

Show equations, substitutions, units, and vector directions. Explain your reasoning. Use sensible rounding.

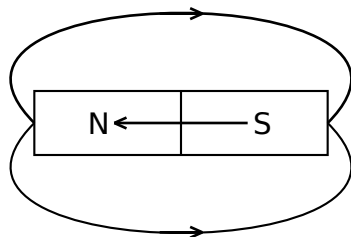
Answers appear below each question beside a vertical bar. Equivalent correct reasoning is acceptable.

Constants	$e = 1.60 \times 10^{-19} \text{ C}$ B in teslas (T) Φ in webers (Wb)
Equations	$F_B = q vB \sin \theta$ $F_{\text{wire}} = ILB$ (wire perpendicular to field) $\Phi = BA$ (field perpendicular to loop) $ \mathcal{E} = N \Delta\Phi /\Delta t$ $I = \mathcal{E} /R$ $V_s/V_p = N_s/N_p$ $P = IV$ $P_{\text{loss}} = I^2R$

Use conventional current. A dot means out of the page and a cross means into the page.

8.1 Magnetic Fields

1. Sketch field lines around a bar magnet with N on the left and S on the right. Show field direction outside the magnet. State how a compass's north end aligns with the field.



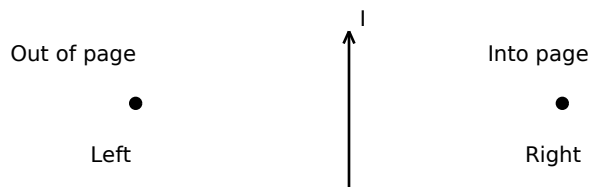
Outside the magnet, field lines point from N to S. They continue through the magnet from S to N in closed loops. A compass's north end points along the local field. Dense lines near poles indicate stronger field.

2. A bar magnet is cut into three pieces. How many north and south poles result? Explain how domain alignment distinguishes a magnetized iron sample from an unmagnetized one.

Each piece is a smaller magnet with a north and south pole: three of each total. Magnetized iron has many domains aligned. Unmagnetized iron has domains oriented in different directions, so their effects largely cancel.

8.2 Magnetic Fields from Currents

3. A straight wire carries conventional current upward on the page. State the magnetic-field direction on its right and left sides. Then reverse the current and describe the change.



Right-hand grip rule: thumb up. On the right side, B is into the page. On the left, B is out of the page. Reversing current reverses both field directions.

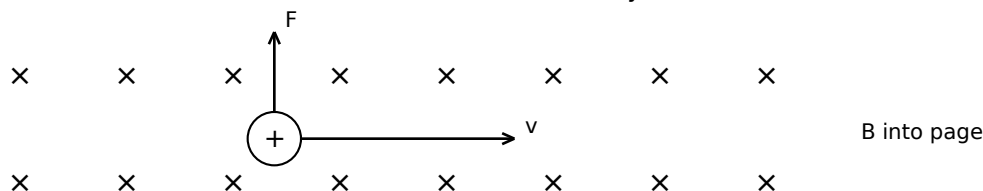
4. A coil is rewound from 100 to 200 turns over the same length and current increases from 1.5 A to 4.5 A. Estimate the factor change in field strength for the same core. Name one other way to strengthen it.

For unchanged coil geometry and core, B is proportional to NI . Factor = $(200/100)(4.5/1.5) = 6$. Replacing an air core with a suitable iron core can strengthen the field.

ANSWER KEY

8.3 Magnetic Force on Moving Charges

5. A proton moves right at 3.0×10^6 m/s in a 0.40 T magnetic field into the page. Find force magnitude and direction. What direction would the force have for an electron with the same velocity?



$F = |q|vB = (1.60 \times 10^{-19})(3.0 \times 10^6)(0.40) = 1.9 \times 10^{-13}$ N. The proton's force is upward. The electron's force is downward, with the same magnitude.

6. A proton travels at 2.0×10^6 m/s at 30° to a 0.50 T field. Find force magnitude. State the force if the proton is at rest or moving parallel to the field.

