Electromagnetic Induction: Faraday's & Lenz's Laws

Induction · 8 questions · step-by-step answers at the end

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USEFUL EQUATIONS

$\Phi = BA\cos\theta$ $\varepsilon = -N\,d\Phi/dt$ $\varepsilon = BLv$ $I(t) = (\varepsilon/R)(1 - e^{-t/\tau})$, $\tau = L/R$ $U = \tfrac{1}{2}LI^2$

Questions

Show your working in the space under each question.

1. A 50-turn coil of area 0.010 m² sits in a field that rises from 0 to 0.40 T in 0.20 s. Find the average emf.

2. A 0.50 m rod slides at 2.0 m/s along rails in a 0.80 T field (perpendicular). The circuit resistance is 2.0 Ω. Find the emf, the current, and the magnetic force on the rod.

3. A loop lies parallel to a uniform field. What is the flux through it?

4. A 0.40 m rod slides at 3.0 m/s on rails in a 0.50 T field, closing a circuit of resistance 2.0 Ω. Find the EMF, the current and the force needed to keep it moving.

5. A magnet dropped through a copper ring falls more slowly than one dropped beside it. Why?

6. The field inside a long solenoid rises at 0.050 T/s. Find the induced E 3.0 cm from the axis.

7. The number of turns in a coil doubles. What happens to the induced EMF for the same changing field?

8. What does an inductor look like to the circuit the instant a switch closes, and long afterwards?

Step-by-step answers

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1. $\varepsilon = N\Delta\Phi/\Delta t = 50(0.40 \times 0.010)/0.20 =$ **1.0 V**.

2. 1. $\varepsilon = BLv = (0.80)(0.50)(2.0) =$ **0.80 V**.
2. $I = \varepsilon/R = 0.80/2.0 =$ **0.40 A**.
3. $F = ILB = (0.40)(0.50)(0.80) =$ **0.16 N**, opposing the motion (Lenz).
4. To keep the rod moving at constant speed, you must push with 0.16 N. Your power $Fv = 0.32$ W equals I^2R, the heat produced in the resistor.

Answer: ε = 0.80 V, I = 0.40 A, F = 0.16 N (opposing)

3. **Zero**: no field lines pass through it ($\cos 90° = 0$).

4. $\varepsilon = BLv =$ **0.60 V**; $I =$ **0.30 A**; $F = BIL =$ **0.060 N**.

5. The changing flux induces a current whose field **opposes the motion** (Lenz), slowing the magnet.

6. $E = (r/2)(dB/dt) = (0.015)(0.05) =$ **7.5×10^{-4} V/m**.

7. $\varepsilon \propto N$, so it **doubles**.

8. At first, an **open circuit** ($I = 0$). Long afterwards, a **plain wire**.