

How to use this worksheet. Thirty-two questions, about 38 minutes. Only a **changing** flux induces an emf. In $\Phi = BA \cos\theta$ the angle is measured from the **normal** to the surface, not from the plane.

Formula sheet

$\Phi = BA \cos\theta$ (weber) | $\epsilon = -N d\Phi/dt$ | Motional emf: $\epsilon = Bvl$ | $q = N\Delta\Phi/R$

Self induction: $\epsilon = -L di/dt$ | $U = \frac{1}{2}LI^2$ | Solenoid: $L = \mu_0 n^2 Al$

Mutual induction: $\epsilon_2 = -M di_1/dt$ | $M = \Delta\Phi/\Delta I$

Section A · Level 1 — Flux, Faraday and Lenz

Ten questions. None should take more than twenty seconds.

1. The SI unit of magnetic flux is the:

- (1) Tesla (2) Weber (3) Henry (4) Gauss

2. Magnetic flux through a plane surface of area A in a uniform field B is given by:

- (1) $BA \sin\theta$ (2) $BA \cos\theta$ (3) $BA \tan\theta$ (4) BA

3. Faraday's law states that the induced emf is proportional to the:

- (1) Magnetic flux (2) Rate of change of magnetic flux (3) Magnetic field strength (4) Area of the coil

4. The negative sign in Faraday's law is a statement of:

- (1) Ohm's law (2) Lenz's law (3) Ampere's law (4) Gauss's law

5. Lenz's law is a direct consequence of the conservation of:

- (1) Charge (2) Momentum (3) Energy (4) Mass

6. The SI unit of inductance is the:

- (1) Weber (2) Tesla (3) Henry (4) Farad

7. An emf is induced in a coil when:

- (1) The flux through it is large (2) The flux through it is constant (3) The flux through it changes (4) The coil has many turns

8. Eddy currents are induced in:

- (1) Insulators (2) Bulk conductors exposed to changing flux (3) Vacuum (4) Only in semiconductors

9. The energy stored in an inductor carrying current I is:

- (1) LI (2) $\frac{1}{2}LI^2$ (3) $\frac{1}{2}L^2I$ (4) LI^2

10. An AC generator converts:

- (1) Electrical energy into mechanical energy (2) Mechanical energy into electrical energy (3) Heat into electrical energy (4) Chemical energy into electrical energy

Working space — Questions 1 to 10

Write the formula before you substitute.

Section B · Level 2 — Induced emf, current and stored energy

Ten questions. Check whether the question wants emf, current or charge.

11. A coil of area 0.2 m^2 lies perpendicular to a uniform field of 0.5 T . The flux through it is:

- (1) 0.1 Wb (2) 0.4 Wb (3) 2.5 Wb (4) 0.025 Wb

12. The flux through a coil changes by 0.02 Wb in 0.1 s . If the coil has 100 turns, the induced emf is:

- (1) 2 V (2) 20 V (3) 0.2 V (4) 200 V

13. A rod of length 0.5 m moves at 5 m/s perpendicular to a field of 0.4 T. The motional emf is:

- (1) 1 V (2) 0.1 V (3) 10 V (4) 2 V

14. An inductor of 2 H carries a current of 3 A. The energy stored is:

- (1) 6 J (2) 9 J (3) 18 J (4) 3 J

15. The current through a 0.5 H inductor changes by 4 A in 0.2 s. The induced emf is:

- (1) 2 V (2) 10 V (3) 0.4 V (4) 20 V

16. Two coils have a mutual inductance of 0.2 H. The current in the first changes at 5 A/s. The emf induced in the second is:

- (1) 0.04 V (2) 1 V (3) 10 V (4) 25 V

17. A coil is rotated so that its plane becomes parallel to the magnetic field. The flux through it is then:

- (1) Maximum (2) Half its maximum (3) Zero (4) Unchanged

18. A coil of resistance 2 Ω has an emf of 4 V induced in it. The induced current is:

- (1) 0.5 A (2) 2 A (3) 8 A (4) 6 A

19. When the north pole of a magnet is pushed towards a coil, the near face of the coil behaves as a:

- (1) South pole (2) North pole (3) Neutral surface (4) Pole that alternates

20. A total charge q flows through a coil of resistance R when the flux changes by $\Delta\Phi$. The charge is given by:

- (1) $\Delta\Phi \times R$ (2) $\Delta\Phi / R$ (3) $R / \Delta\Phi$ (4) $\Delta\Phi / R^2$

Working space — Questions 11 to 20

Write the formula before you substitute.

Section C · Level 3 — Self and mutual inductance, eddy currents

Ten questions. Each needs a formula plus a piece of reasoning.

21. The self inductance of a long solenoid of n turns per unit length, cross-sectional area A and length l is:

- (1) $\mu_0 n A l$ (2) $\mu_0 n^2 A l$ (3) $\mu_0 n^2 A / l$ (4) $\mu_0 n A / l$

22. A solenoid has 1000 turns per metre, cross-sectional area 10^{-4} m^2 and length 0.5 m. Its self inductance is closest to:

- (1) $6.3 \times 10^{-5} \text{ H}$ (2) $6.3 \times 10^{-4} \text{ H}$ (3) $1.3 \times 10^{-4} \text{ H}$ (4) $6.3 \times 10^{-6} \text{ H}$

23. If the number of turns of a coil is doubled, its self inductance becomes:

- (1) Twice as large (2) Half as large (3) Four times as large (4) Unchanged

24. Eddy current losses in a transformer core are reduced by:

- (1) Using a thicker solid core (2) Laminating the core (3) Raising the supply voltage (4) Using a copper core

25. A metal plate swinging between the poles of a magnet comes to rest quickly because of:

- (1) Air resistance alone (2) Eddy currents opposing the motion (3) Loss of magnetisation (4) Increased friction at the pivot

26. In a coil rotating uniformly in a magnetic field, the induced emf is maximum when the plane of the coil is:

- (1) Perpendicular to the field (2) Parallel to the field (3) At 45° to the field (4) The emf is constant throughout

27. Two coils are placed so that no flux from one links the other. Their mutual inductance is:

- (1) Maximum (2) Zero (3) Equal to the sum of their self inductances (4) Infinite

28. The induced charge in a circuit depends on:

- (1) How fast the flux changes (2) The total change in flux only (3) The resistance only (4) The self inductance only

29. A current-carrying inductor is suddenly disconnected from its supply. A large spark often appears at the switch because:

(1) The current increases (2) The inductor opposes the sudden fall in current, inducing a large emf (3) The resistance falls to zero (4) The magnetic field reverses

30. Which of the following does **not** induce an emf in a stationary coil placed in a magnetic field?

(1) Changing the field strength (2) Rotating the coil (3) Changing the area of the coil (4) Keeping the flux constant

Working space — Questions 21 to 30 Write the formula before you substitute.

Section D · Previous year questions — Straight from the AAI ATC papers

Two questions from the 2023 papers, recovered by optical character recognition of the scanned answer sheets and independently re-solved.

31. A constant current I is maintained in a coil of pure inductance L . The energy stored in the coil is: **[PYQ 2023 · Morning]**

(1) $\frac{1}{4}LI^2$ (2) $\frac{1}{2}LI^2$ (3) LI (4) LI^2

32. Two coils are arranged close to each other. When the current in one coil changes from 0 A to 10 A in 0.5 s, the flux linked with the other coil changes by 40 Wb during the same period. The mutual inductance of the coils is:

[PYQ 2023 · Morning]

(1) 4.0 H (2) 8.0 H (3) 6.0 H (4) 2.0 H

Working space — Questions 31 to 32 Write the formula before you substitute.

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