$F = (1.60 \times 10^{-19})(2.0 \times 10^6)(0.50)\sin 30^\circ = 8.0 \times 10^{-14}$ N. At rest, $v = 0$, so $F = 0$. Parallel motion gives $\sin 0^\circ = 0$, also $F = 0$.

7. A 0.25 m wire carries 6.0 A to the right through a 0.40 T magnetic field out of the page. Find force magnitude and direction.

$F = ILB = (6.0)(0.25)(0.40) = 0.60$ N. The right-hand rule for conventional current gives a downward force.

8. A charged particle enters a uniform magnetic field with velocity perpendicular to the field. Explain why its path curves but speed stays constant. State the direction of the magnetic force relative to velocity.

The force is always perpendicular to velocity, so it changes direction without doing work or changing kinetic energy. In a uniform field with no other forces, perpendicular entry gives circular motion at constant speed.

ANSWER KEY

8.4 Electromagnetic Induction

9. A magnet's north pole is pushed into a closed conducting coil. A meter deflects right. Predict its reading when (a) the magnet is held still, (b) the north pole is pulled out, and (c) the south pole is pushed in.

(a) No induced current once flux stops changing. (b) Left deflection. (c) Left deflection. Reversing motion or pole reverses the flux change and induced current direction.

10. A loop is 0.15 m by 0.20 m. A uniform 0.50 T magnetic field passes perpendicular to its plane. Find magnetic flux. What happens to flux if field strength doubles with area fixed?

$A = (0.15)(0.20) = 0.030 \text{ m}^2$. $\Phi = BA = (0.50)(0.030) = 0.015 \text{ Wb}$. Doubling B doubles flux to 0.030 Wb.

11. A 200-turn coil has area 0.010 m² per turn. A perpendicular field increases from 0.10 T to 0.40 T in 0.20 s. Find induced emf magnitude and current if total resistance is 6.0 Ω .

$\Delta\Phi = A\Delta B = (0.010)(0.40 - 0.10) = 0.0030 \text{ Wb per turn}$. $|\epsilon| = N|\Delta\Phi|/\Delta t = 200(0.0030)/0.20 = 3.0 \text{ V}$. $I = 3.0/6.0 = 0.50 \text{ A}$.

12. Explain why moving a magnet through a closed conducting coil takes work. Predict how induced emf changes when the same flux change occurs in half the time.

The induced current produces a magnetic effect opposing the flux change. External work supplies electrical energy, which may become thermal energy in the circuit. Half the time doubles $|\epsilon| = N|\Delta\Phi|/\Delta t$. This opposition prevents energy creation from nothing.

ANSWER KEY

8.5 Motors and Generators

13. Compare a motor and a generator. State each device's energy input, energy output, and physical principle. Explain the role of the split-ring commutator in a simple DC motor.

Motor: electrical input to mechanical output through magnetic force on current-carrying wire. Generator: mechanical input to electrical output through changing magnetic flux. The commutator reverses coil current each half-turn to keep torque in the same rotational direction.

14. An ideal transformer has 800 primary turns and 40 secondary turns. The primary connects to 120 V AC. Find secondary voltage. Is it step-up or step-down? Explain why steady DC does not sustain transformer operation.

$V_s = V_p (N_s/N_p) = 120(40/800) = 6.0 \text{ V}$. It is step-down. Steady DC produces no continuing change in magnetic flux after the initial switching transient, so it cannot sustain secondary induction.

Unit 8 Review

15. An ideal transformer raises 12,000 V to 240,000 V. Its primary has 150 turns. Find the secondary turns. For 480,000 W transmitted power, find current at each voltage.

$N_s = N_p (V_s/V_p) = 150(240,000/12,000) = 3000 \text{ turns}$. At 12,000 V, $I = P/V = 40 \text{ A}$. At 240,000 V, $I = 2.0 \text{ A}$.

16. Using Question 15, compare resistive power loss in the same transmission line at the two currents. Explain why a generator requires a continuing mechanical energy supply.

$P_{\text{loss}} = I^2 R$. The current falls by a factor of 20, so loss falls by $20^2 = 400$, to 1/400 of its former value. A generator transfers mechanical energy into electrical energy. Its induced current opposes the motion, so sustained output requires continuing work.