



Attempt all questions before checking the answer key. Show the direction of induced current and explain it using Lenz's law.

A. Very short answers - 1 mark each

1. State Faraday's law of electromagnetic induction.
2. What does the negative sign in Faraday's law represent?
3. Define self-inductance and its SI unit.
4. Can a stationary coil have induced emf? Give an example.
5. Why is induced emf sometimes called a back emf?

B. Short answers / practice - 2 marks each

6. Flux through each turn of a 50-turn coil changes from 0.02 Wb to 0.005 Wb in 0.10 s. Find average induced emf.
7. A magnet's north pole approaches a coil. State the polarity of the near face and explain what happens when the magnet recedes.
8. A 0.4 m rod moves at 5 m/s perpendicular to a 0.2 T field, with rod, velocity and field mutually perpendicular. Find the emf.
9. Current in a 0.5 H coil rises uniformly from 0 to 4 A in 0.02 s. Find the self-induced emf.
10. Explain why relative motion alone does not guarantee an emf: use a coil translated wholly within a uniform magnetic field.
11. Does induced emf require a closed conducting circuit?
12. Find flux through a 0.02 m^2 loop whose normal is parallel to a 0.3 T field.
13. A 2 H coil carries a current changing at 3 A/s. Find emf magnitude.
14. Why does Lenz's law agree with conservation of energy?
15. A coil's turns double at unchanged flux change per turn. How does induced emf change?
16. State two ways of changing flux through a stationary loop.
17. Find mutual inductance if a current change of 4 A/s induces 0.20 V.
18. Can a loop moving wholly within a uniform steady field have zero induced emf?
19. A 1 m rod moves at 2 m/s along its own length in a magnetic field. Find motional emf between its ends.
20. Sketch flux and emf versus time when flux decreases linearly to zero and then remains zero.

C. Short answers - 3 marks each

21. A coil has 200 turns and area 0.01 m^2 . Its normal rotates from parallel to perpendicular to a 0.4 T field in 0.05 s. Find average emf.
22. For a one-turn loop, flux $\Phi = 3t^2 - 2t + 1 \text{ Wb}$. Find emf at $t = 2 \text{ s}$ and the time when it is zero.
23. Two coils have mutual inductance 0.08 H. A primary current decreases from 5 A to 1 A in 0.02 s. Find secondary emf and describe the induced field's role.
24. A rectangular loop is pulled out of a uniform magnetic field at constant speed. Explain when current flows and why external work is needed.
25. A rod of length 0.5 m slides on conducting rails at 4 m/s in a perpendicular field of 0.8 T. Circuit resistance is 2 Ω . Find emf, current and opposing magnetic force.

D. Long answers - 5 marks each

26. Derive motional emf across a conducting rod moving perpendicular to a uniform magnetic field. Verify energy conservation by comparing mechanical and electrical power.
27. Using Lenz's law, explain the induced current for a loop entering, remaining wholly inside and leaving a uniform magnetic-field region. Sketch qualitative current versus time for constant speed.
28. Derive self-inductance of a long air-core solenoid in terms of turns, cross-sectional area and length. Explain its dependence on geometry.
29. Derive mutual inductance of two long coaxial solenoids of equal length, one tightly enclosing the other. Explain which cross-sectional area enters the formula.
30. A 100-turn coil of area 0.02 m^2 and resistance 5 Ω has its normal parallel to a field decreasing uniformly from 0.5 T to zero in 0.10 s. Find induced emf, current, charge transferred and joule heat.

ANSWER KEY - Numerical / short answers

- 4) Yes; a time-varying magnetic flux can link a stationary coil. 6) 7.5 V. 8) 0.40 V. 9) -100 V for positive increasing current; magnitude 100 V. 11) No; induced current does, but emf can exist in an open circuit. 12) 0.006 Wb. 13) 6 V. 15) It doubles. 17) 0.050 H. 18) Yes, if its area and orientation stay fixed. 19) Zero; ($\mathbf{v} \times \mathbf{B}$) is perpendicular to the rod. 21) 16 V average magnitude. 22) -10 V ; zero at $t = 1/3 \text{ s}$. 23) 16 V; the induced field opposes the decrease in linked flux. 25) 1.6 V; 0.80 A; 0.32 N opposing motion. 30) 10 V; 2 A; 0.20 C; 2 J.