

Chapter 6 · Electromagnetic Induction

CBSE Class 12 Physics (042) · Unit IV · Unit III + IV = 17 marks · Ultimate Revision Sheet

60-SECOND RECALL

Magnetic flux	$\phi = BA \cos\theta$ · unit weber (Wb)
Faraday's law	$\epsilon = -N d\phi/dt$
Lenz's law	The minus sign — induced effect opposes the change that caused it
Motional EMF	$\epsilon = Blv$
Self-inductance	$\epsilon = -L dI/dt$ · solenoid $L = \mu_0 n^2 Al$
Mutual inductance	$\epsilon_2 = -M dI_1/dt$ · $M_{12} = M_{21}$
Energy in an inductor	$U = \frac{1}{2}LI^2$

1. Magnetic Flux

DEFINITION Magnetic flux through a surface is the product of the field and the area perpendicular to it: $\phi = \mathbf{B} \cdot \mathbf{A} = BA \cos\theta$. It is a scalar; SI unit the **weber**, where $1 \text{ Wb} = 1 \text{ T m}^2$.

TRAP θ is measured between **B** and the **NORMAL** to the surface, not the surface itself. When the plane of the coil is **parallel** to **B**, $\theta = 90^\circ$ and the flux is **zero**, not maximum.

2. Faraday's Laws and Lenz's Law

WRITE THIS VERBATIM **First law:** whenever the magnetic flux linked with a circuit changes, an EMF is induced in it, and it lasts only as long as the change continues.
Second law: the magnitude of the induced EMF is equal to the rate of change of magnetic flux.
Lenz's law: the induced current flows in such a direction that it **opposes the change** producing it.

FORMULAS

$$\epsilon = -N d\phi/dt \quad N = \text{number of turns}$$

$$\text{Induced current } I = \epsilon/R \quad \text{Induced charge } q = N\Delta\phi/R \quad (\text{independent of time taken})$$

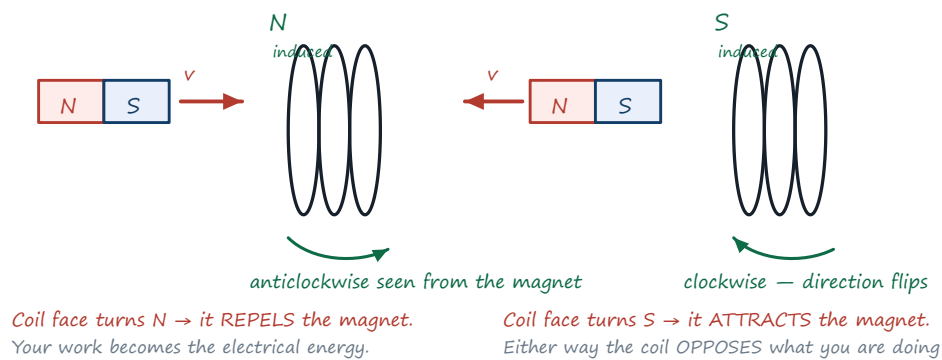
LENZ'S LAW IS CONSERVATION OF ENERGY If the induced current helped the change instead of opposing it, the motion would accelerate on its own and produce energy from nothing. The **minus sign** in Faraday's law is the statement of energy conservation — say this sentence, it is the mark.

Approaching N pole → the near face becomes **N** (repels) → current **anticlockwise** as seen from the magnet.

Receding N pole → the near face becomes **S** (attracts) → current **clockwise**.

(a) magnet moving TOWARDS the coil

(b) magnet moving AWAY



Lenz's law is the minus sign in $\mathcal{E} = -N d\Phi/dt$, and it is a statement of **conservation of energy** — say that sentence in the answer, it is the marked point.

3. Motional EMF

FORMULA AND ITS ORIGIN

$\mathcal{E} = Blv$ rod of length l moving with velocity v perpendicular to B

Force needed to keep it moving: $F = B^2 l^2 v / R$ · Power delivered: $P = B^2 l^2 v^2 / R = \mathcal{E}^2 / R$

The work done against this opposing force is exactly the electrical energy produced — another statement of Lenz's law.

4. Self and Mutual Inductance

SELF-INDUCTANCE

$\Phi = LI$ · $\mathcal{E} = -L dI/dt$ unit henry (H)

Solenoid: $L = \mu_0 n^2 A l = \mu_0 N^2 A / l$

Energy stored: $U = \frac{1}{2} LI^2$

Self-inductance is called **electrical inertia** — it opposes any **change** in current, just as mass opposes change in motion.

MUTUAL INDUCTANCE

$\Phi_2 = M I_1$ · $\mathcal{E}_2 = -M dI_1/dt$

Two coaxial solenoids: $M = \mu_0 n_1 n_2 A l$

$M_{12} = M_{21}$ always — the mutual inductance of a pair does not depend on which coil carries the current.

M depends on the **geometry, separation, orientation** of the coils and the **core material** — an iron core raises it greatly.

WORKED EXAMPLE A coil of **500 turns** has its flux changed from **0.1 Wb** to **0.02 Wb** in **0.1 s**.
Coil resistance **20 Ω** .

$$\Delta\phi = 0.02 - 0.1 = -0.08 \text{ Wb}$$

$$\varepsilon = -N \Delta\phi/\Delta t = -500 \times (-0.08)/0.1 = 400 \text{ V}$$

$$I = \varepsilon/R = 400/20 = 20 \text{ A}$$

$$\text{Charge } q = N\Delta\phi/R = 500 \times 0.08/20 = 2 \text{ C}$$

5. Question Triggers what the wording is really asking

If the question says...	Use
"magnet pushed towards a coil"	Lenz — near face becomes N, current opposes approach
"rod moving on rails in a field"	$\varepsilon = Blv$
"charge that flows", time not given	$q = N\Delta\phi/R$ — time cancels out
"EMF induced in a coil by current in another"	Mutual inductance
"opposes growth of current when switched on"	Self-inductance
"plane of the coil parallel to B"	$\phi = 0$ ($\theta = 90^\circ$ with the normal)
"why does the minus sign appear"	Conservation of energy

MOST-ASKED BOARD QUESTIONS

1. **[3M]** State Faraday's laws and **Lenz's law**; show that Lenz's law follows from conservation of energy.
2. **[3M]** Derive an expression for the **self-inductance of a long solenoid**.
3. **[3M]** Derive **motional EMF $\varepsilon = Blv$** and find the power required to keep the rod moving.
4. **[2M]** Define **mutual inductance** and list the factors it depends on.
5. **[2M]** Numerical on induced EMF, current and charge.
6. **[1M]** Give the SI unit of magnetic flux and of inductance. $\rightarrow$ **weber, henry**

THE HABIT THAT SCORES — Whenever a question asks for a **direction**, answer it in two steps: first say which way the flux is changing, then say the induced current opposes that change. Writing the reasoning, not just "anticlockwise", is what earns the second mark.