Physics · Electric Current and Electromagnetism · Electromagnetic Induction

Faraday's Law

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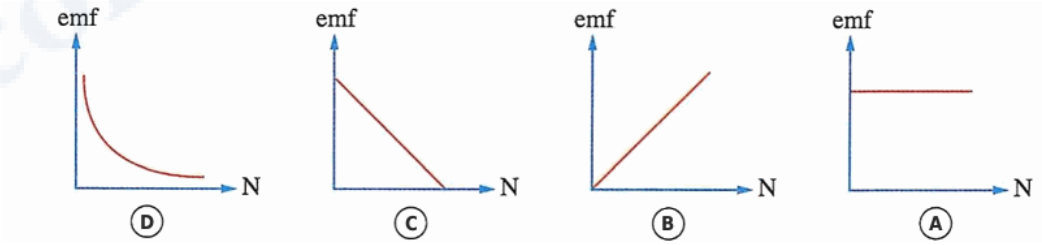
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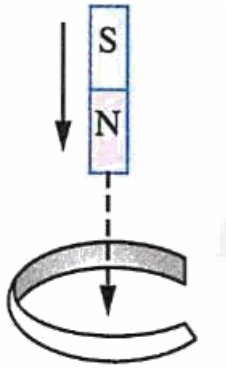
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Multiple choice questions — 118 questions

1 Which of the following graphs represents the relation between the induced emf in a coil placed in a magnetic field that changes uniformly with time and the number of turns of the coil (N)?



2 In the opposite figure, a magnet falls through an open aluminium ring placed horizontally. Which of the following choices describes what happens between the magnet and the ring while the magnet approaches it and while it moves away from it?



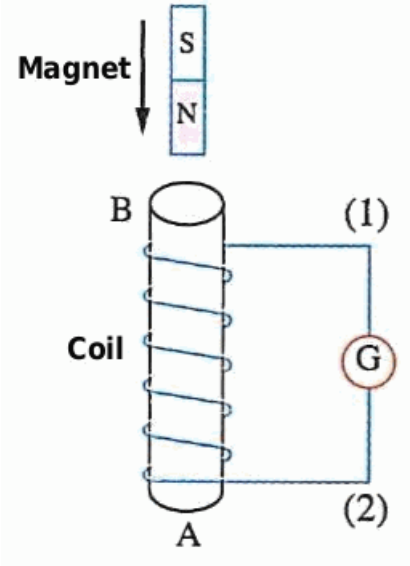
(A) While the magnet approaches the ring: a repulsive force is produced; while it moves away: an attractive force is produced

(B) While the magnet approaches the ring: an attractive force is produced; while it moves away: a repulsive force is produced

(C) While the magnet approaches the ring: a repulsive force is produced; while it moves away: a repulsive force is produced

(D) While the magnet approaches the ring: no magnetic force is produced; while it moves away: no magnetic force is produced

3 A magnet falls towards a coil as shown in the figure. Which of the following choices is correct?



(A) Direction of the current in the galvanometer: from 1 to 2; pole formed at (A): north

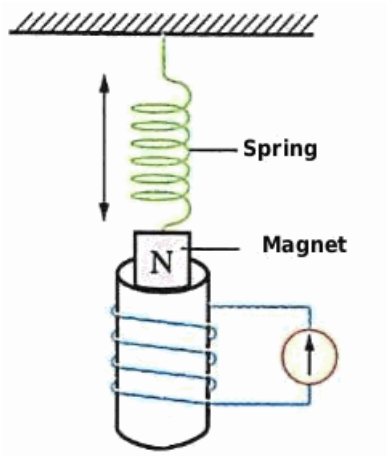
(B) Direction of the current in the galvanometer: from 1 to 2; pole formed at (A): south

(C) Direction of the current in the galvanometer: from 2 to 1; pole formed at (A): north

(D) Direction of the current in the galvanometer: from 2 to 1; pole formed at (A): south

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4 In the opposite figure, a magnet hangs from a freely moving spring and moves into and out of a coil whose ends are connected to a centre-zero galvanometer. When the magnet oscillates up and down, the pointer of the galvanometer .....



