence of learning is shown when students are able to….*  Students are open to give/receive comments to/from other students.  Students are able to explain that the copper coil turns because of the interaction between the magnetic field of the magnet and the current. | **Communicating Findings and Explanations .**   * Teacher selects students to share their findings and explanations with other students should be given opportunities to comment. The teacher should guide students towards the established explanation. The students will then make the necessary addition or modification to their explanation.   Teacher can explain that scientists communicate their explanations for other scientists to evaluate and reviewed. The comments can help to affirm that the validity of the explanation, and identify wrong and alternative reasoning. | EF5: Students communicate their findings and explanations. Sharing explanations provides students opportunities to ask questions, identify faulty reasoning and statements that go beyond evidence.  (EF: Essential Feature of Inquiry)  21CC: Students practise effective communication as they present and defend their findings and explanations. As they communicate their findings and explanations to be critiqued by fellow students, they learn to take risk.  Ethics and Attitudes: Students learn to be objective and open-minded as they listen to other’s views which may be different from their own. |
|  | **Conclusion**   * Teacher can extend the learning by asking students to suggest possible applications for this effect. * Teacher can then reveal to students that the setup is actually a simplified version of the motor which is used in many common household appliances such as electric fans. |  |

* **Suggested answers to activity**

(2) The copper coil starts to turn.

(3) Some questions that students may ask are: What cause the copper coil to turn? How to make the copper coil turn faster? Will the coil still turn without the magnet?

(4) The compass needle will deflect. There is a magnetic field around the neodymium magnets which cause the compass needle to deflect.

(5) The compass needle will deflect. In both step 4 and step 5, the compass needle shows a deflection. Therefore, the current could have produced a magnetic field too.

* **References**

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* Washington, D.C.: National Academic Press.