E & M Induction

Flux, Induction, Faraday, & Lenz

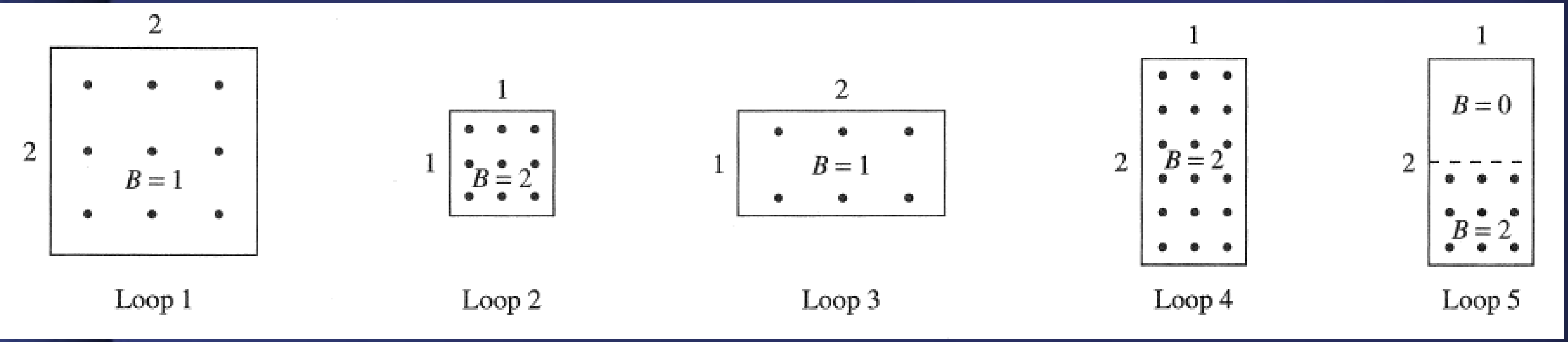
EM Induction - Discovery

- 1820 Oerstad a constant I → Bfield
- Symmetry ∴ B → I easy?
- 1831 Faraday discovers the switch
- Note: 1830 Joseph Henry

Source: Hecht's Physics w/ Algebra & Trig.

Flux

- The figure below shows 5 loops in a **B** field. Rank the magnetic flux (Φ)from largest to smallest.



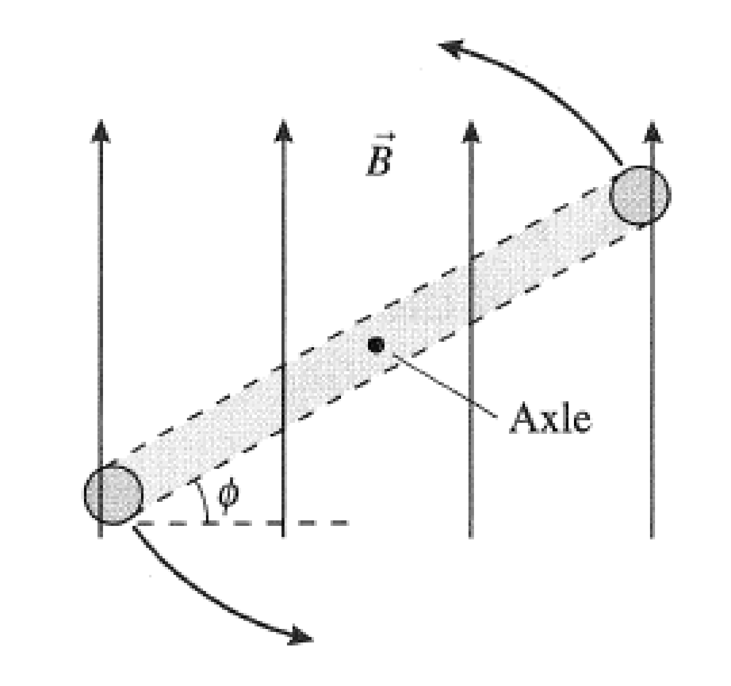
1. 2=4, 1, 3, 5
2. 1=4, 2=3=5
3. 4, 2, 1, 3, 5
4. 4=2, 1, 5, 3

Flux Instruction Slide is # 5

From Knight's Physics for Scientists & Engineers

Flux

- A circular loop rotates at constant speed. The figure shows an edge view & defines the angle which rotates from 0º-360º as the loop rotates
- At what angle(s) is the magnetic flux a maximum?
- At what angle(s) is the magnetic flux a minimum?



