Electromagnetic Induction Lesson Plan

Akmal bin Abd Rahman

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Contents

1 Introduction

Subject: Physics

Topic: Electromagnetic Induction

Targeted Group: Secondary Four Express

Learning Environment: Classroom equipped with whiteboard, computer able to play multi-media files and projector

1.1 Lesson Objectives

At the end of the lesson, students should be able to:

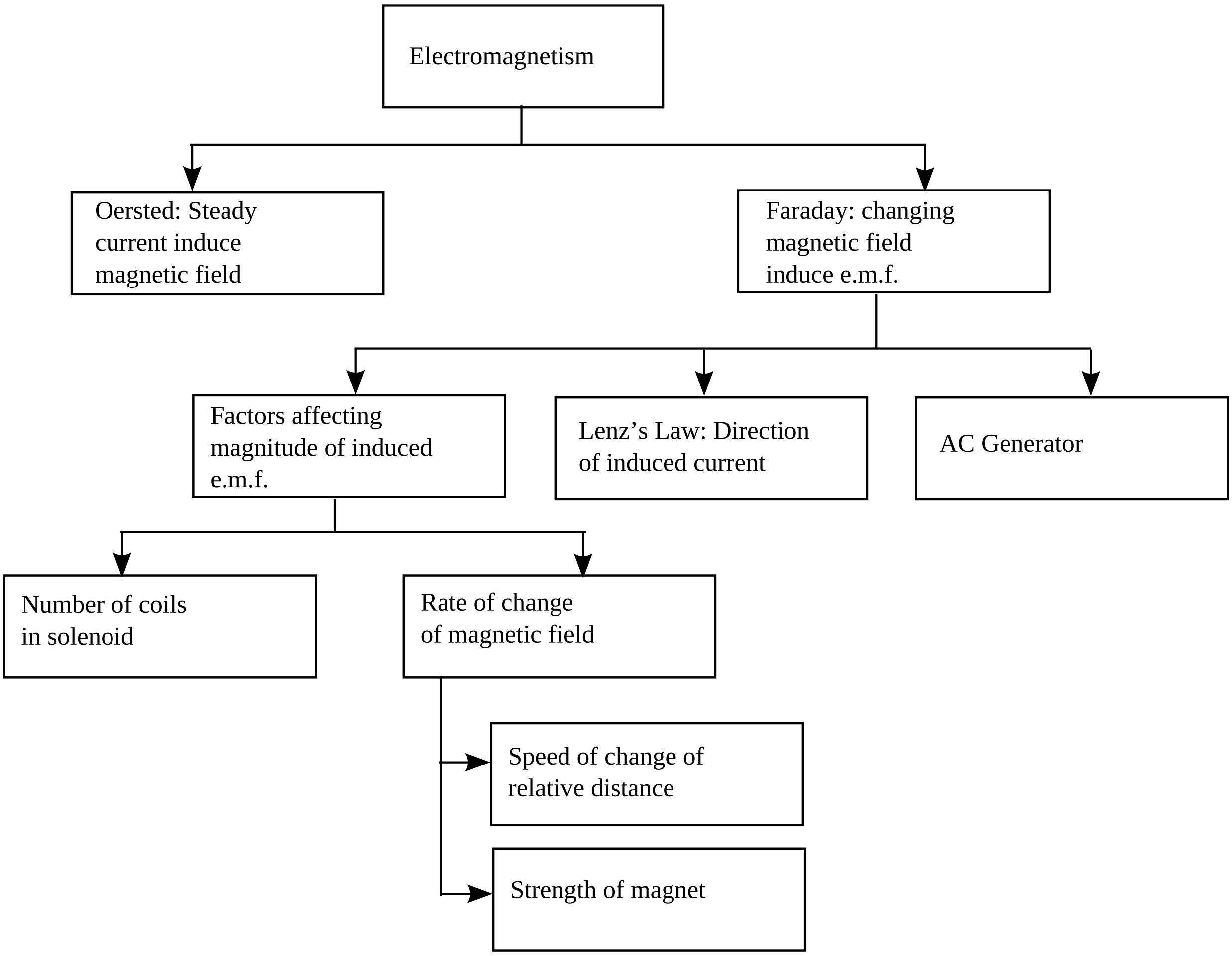
- deduce from Faraday's experiments on electromagnetic induction:
  - that a changing magnetic field can induce an electromotive force(e.m.f.) in a circuit
  - that the direction of the induced e.m.f. opposes the change producing it
  - the magnitude of the induced e.m.f. is:
    * directly proportional to the rate of change of magnetic field
    * directly proportional to the number of loops in the solenoid
- describe a simple form of a.c. generator
- sketch a graph of voltage output against time for a simple a.c. generator

