ICSE CLASS 10 · PHYSICS

Chapter 10 : ELECTRO-MAGNETISM

STEP-BY-STEP SOLUTIONS & MARKING SCHEME (40 MARKS)

Maximum Marks: 40 · Section A (20) compulsory · Section B: any two of three questions (2 × 10 = 20) · $F = BIl$ · $e = N \times$ (change in flux ÷ time) · $E_s \div E_p = N_s \div N_p = I_p \div I_s$ · $f = 1 \div T$

Marks for each step are shown in square brackets on the right. Parts added in the solution diagrams are drawn in red.

SECTION A (20 Marks)

Question 1 — Multiple choice [8 marks, 1 mark each]

No.	Answer	Reason
(i)	**(b)** concentric circles around the wire	Iron filings and a compass show that the field lines form concentric circles around the wire (right hand thumb rule).
(ii)	**(a)** north pole	By the clock rule, anticlockwise current at a face makes it a north pole; clockwise makes it a south pole.
(iii)	**(d)** soft iron	Soft iron has high magnetic permeability and low retentivity, so it magnetises strongly and loses magnetism when the current is off.
(iv)	**(c)** current	Fleming's left hand rule: forefinger – field, central finger – current, thumb – force (motion).
(v)	**(c)** Both (A) and (R) are true, and (R) is the correct explanation for (A).	Both are true: with d.c. the flux linked with the secondary does not change, so no e.m.f. is induced; (R) explains (A).
(vi)	**(c)** 100 V	$E_s \div E_p = N_s \div N_p$, so $E_s = 20 \times 500 \div 100 = 100$ V.
(vii)	**(b)** mechanical to electrical	An a.c. generator converts mechanical energy into electrical energy (electromagnetic induction).
(viii)	**(b)** Fleming's right hand rule	Induced current direction is given by Fleming's right hand rule (or Lenz's law).

Question 2 [6 marks]

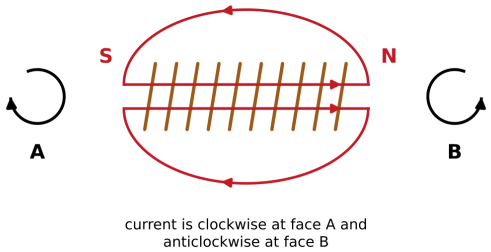
(a) An **electromagnet** is a temporary strong magnet made by passing current through a coil wound on a piece of soft iron. [1] **[2]**

The core is made of **soft iron**. [1]

(b) (i) Clockwise current at face A: **south pole**; anticlockwise current at face B: **north pole** (clock rule). [1] **[3]**

(ii) Inside the solenoid the lines are straight and parallel, directed from A (S) to B (N); outside they form closed curves from the north pole B round to the south pole A (red lines). [1]

(iii) The field inside becomes **stronger** (lines closer), because soft iron has high magnetic permeability. [1]



current is clockwise at face A and anticlockwise at face B

Solution to Q2(b)

(c) Only a.c. voltage can be stepped up with a transformer, so power can be transmitted at high voltage and low current, which reduces the loss of energy (I^2Rt) in the line wires. [1] **[1]**

Question 3 [6 marks]

(a) Given: N = 100, $\Phi_1 = 2 \times 10^{-3}$ Wb, $\Phi_2 = 8 \times 10^{-3}$ Wb, t = 0.05 s. **[3]**

(i) Change in flux = $8 \times 10^{-3} - 2 \times 10^{-3} =$ **6×10^{-3} Wb**. [1]

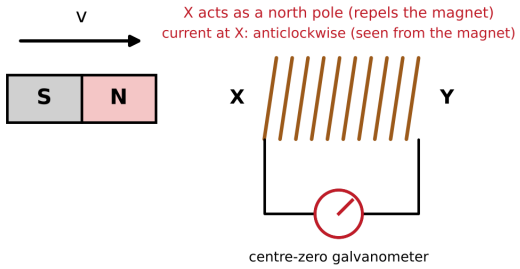
(ii) Rate of change of flux per turn = $(6 \times 10^{-3}) \div 0.05 =$ **0.12 Wb s^{-1}**. [1]

(iii) e = N × rate of change of flux = $100 \times 0.12 =$ **12 V**. [1]

(b) (i) A **momentary deflection** is seen in the galvanometer while the magnet moves, since the flux linked with the coil is changing. [1] **[3]**

(ii) The end X facing the magnet becomes a **north pole** (current anticlockwise as seen from the magnet) to oppose the approach of the magnet; the law is **Lenz's law**. [1]

(iii) **No deflection**: when the magnet is stationary the flux linked with the coil does not change, so no e.m.f. is induced. [1]



Solution to Q3(b)

SECTION B (20 Marks) — any two questions

Question 4 [10 marks]

(a) Given: l = 0.5 m, I = 4 A, B = 0.2 T. **[3]**

(i) F = BIl = $0.2 \times 4 \times 0.5 =$ **0.4 N**. [1]

(ii) The current is parallel to the field, so **F = 0**. [1]

(iii) I′ = 8 A and l′ = 0.25 m: F = $0.2 \times 8 \times 0.25 =$ **0.4 N** (unchanged, since I × l is the same). [1]

(b) (i) Soft iron has high permeability and low retentivity, so it becomes strongly magnetised when current flows and loses its magnetism when the current is switched off. [1] **[3]**

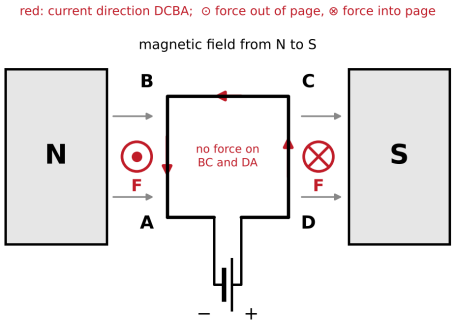
(ii) It reverses the direction of current in the coil every half rotation, so the couple always acts in the same sense and the coil keeps rotating in one direction. [1]

