ANSWER KEY.

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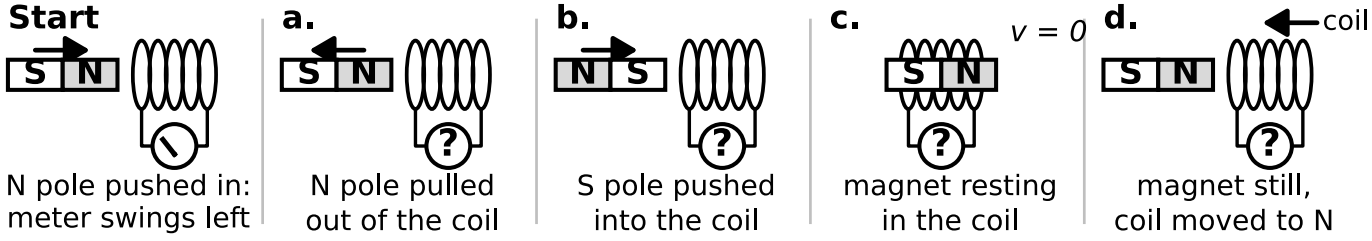
Electromagnetic Induction

Physics | Answer Key

Part A: When Is Current Induced?

1. When Ava pushes the N pole of a magnet into a coil, the meter swings to the **left** (Start). For each case a through d, predict whether the meter swings left, swings right, or stays at zero. Explain each answer.



a. Right. Pulling out instead of pushing in reverses the change in field, so the current reverses.

b. Right. Leading with the S pole instead of the N pole reverses the current.

c. Zero. The field through the coil is strong but not changing, so nothing is induced.

d. Left. The field through the coil increases just as it does when the N pole is pushed in. Only the relative motion matters, so the meter swings the same way as at the start.

2. Name three changes that would make the induced current in a coil bigger. Then explain why Ava has to push harder to move a magnet into a coil when the coil is connected to a light bulb, and describe the energy changes.

Bigger current: use a coil with more turns, use a stronger magnet, or move the magnet faster.

Pushing back: the induced current turns the coil into an electromagnet that pushes back on the moving magnet, so Ava must do work to keep the magnet moving.

Energy: her work (the kinetic energy of the moving magnet) becomes electrical energy in the coil, which becomes light and heat in the bulb. Energy is conserved.

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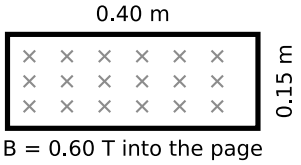
Part B: Flux and Faraday's Law

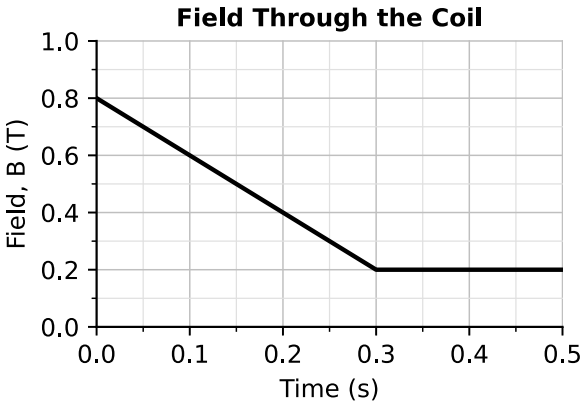
Use $\Phi = BA$, $\varepsilon = N\,\Delta\Phi / \Delta t$, and $I = \varepsilon / R$.

3. A rectangular loop of wire sits in a magnetic field that points straight into the page, as shown. What is the magnetic flux through the loop?



Knowns: B = 0.60 T, loop is 0.40 m × 0.15 m, field straight through the loop
Area: A = (0.40 m)(0.15 m) = 0.060 m^2
Equation: $\Phi = BA$
Substitute: Φ = (0.60 T)(0.060 m^2)
Answer: Φ = 0.036 Wb

4. A coil with 200 turns, each with an area of 0.010 m^2, sits in a magnetic field that changes as shown in the graph. The coil is connected to a circuit with a total resistance of 8.0 Ω.



a. Find the induced voltage from 0 s to 0.30 s.
b. Find the induced current from 0 s to 0.30 s.
c. What is the induced voltage from 0.30 s to 0.50 s? Explain.

a. Knowns: N = 200, A = 0.010 m^2, B drops from 0.80 T to 0.20 T, so ΔB = 0.60 T (in size), Δt = 0.30 s
Change in flux: $\Delta\Phi = \Delta B \times A$ = (0.60 T)(0.010 m^2) = 0.0060 Wb
Equation: $\varepsilon = N\,\Delta\Phi / \Delta t$ = (200)(0.0060 Wb) / (0.30 s)
Answer: ε = 4.0 V
b. $I = \varepsilon / R$ = 4.0 V / 8.0 Ω = **0.50 A**
c. 0 V. The field stays at 0.20 T, so the flux is not changing and nothing is induced.

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5. A bike light's generator coil has 300 turns. To light the bulb, the coil needs an induced voltage of 12 V. If the flux through the coil changes by 0.020 Wb each time the magnet passes, how much time can each change take?

Knowns: $N = 300$, $\varepsilon = 12$ V, $\Delta\Phi = 0.020$ Wb

Equation: $\varepsilon = N\,\Delta\Phi / \Delta t$, so $\Delta t = N\,\Delta\Phi / \varepsilon$

Substitute: $\Delta t = (300)(0.020\text{ Wb}) / (12\text{ V})$

Answer: $\Delta t = 0.50$ s (or less; a faster change gives a bigger voltage)

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