Arvind Borde / PHY 12, Week 6: Electromagnetic Induction

The story so far

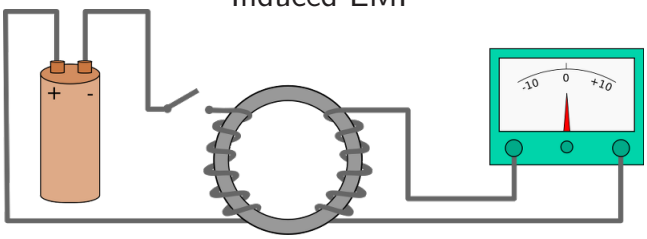
▷ Electric currents (moving charges) produce magnetic fields.

▷ Electric currents (moving charges) "feel" magnetic fields.

(1) Wouldn't it be fantabulous – or, at least, not-bad – if moving magents could produce electric fields and currents? _____

1

Induced EMF



Battery Iron ring Galvanometer

Experiment by Faraday, around the mid 1800s.

Steady current produced no needle deflection.

2 Switching on and off did.

Faraday reasoned that a constant current produced a constant magnetic field. This did not seem to induce a current in the second circuit.

But switching the current on or off would produce a _____ and that was what seemed to produce the current.

3

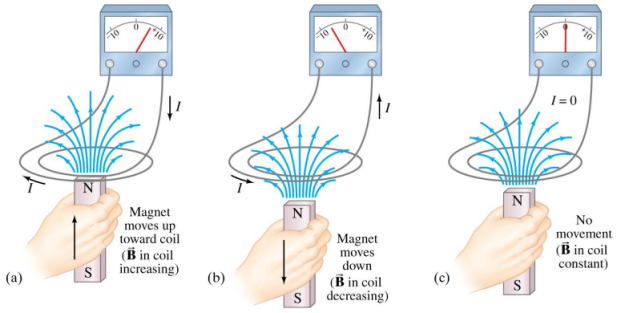
He concluded that

_____

This is called _____

4

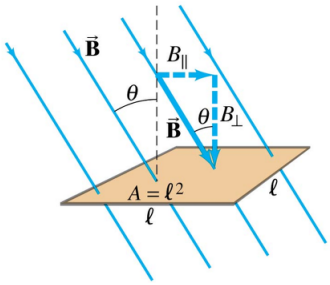
Any changing magnetic field induces a current:



From these phenomena, Faraday got a law.

5

The law uses the idea of flux, roughly the "amount of magnetic field that goes through an area":



6 _____

ADDITIONAL NOTES

The unit of flux is called a weber (Wb).

(2) What is a weber in terms of the units of the quantities that were used in the definition of flux?

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(3) A square loop of wire, side $3\,\text{cm}$, is placed in a $0.17\,\text{T}$ magnetic field so that its plane is

(a) perpendicular to $\vec{B}$, and

(b) at an angle of 40° to it.

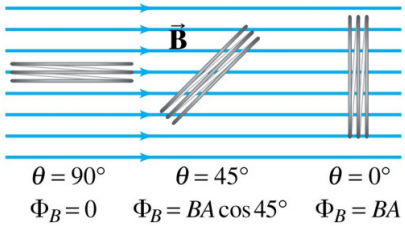
What's the flux through the loop?

(a)

8 (b)

Flux measures "how many magnetic field lines pass through a given area."

Examples of fluxes through looped circuits:



9

Faraday's Law of Induction

We've seen that if a magnetic field through a loop changes, it induces a current in the loop.

If the field changes so does the flux. Faraday's Law states precisely what emf is generated as the magnetic flux changes:

10

If the circuit has N closed loops,

11

(4) A circular loop of wire, radius $2\,\text{cm}$, is placed perpendicular to a magnetic field that changes from $0.1\,\text{T}$ to $0.5\,\text{T}$ in $10\,\text{sec}$. What's the induced emf?

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ADDITIONAL NOTES

(5) Flux changes occur when the magnetic field changes, but even with the magnetic field unchanging, the flux can change. Gaze at the formula for Φ_B and tell me how.

13

(6) A square loop of wire, side $6\,\text{cm}$, is placed in a $0.2\,\text{T}$ magnetic field and rotated in $0.23\,\text{s}$ so that its plane moves from perpendicular to $\vec{B}$, to an angle of $30°$ to it. What's the induced emf?

(a) _____

(b) _____

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(7) What is the current induced in the loop from the previous question, if its resistance is $3.2\,\Omega$?

_____

(8) But a current, induced or not, produces what?

_____

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So, we have:

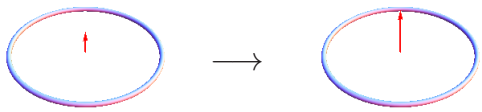
- Changing magnetic flux induces current.
- Induced current creates new magnetic field.

The minus in Faraday's Law means that the induced magnetic field opposes the change in the magnetic flux that started the whole chain.

This is called Lenz's Law.

16

For example, suppose you have a horizontal circular loop with a magnetic field vertically through it. The field increases.



It induces a current through the loop. In what direction will the current flow? _____

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ADDITIONAL NOTES

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