

Eddy Currents - Lesson Outline

Syllabus Reference

- 9.3.2.2.7 – explain the production of eddy currents in terms of Lenz's Law.
- 9.3.2.3.4 – gather secondary information to identify how eddy currents have been utilised in electromagnetic braking.

Resources

Video: Eddy Currents
<http://www.hscphysics.edu.au/resource/EddyCurrents.flv>

Video: Magnet Race
<http://www.hscphysics.edu.au/resource/MagnetRace.flv>

Pre-video Activities

Brainstorming activity: Students contribute key physics words pertaining to the production of an electric current by electromagnetic induction. Record words on board or screen.

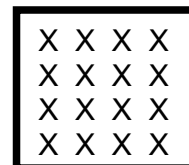
Matching exercise: Students should match key terms to definitions by matching the numbers 1-6 to the corresponding letters in the right-hand column.

Key terms	Definitions
1. Eddy currents	A. An induced emf (voltage) always gives rise to a current whose magnetic field opposes the original change in flux
2. Lenz's Law	B. The amount of magnetic flux per unit area
3. Faraday's Law	C. A flow of charges induced in a conductor when there is relative movement between a magnetic field and a conductor
4. Induced current	D. The production of a voltage across a conductor exposed to a changing magnetic field
5. Electromagnetic induction	E. Circular currents which are induced in a conductor exposed to a changing magnetic field
6. Magnetic flux density	F. The induced emf (voltage) is equal to the rate of change of magnetic flux interacting with a conductor $Emf = -n \frac{\Delta\Phi}{\Delta t}$

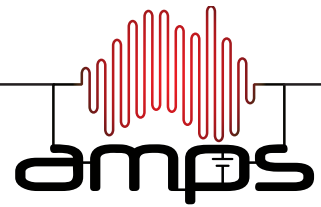
Group Work:

1. Organise students into groups of three
2. Provide each group with a blank sheet of A3 paper and a marker
3. Students divide page into two with a horizontal line

Example:



Have students draw a large square on the top half of the sheet. Describe the following situation: Imagine you are holding the north pole of a bar magnet 1 cm above the square. The square represents a square copper coil. Students draw lines of magnetic flux inside the square coil (a relatively strong magnetic flux density).



Have students draw another square of the same size on the lower half of the A3 page. Describe the new situation: the imaginary bar magnet is now lifted to a height of 5cm above the square coil. Students draw the magnetic flux lines inside the square for this new situation when the bar magnet is stationary 5 cm above the square. Students then write a statement to justify what they have drawn.

Describe new situation: Imagine now how the flux lines change while the magnet is in motion from close to the square to a height of 5cm. The square copper coil contains free electrons in its lattice. Students amend their diagram to show what will happen to the electrons in the coil while the magnet is moving away. Students predict what will happen to the same electrons as the magnet is moved back down towards the square coil. Students show this on their diagram

One representative presents the group's interpretations to the rest of the class. Encourage class discussion and questioning

Option 1: Pre-video Experiments

For teacher background information, refer to video: Eddy Currents
<http://www.hscphysics.edu.au/resource/EddyCurrents.flv>

Students continue to work in groups of three. Give each group a rectangular sheet of galvanised steel and a rare earth magnet (with one half cut like a comb, as per video)

Students firstly verify that the magnet is not magnetically attracted to the metal sheet. Students place the metal sheet so that it sits like a ramp and slide the magnet down the solid metal surface. Record observations.

Students then slide the magnet down across the combs of the metal sheet. Record any observations and note any differences.

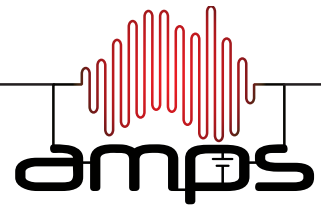
For each of these investigations students should use a predict-observe-explain format. That is, they make a prediction before sliding the magnet, then record observations and generate plausible explanations. Format of tables:

Situation 1: the magnet slides down the solid metal surface	
Prediction	
Observation	
Explanation	

Situation 2: the magnet slides across the metal combs	
Prediction	
Observation	
Explanation	

One representative presents the group's interpretations to the rest of the class. Encourage class discussion and questioning. Collate all groups' responses on board or screen.

Back in groups, students draw models on A3 paper to illustrate how the eddy currents are induced in the metal sheet as the magnet slides



Again, one representative presents the group's interpretations to the rest of the class. Ensure that different group members are presenting findings to class

Option 2: View Video

Video: Eddy Currents

<http://www.hscphysics.edu.au/resource/EddyCurrents.flv>

If unable to get the materials needed for option 1, students can watch the demonstrations in the video.

View Video

Video: Magnet Race

<http://www.hscphysics.edu.au/resource/MagnetRace.flv>

Activities

Students again use the predict-observe-explain model to describe and interpret the results of the demonstration in the video. Each group should again report back to the class

Students develop diagrams to model the production of eddy currents in the metal pipes

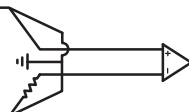
Post-Video Activities

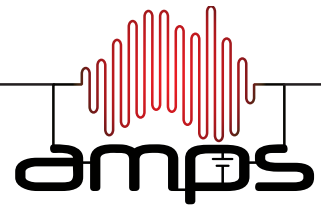
Post-video Test: Eddy Currents - Extended Answer

Students complete the post test individually to check for conceptual change.

In groups of 3 students use the following key words to produce a concept map in groups.

Lenz's Law
Eddy currents
Induced current
Electromagnetic induction
Braking systems



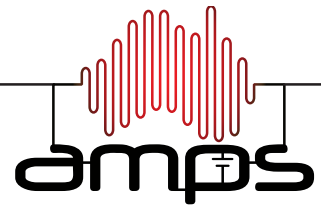


Eddy Currents - Extended Answer

Q1. Will an eddy current braking mechanism work on an aluminium wheel or should the wheel be made of a ferromagnetic material such as iron? Explain your answer.

Q2. A thin, solid metal sheet is set up to hang from an axle so that it can swing freely (with minimal friction). The metal sheet is made to swing between the poles of a strong magnet. It soon comes to a stop after only one and a half swings. The metal sheet is then replaced by another one with the same properties, however this time the sheet has been cut so that it resembles a large comb. Predict what will happen when this new metal sheet is made to swing between the magnetic poles. Justify your prediction.

Q3. An aluminium sheet is held between the poles of a large permanent magnet. It requires considerable force to pull it out from the magnetic field. Explain.



Q4. A magnet falling inside an aluminium pipe soon reaches a rather slow terminal velocity. Explain.

Q5. After viewing this, a student asks his teacher if it is possible for the magnet to be brought to a complete stop so that it just sits suspended inside the vertical pipe. How would you respond to this student?

Q6. Explain how eddy currents are applied in an induction stove top.

