

Electromagnetic Induction — Assignment 2

Class 12 Physics · Higher-difficulty challenge set + integrated problems · Answer key included · Narayan Gurukul Academy

Instructions: (1) Attempt all questions; start with the topic-wise challenge set, then attempt the integrated (multi-topic) problems.
(2) Give all answers with correct SI units. $g = 10 \text{ m/s}^2$ unless stated.
(3) A final answer key is provided at the end — try the full set before checking it.

Part A — Topic-wise challenge questions

Magnetic Flux and Faraday's Law

1. Define magnetic flux and state Faraday's laws.
2. The flux through a 100-turn coil changes from 0.01 Wb to 0.05 Wb in 0.2 s. Find the emf.
3. A coil of area 0.1 m^2 is rotated so its flux changes fully in 0.1 s. Find the average emf for 200 turns in a 0.5 T field.

Lenz's Law

1. State Lenz's law and explain its basis in the conservation of energy.
2. A bar magnet moves towards a coil. State the direction of the induced current.
3. A ring is dropped over a vertical bar magnet. Explain the induced current and force.

Motional EMF

1. Derive the expression for the motional emf in a rod moving in a field.
2. A rod 0.5 m long moves at 2 m/s perpendicular to a 0.4 T field. Find the emf.
3. Show that the mechanical power supplied equals the electrical power dissipated.

Self and Mutual Inductance

1. Define self-inductance and derive it for a long solenoid.
2. The current in a 0.5 H coil changes at 2 A/s. Find the induced emf.
3. Derive the mutual inductance of two coaxial solenoids.

AC Generator and Transformer

1. Describe an AC generator and derive its emf.
2. A transformer has 100 primary and 500 secondary turns with 220 V primary. Find the secondary voltage.
3. Describe a transformer and state its energy losses and how they are reduced.

Part B — Integrated problems (multi-topic)

1. A circular coil of 200 turns and radius 0.1 m is placed in a magnetic field that changes from 0.2 T to 0.6 T in 0.1 s. Find the induced emf and the current if the coil resistance is 5Ω .
2. A rod of length 1 m slides on rails 1 m apart connected to a 2Ω resistor in a 0.5 T field at 3 m/s. Find the emf, the current, the force needed and the power dissipated.

3. A long solenoid of 1000 turns and length 0.5 m carries a varying current $di/dt = 5 \text{ A/s}$. Find the self-induced emf if its cross-section is $4 \times 10^{-4} \text{ m}^2$.
4. Two coils are arranged so that a current change of 2 A/s in the primary induces 0.5 V in the secondary. Find the mutual inductance of the coils.
5. A transformer steps down 2200 V to 220 V. If the primary has 2000 turns and the output current is 10 A, find the secondary turns, the primary current (ideal) and the power delivered.

Answer Key

Magnetic Flux and Faraday's Law

$\Phi = BA \cos\theta$ (weber); $e = -N d\Phi/dt$. $\Delta\Phi = 0.04 \text{ Wb}$, $e = 100 \times 0.04/0.2 = 20 \text{ V}$. For the rotating coil: $e = NBA/\Delta t = 200 \times 0.5 \times 0.1/0.1 = 100 \text{ V}$.

Lenz's Law

The induced current opposes the flux change; it follows from the conservation of energy because otherwise energy would be created from nothing.

Motional EMF

$e = Blv$. For $l = 0.5$, $v = 2$, $B = 0.4$: $e = 0.4 \text{ V}$. $F = B^2 l^2 v/R$ and $P_{\text{mech}} = P_{\text{electrical}}$.

Self and Mutual Inductance

$e = -L di/dt$; $L = \mu_0 N^2 A/l$. For 0.5 H at 2 A/s: $e = 1 \text{ V}$. $M = \mu_0 N_1 N_2 A/l$.

AC Generator and Transformer

$e = NBA\omega \sin\omega t$; $e_0 = NBA\omega$. $V_s/V_p = N_s/N_p = I_p/I_s$; losses: copper, eddy-current, hysteresis, flux leakage.

Integrated problems

1: $e = N(\Delta B/\Delta t)A = 200 \times 4 \times \pi(0.1)^2 \approx 25.1 \text{ V}$; $I = e/R \approx 5.0 \text{ A}$. 2: $e = Blv = 1.5 \text{ V}$; $I = 0.75 \text{ A}$; $F = BIl = 0.375 \text{ N}$; $P = 1.125 \text{ W}$. 3: $L = \mu_0 N^2 A/l \approx 1.0 \text{ mH}$; $e = L di/dt \approx 5.0 \times 10^{-3} \text{ V}$. 4: $M = e/(di/dt) = 0.5/2 = 0.25 \text{ H}$. 5: $N_s = 200$; $I_p = I_s \times 220/2200 = 1 \text{ A}$; $P = 2200 \text{ W}$.