1.2 Prior Knowledge

Students should be able to:

- explain e.m.f. as the work done by a source in driving a unit charge around a complete circuit
- draw the pattern of the magnetic field due to currents in straight wires and in solenoids
- state the effect on the magnetic field of changing the magnitude and/or direction of the current
- describe experiments to show the force on a current-carrying conductor and on a beam of charged particles, in a magnetic field and the relative directions of force, field and current when any two of these quantities are at right angles to each other, using Fleming's left hand rule

1.3 New Concepts



1.4 Learning Difficulties

Electromagnetism is an abstract concept that is difficult to fully grasp due to the non-intuitive notion that electricity can induce magnetism and vice versa. This is above and beyond the fact that both the topics electricity and magnetism are only recently taught to the students and they also involve abstract concepts of e.m.f. and fields.

Therefore, the focus of the lesson will be on concrete examples to convince the students on the validity of the phenomenon. The factors that determine the magnitude of the induced e.m.f. should also be demonstrated in a qualitative manner: i.e. rate of change of magnetic field and the number of coils in the solenoid.

To further help students appreciate the concept, the teacher could also use the humanist approach and bring in the main characters in the discovery of electromagnetism: Hans Christian Ørsted and Michael Faraday. The teacher could also highlight the fact that Faraday did not know much mathematics, having little formal education, but yet could discover such complex concepts.

When introducing the generator, emphasise to the students that this is the primary means of producing electricity in the world; whether in coal-powered power stations, hydroelectric dams, or even nuclear reactors.

1.5 Resources

- Real Player video demonstration of levitating coil taken from `http://ocw.mit.edu/OcwWeb/Physics/8-02Electricity-and-MagnetismSpring2002/CourseHome/index.htm`

2 Lesson Presentation

2.1 Set Induction/Trigger Activity

- Declare to the students that they are going to watch some magic; they will see a person (specifically a woman) levitate.
- Show video of levitating person (starting from 48:45). Also show alternative video of levitating coil (starting from 44:00)
- Seek the students' responses. Why did they think the coil levitated? It is not simply electromagnetism because if the coil is an electromagnet, it will attract to the metal plate and not repel it.
- They did not see a mysterious demonstration by a magician, but an openly technical demonstration by a physics professor at MIT. This is not unexplainable phenomenon but a result of physical phenomenon of electromagnetic induction which they will learn.

2.2 Lesson Development

Time (min)	Teaching and Learning Activities	Materials	Rationale
5	• Show a video demonstration of levitating woman as the trigger activity discussed above.	Real Player video	• Show an interesting and non-intuitive demonstration to trigger students' interest. • Begin to set the stage for further discussions on electromagnetism.
5	• Revisit Hans Christian Øersted's discovery(1820): that a steady electric current produces a steady magnetic field. • Emphasise the mind-boggling nature of this discovery. Two previously separate domains - (a) *electricity*: current, batteries, lightbulbs and (b) *magnetism*: compass, magnetic holders - are now discovered to be closely related. • But now that it has been known to happen, people began asking about the reverse: can a steady magnetic field in turn induce a current?	Slides	• Recall students' previous knowledge in electromagnetism and establish a link between the two topics again. It prepares the students for further discoveries in the relationship between electricity and magnetism. • Reveals historical motivation in discovery of electromagnetic induction.

