

Teaching ideas for Topic 5: *Electricity and magnetism*, AHL

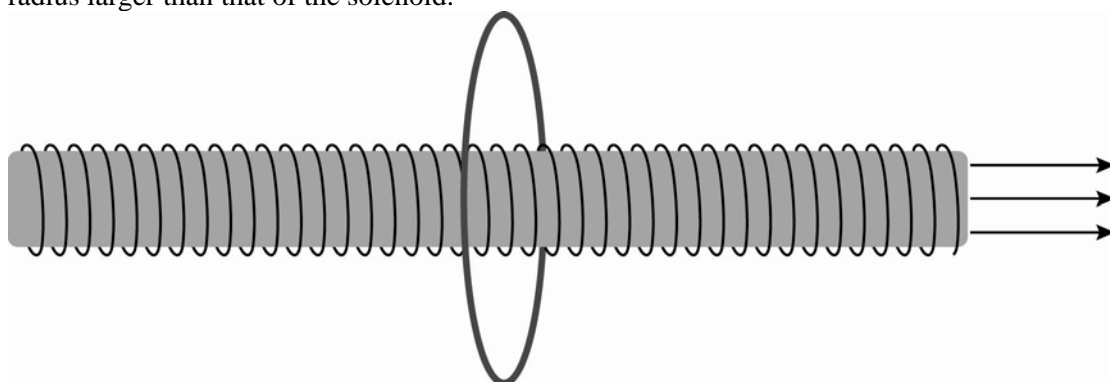
Questions

A number of worksheets are provided for this Topic:

- support questions examine the very basic concepts of the syllabus
- extended questions delve deeper and are equivalent to exam level questions.

Teaching ideas

- This is a topic that students find difficult. Before starting, it is essential to review the rules for finding the direction of the magnetic field created by various current configurations.
- One example that can be used in class when talking about electromagnetic induction is the following classic piece: a very long current-carrying solenoid goes through a metallic ring of radius larger than that of the solenoid.



The solenoid is very long, so the magnetic field is inside the solenoid – there is no magnetic field at the position of the ring. Now if the current in the solenoid is increased, the flux through the ring will change and so there will be a current in the ring. The question is: ‘What causes the current since the ring is not in a magnetic field?’ This is the type of discussion that leads to interesting things in the classroom. The idea, of course, is that the changing flux *creates an electric field along any closed loop around the solenoid* and it is this electric field that pushes electrons in the ring to make a current. This is a somewhat advanced topic, but one that is crucial in understanding electromagnetic induction.

- Asking students to find out about the life of Michael Faraday is always a rewarding experience for them.
- See http://www.pbs.org/tesla/II/II_warcur.html about the interesting events leading to the adoption of a.c. current for the distribution of electrical power in the US and the strong personalities involved – Tesla, Edison, Westinghouse.

Practical activities/ICT

- Classic simulations of electromagnetic induction and Faraday’s law are provided at <http://phet.colorado.edu/en/simulation/faraday> and <http://phet.colorado.edu/en/simulation/faradays-law>
- It is a shame to talk about electromagnetic induction and never to show the demonstration of a magnet moving in and out of a coil that is connected to a galvanometer. This is a very convincing and very simple demonstration, where you can play with the speed and angle of the magnet, the number of turns in the coil and the strength of the magnet.
- It is good to get the classic demonstration kit in which a small magnet and then an ordinary piece of non-magnetic metal are allowed to fall through a long metallic tube. The magnet induces a current in the tube and this exerts an upwards magnetic force on the falling magnet, slowing it down substantially. It is a very convincing demonstration of electromagnetic induction.

- A virtual circuit lab with a.c. voltages and currents can be found here:
<http://phet.colorado.edu/en/simulation/circuit-construction-kit-ac-virtual-lab>

Common problems

- Students often believe that if the 'loop' is made out of non-conducting material then no e.m.f. will be induced. In fact an e.m.f. will be induced, but no current will be established within the loop.

Theory of knowledge (TOK)

- The discovery of electromagnetic induction, in other words the way to produce electric fields out of magnetic fields, was work that followed the discovery of the 'reverse' process, namely the production of magnetic fields from currents. The creation of magnetic fields from currents was an accidental discovery by H. C. Ørsted in 1820 and Faraday's discovery of electromagnetic induction came about 10 years later. The quest for this discovery was based on the expected symmetry between electric and magnetic fields and it shows that considerations such as symmetry are often guiding principles in discovering new things. The symmetry brought about by Faraday's discovery also guided James Clerk Maxwell in writing down his laws of electromagnetism that led eventually to one of the crowning achievements of 19th century physics, the discovery of electromagnetic waves. In turn, the mathematical structure and formalism of Maxwell's equations was to serve as the basis of most of the efforts in the 20th century for a theory of particles based on symmetries.