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EM Induction & B Flux

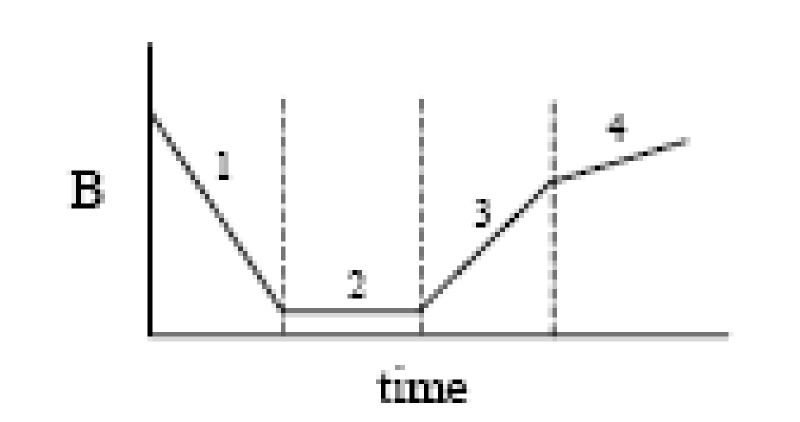
- Magnetic Flux = magnetic field passing ⊥ to area x that area

- $\Phi_M = B_\perp A = BA_\perp = BA\cos\theta$

Back to Flux Questions

Flux Check

- The graph shows the magnitude B of a uniform magnetic field that is perpendicular to the plane of a conducting loop. Rank the five regions indicated on the graph according to the **magnitude** of the CHANGE in flux in the loop, from greatest to least.



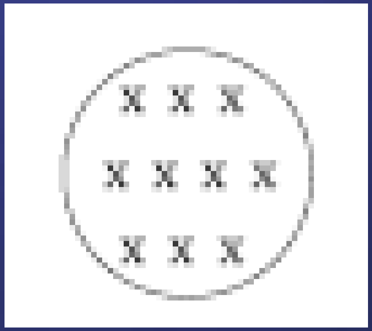
1. 1, 2, 3, 4
2. 4, 3, 1, 2
3. 2, 4, 3, 2
4. 1, 3, 4, 2

How can you $\Delta\Phi_M$

- Recall: $\Phi_M = B_\perp A = BA_\perp = BA\cos\theta$
  - Change B
  - Change A
  - Change θ

Induction check

A loop of wire lies in the plane of the page. A decreasing magnetic field is directed into the page. The induced current in the loop is:

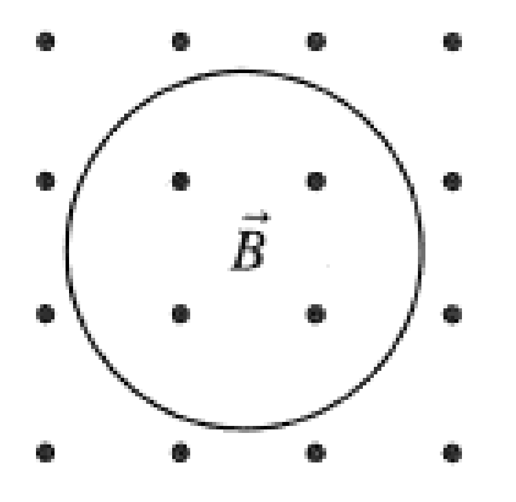


1. counterclockwise
2. clockwise
3. zero
4. depends upon whether or not B is decreasing at a steady rate

Question modified from unknown source

Induction Instruction

Faraday's Law



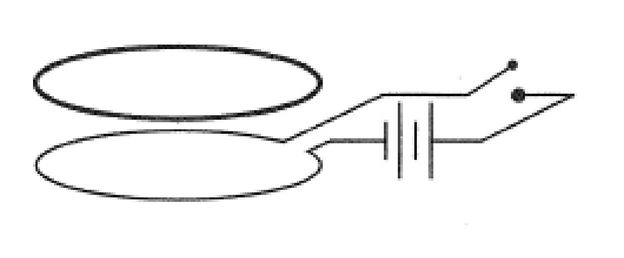
- Does the loop of wire have a 1-clockwise, 2-counter-clockwise, or 3-no current when:

1. The B field strength is increasing.
2. The B field strength is constant.
3. The B field strength is decreasing.

1. 1
2. 3
3. 2

From Knight's Physics for Scientists & Engineers

Flux, Faraday & Lenz



- Two loops of wire are vertically stacked as shown in the diagram. Does the upper loop have current that is:

***1**- clockwise,* ***2**-counter-clockwise,* ***3**- no current*

1. Before switch is closed	1. 3 Why?
2. Immediately after switch is closed	2. 1 Why?
3. Long after switch is closed	3. 3 Why?
4. Immediately after switch is re-opened.	4. 2 Why?

From Knight's Physics for Scientists & Engineers

Changing Flux→ Voltage

- Faraday's Induction Law, by Faraday Not .
- Tough to avoid *EMF* in place of Voltage
- $\varepsilon = - N(\Delta\Phi_M)/\Delta t$
- WOW!
- Hold On… Conservation of Energy

Faraday's Law of Inductance Part 2: Lenz's Law

- $\varepsilon = -N(\Delta\Phi_M)/\Delta t$
- Lenz's Law: Induced EMF must produce current that opposes the change that caused it.

Back to Induction Questions

Apply Faraday's Induction

- Motor Motor Website Wiki motor website
- Generator website
- BackPack Battery