Time (min)	Teaching and Learning Activities	Materials	Rationale
10	• One of the people who investigated this phenomenon was Michael Faraday who, in 1831, discovered electromagnetic induction. • Introduce experimental setup consisting of a solenoid which will create a magnetic field and a loop of wire around it with a galvanometer to detect current. Faraday had created a similar setup in his experiments. • When Faraday switched on his circuit, there was no steady current. • But Faraday noticed that there was a small deflection in the galvanometer at the instant he switched on and off his circuit. • Ask for students' opinions on the cause of this deflection. As a hint, ask the students what *changes* occur at this instance. • Conclude that it is not a steady magnetic field that will induce current, but a changing magnetic field. • Extend the idea of induced current to induced e.m.f. Recall the students' knowledge from current electricity that current only flows in a circuit if there is an e.m.f. So in other words, an e.m.f. that has been induced.	Experiment setup Slides	• Reconstruct Faraday's discovery starting from the initial failure to the attention paid to the momentary deflection. The crucial ingredient in Faraday's breakthrough was a split-second observation. • Highlight that e.m.f. is induced only in a changing magnetic field and not a steady magnetic field in a concrete way so that students can internalise the knowledge more easily.

Time (min)	Teaching and Learning Activities	Materials	Rationale
10	• **Lenz's Law** • Ask the class why the current induced flows in one direction when the magnet moves towards the solenoid and flows the other direction when the magnet moves away from the solenoid. Demonstrate this by showing the galvanometer deflecting in opposite directions. • Alternatively, demonstrate having the North pole and South pole of the magnet approach the solenoid respectively. The direction of the current induced will be different. • Group students into pairs to work on worksheet. The worksheet will prompt the students to devise a thought experiment. By following the consequences of the current flowing in one direction versus the other, the students will discover that one of the choice will lead to an impossibility. Connect it to the Law of Conservation of Energy. • Conclude that the induced e.m.f. always gives rise to a current whose magnetic field opposes the original change in magnetic flux.	Experiment setup Slides Worksheet	• Show concrete demonstration of Lenz's Law at work using two alternative experiments to emphasize the deliberateness of direction of induced current. • By working in pairs, students will be able to help each other reason out Lenz's Law (Vygotsky). By articulating their reasoning to each other, they will be able to internalize the concept easier.

Time (min)	Teaching and Learning Activities	Materials	Rationale
10	• **Factors Affecting the Magnitude of the Induced e.m.f.** • Ask students how to increase the magnitude of the induced e.m.f. • Demonstrate moving the magnet towards the solenoid at a slower and faster speed. This will change the rate at which the magnetic field is changing (Magnet can move towards solenoid, or solenoid can move towards magnet). Conclude that the induced e.m.f. is directly proportional to the rate of change of magnetic field. • Related to above, demonstrate using a stronger magnet to induce a bigger e.m.f. and relate it to a faster rate of changing magnetic field. • Demonstrate using different number of coils in the solenoid. Conclude that the induced e.m.f. is directly proportional to the number of coils in the solenoid.	Experiment setup Slides	Show concrete demonstration of factors affecting magnitude of induced e.m.f. to help students internalize the concept.

