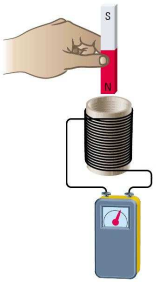
SPH3U UNIVERSITY PHYSICS

ELECTRICITY & MAGNETISM
☞ Lenz's Law
(P.592-594)

Faraday's Discovery

Faraday's discovery of induced current opened the door to readily accessible and cheap sources of current. This current could be used to power electric motors and other devices, saving time and money for many people and industries. However, there were still some questions to be answered.

1. *What determines the direction of the induced current?*
2. *Where does the energy associated with the induced current come from?*



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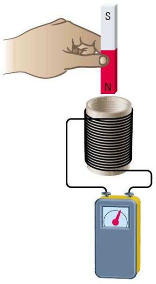
Faraday's Discovery

Consider the case where the N-pole of a bar magnet is pushed into a coil.

1. *When the N-pole of a bar magnet enters a coil, a galvanometer will indicate an induced current through the coil.*
2. *When the N-pole is removed, the galvanometer will indicate a current in the opposite direction.*
3. *Using the S-pole of the bar magnet causes induced currents in the opposite directions.*



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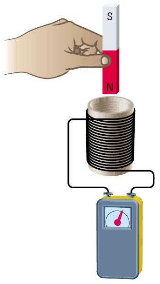
Faraday's Discovery

Evidently, there is some simple relationship between the action of the inducing field and the direction of the induced current.

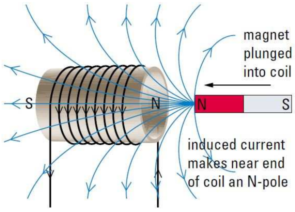
NOTE!

*In 1834, a few years after Faraday's discovery of induction, a German physicist working in Russia, Heinrich Lenz (pronounced "Lents"), applied the law of conservation of energy and succeeded in stating this relationship – **Lenz's law**.*



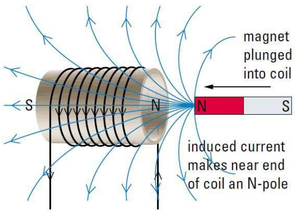
Lenz's Law

*Heinrich Lenz discovered that when a current is induced through a conductor due to a changing magnetic field (known as the **inducing field**), the induced current sets up a magnetic field (known as the **induced field**) that opposes the motion of the inducing field.*



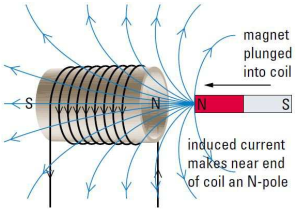
Lenz's Law

For example, if the N-pole of a bar magnet is inserted into the core of a coil, the induced current in the coil creates a N-pole at the right end of the coil that opposes the motion of the magnet. A similar situation occurs if the S-pole of a bar magnet is removed from the core of a coil.



Lenz's Law

NOTE!
The changing magnetic field really produces an electric field – the induced current is just a way it can be detected.



Lenz's Law

LENZ'S LAW

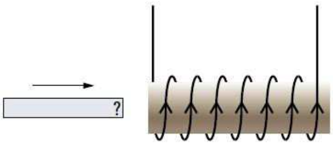
- for a current induced in a coil by a changing magnetic field, the electric current is in such a direction that its own magnetic field opposes the change that produced it

NOTE!
It is the work done in moving the magnet against this opposing force that is transformed into electrical energy in the induction coil (conservation of energy).

Lenz's Law

PRACTICE

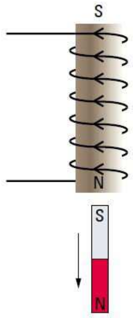
1. Determine the pole of the bar magnet that is being inserted into the induction coil shown.



Lenz's Law

PRACTICE

2. Determine the direction of the electric current in the induction coil shown.

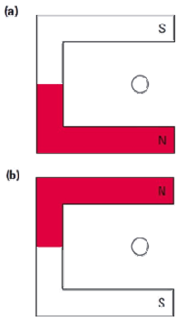


Lenz's Law

PRACTICE

3. Conductors are being pushed to the left in each of the following diagrams. Use Lenz's law and the right-hand rule for straight conductors to determine the direction of the induced electric current.

   (a) in
   (b) out

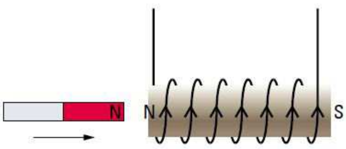


Induction

PRACTICE

4. When a magnet is pushed into a coil to induce a current, the magnetic field that is created never attracts the magnet into the coil. Explain why this is the case.

   If the mag ... current would increase b ... This in turn would proc ... ng the magnet to speed u ... ffect, creating energy fro ... ergy does not permit suc ... onverted from one form t



Applications of Lenz's Law – Drop Towers

Drop-tower rides are popular attractions at amusement parks. To prevent disaster, the braking system must be extremely reliable. If a friction-based braking system were used, it would need to be triggered at just the right time, and the brakes would wear out quickly and need constant replacement. Drop-tower rides use an ingenious system that relies on electromagnetic induction. It can be explained using Lenz's Law.

Applications of Lenz's Law – Drop Towers

Each cart on the ride has permanent magnets under the seats. After approximately 45 m of free fall, an electromagnetic braking system kicks in. Along the bottom third of the tower are copper strips mounted vertically on the tower. When the cart falls and the permanent magnets move past the copper conductor, an electric current is induced in the copper. The induced current then produces a magnetic field. Applying Lenz's law, the induced magnetic field must oppose the field that created it. The opposing repulsion force acts to create a reliable, no-friction braking system.

Applications of Lenz's Law – Drop Towers

PRACTICE

5. In a drop-tower ride, would using an electromagnet in the carts, instead of the permanent magnets under the seats, work equally well? Would it be equally reliable? Explain.

✔ Check Your Learning

TEXTBOOK
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