(iii) Laminations insulated from each other reduce the eddy currents in the core, so the loss of energy as heat is small. [1]

(c) (i) The positive terminal is on the D side, so the current flows in the direction **D → C → B → A** (DCBA). [1] **[4]**

(ii) By Fleming's left hand rule (field from N to S): on **AB** the force is **outwards** (out of the page); on **CD** it is **inwards** (into the page); on **BC** and **DA** the arms are parallel to the field, so there is **no force**. [2]

(iii) The forces on AB and CD form a couple, so the coil rotates. On interchanging the battery connections, the current and the forces reverse, so the coil rotates in the **opposite direction**. [1]



Solution to Q4(c)

Question 5 [10 marks]

(a) Any three (1 mark each): **[3]**

• An electromagnet is made of soft iron; a permanent magnet is made of steel.

• An electromagnet produces a field only while current flows; a permanent magnet produces a permanent field.

• The strength of an electromagnet can be changed (by current or turns); that of a permanent magnet cannot.

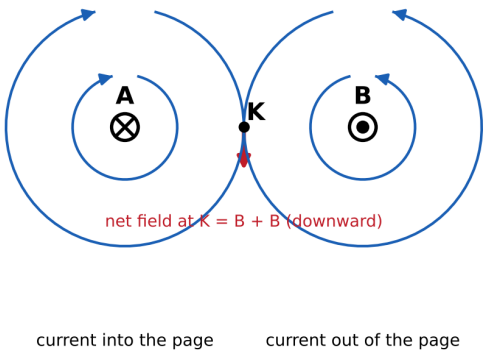
• The polarity of an electromagnet can be reversed (by reversing the current); that of a permanent magnet cannot.

• An electromagnet can be very strong and is easily demagnetised; a permanent magnet is weaker and not easily demagnetised.

(b) (i) The **right hand thumb rule**. [1] **[3]**

(ii) A (current into the page) gives clockwise field lines, so at K the field is **downward** in the plane of the paper; B (current out of the page) gives anticlockwise lines, so at K the field is also **downward**. [1]

(iii) The two fields are in the same direction and equal in magnitude, so they add: the resultant is **downward** and **twice** the field due to one wire. [1]



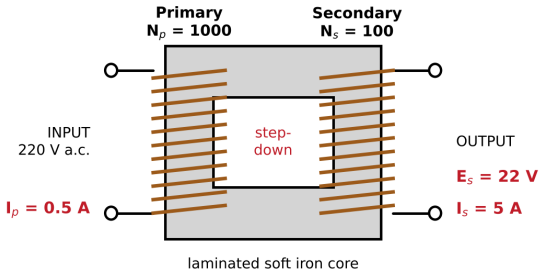
Solution to Q5(b)

(c) (i) N_s (100) < N_p (1000), so it is a **step-down transformer**. [1] **[4]**

(ii) $E_s = E_p \times N_s \div N_p = 220 \times 100 \div 1000 =$ **22 V**. [1]

(iii) For an ideal transformer $E_p I_p = E_s I_s$: $I_p = (22 \times 5) \div 220 =$ **0.5 A**. [1]

(iv) The **secondary** coil has thicker wire, since it carries the larger current (5 A); a thicker wire has less resistance, so less heat (copper loss) is produced. [1]



Solution to Q5(c)

Question 6 [10 marks]

(a) Any three (1 mark each): **[3]**

• An a.c. generator converts mechanical energy into electrical energy; a d.c. motor converts electrical energy into mechanical energy.

• A generator works on electromagnetic induction; a motor works on the force on a current-carrying conductor in a magnetic field.

• In a generator the coil is rotated in the field to produce current; in a motor current is passed in the coil so that it rotates.

• A generator uses two slip rings; a motor uses a split ring commutator.

(b) (i) **Lenz's law**: the direction of the induced e.m.f. (or current) is such that it opposes the change (cause) which produces it. [1] **[3]**

(ii) The magnitude of the induced e.m.f. is directly proportional to the rate of change of magnetic flux linked with the coil (and to the number of turns). [1]

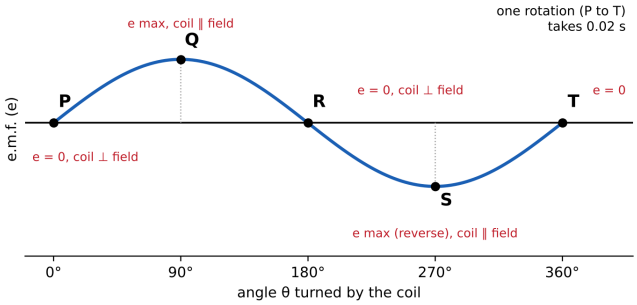
(iii) **Mechanical energy** is converted into **electrical energy**. [1]

(c) (i) At Q (90°) the coil is **parallel** to the magnetic field. [1] **[4]**

(ii) The e.m.f. is maximum at **Q** and **S** (positive and negative peaks), where the coil is parallel to the field. [1]

(iii) T = 0.02 s, so f = 1 ÷ T = 1 ÷ 0.02 = **50 Hz**. [1]

(iv) The frequency doubles (**100 Hz**) and the maximum e.m.f. also doubles. [1]



Solution to Q6(c)

Marks summary	
Section A: Q1 (8) + Q2 (2 + 3 + 1 = 6) + Q3 (3 + 3 = 6)	**20**
Section B: any two of Q4 – Q6 (10 marks each)	**20**
Total	**40**