Time (min)	**Teaching and Learning Activities**	**Materials**	**Rationale**
20	• **AC Generator** • Ask students for possible uses of electromagnetic induction. As a hint, recall students' knowledge of DC Motors. In that example, electricity will produce motion. Conversely, using electromagnetic induction, we can produce electricity from motion. • Show picture or animation of an AC generator. Briefly explain the principles behind what makes the generator work. Group the students in pairs to work on worksheet that goes into further details of how the generator works. • Get the attention of the students after the worksheet activity. Debrief students on what they should have discovered about the AC generator from the worksheet. Extend their learning by asking them to collaboratively sketch the voltage output over time for the AC generator based on their understanding of factors affecting magnitude of the induced e.m.f. • Emphasise to students that this method of generating electricity is the primary method used throughout the world in all kinds of power stations: coal and oil, hydroelectric, wind, nuclear. • Electromagnetic induction is the principle at work to generate the electricity we use every day.	Slides	• By exploring an application of electromagnetic induction, students will be able to consolidate their learning thus far. They will have to apply Lenz's Law in order to work out the direction of induced current. • By working collaboratively, students will be able to help each other reason out the direction of induced current (Vygotsky). Articulating their reasoning will also help them to internalize the concept. • To be able to sketch the voltage output over time for the generator, students will have to apply their understanding of factors affecting magnitude of the induced e.m.f. • Emphasising the usefulness of electromagnetic induction will help students to internalize the concept better. They will be conditioned to think about electromagnetic induction every time they use an electrical appliance.

Time (min)	Teaching and Learning Activities	Materials	Rationale
10	• Summarize the learning that has taken place so far. • Electromagnetism is the study of the interaction between the domains of electricity and magnetism. • Recall the scientists that have worked on discovering the principles of electromagnetism: Ørsted, Faraday and Lenz; and their contributions to the field. • Recall that Ørsted discovered a steady current will induce a steady magnetic field. And that Faraday discovered that a changing magnetic field will induce a current and e.m.f. • Recall that Lenz discovered that the induced e.m.f always gives rise to a current whose magnetic field opposes the original change in magnetic field. • Recall that the AC generator is based on the principle of electromagnetic induction, and that the primary method of generating electricity is based on this simple generator model. • Emphasise the awesome influence of electromagnetic induction on the way the world works today.	Slides	• Consolidate the students' learning. A systematic summary of their learning will give the students a big picture view of the various relationships. • Emphasize the humanist approach to keep the students' interest. • Reminding them of the important application of induction in generating electricity will further keep their interest and help them to remember the principle.

2.3 Reflection

I've learnt a lot of new things after my microteaching. Firstly, I realised on the need to include more back linkages in my lesson plan. For example, I would need to refer back to my trigger activity after I've taught them the principles of electromagnetic induction, and try to explain the phenomenon in terms of what the students have just learnt. Furthermore, I would want to keep revisiting the key concepts over and over again so that the students will fully absorb the principles. By explaining varied phenomenon using the same principles, the students will be able to expand their experience-base with these principles and hopefully generalize these principles in other phenomenon. For instance, when teaching the AC Generator, I would try as much as possible to teach it in terms of the principles of electromagnetic induction as well as highlight how the factors that affect the magnitude of the induced e.m.f. will give rise to the characteristic alternating voltage curve.

I believe that the humanistic approach of teaching physics can keep the students' interests in the topic. However, during my microteaching lesson, I felt a strong urge to cut down on the non-essential aspects such as the lives of these physicists and go straight to the contents; this was due to the pressure of time. To be more effective in the humanistic approach, I would need to be more serious in setting aside time to these "non-academic" content but which I feel will enhance the students' learning.

3 References

- Lecture notes and videos from MIT Course 8.02 and 8.022. Retrieved Oct 1, 2005, from `http://ocw.mit.edu/OcwWeb/Physics/index.htm`.
- 5052 Physics GCE O Level Syllabus. Retrieved Oct 1, 2005, from `http://www.seab.gov.sg/2005%20GCE%20O%20Level%20Syllabuses%20School%20Candidates/5052_Physics_2005.pdf`.
- Giancoli, D. C.(1995). *Physics: principles with applications.* New Jersey: Prentice Hall.

4 Appendices

- Presentation slides
- Worksheet on Lenz's Law
- Worksheet on AC Generator