(A) oscillates right and left

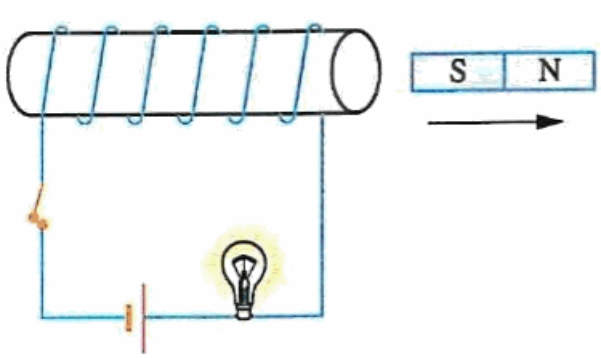
(B) stays at the left

(C) stays at the right

(D) stays at zero

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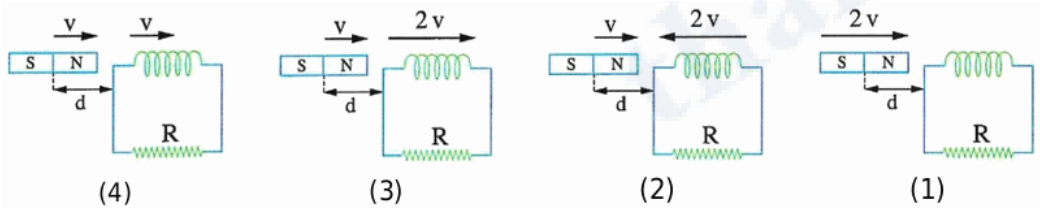
5 In the opposite figure, while the magnet is moved in the shown direction, the brightness of the lamp .....



(A) decreases momentarily
(B) increases momentarily
(C) becomes zero
(D) stays unchanged

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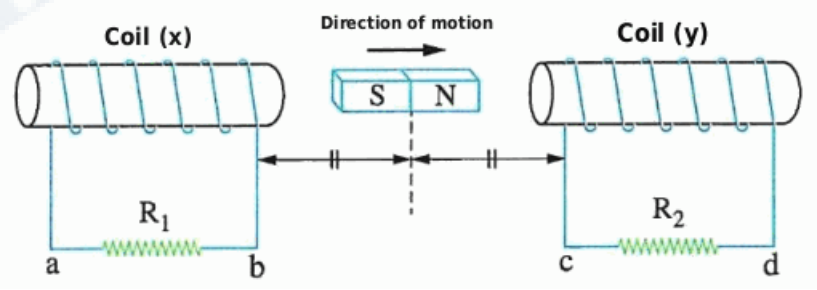
6 The following figures show a student's attempts to study the effect of the direction and size of the relative velocity between a magnet and a coil on the induced emf in the coil. If the magnet moves at a uniform velocity over the distance d in each attempt, the correct descending order of the average induced emf in the coil in these attempts is .....



(A) (3) then (2) then (4) then (1)
(B) (2) then (1) then (3) then (4)
(C) (1) then (3) then (2) then (4)
(D) (2) then (3) then (4) then (1)

---

7 Two identical neighbouring coils (x) and (y) have resistances R_1 and R_2 respectively connected between their ends, and a magnet is placed midway between the two coils along their axes as shown in the following figure. When the magnet is moved along the axes of the coils towards coil (y), an induced current flows in the two resistances in the direction .....



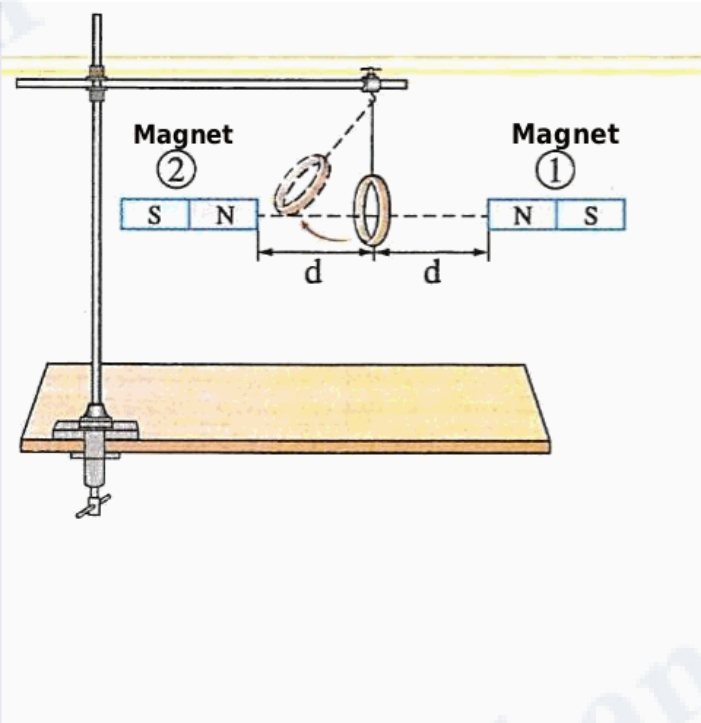
(A) Resistance R_1: $a \rightarrow b$, resistance R_2: $c \rightarrow d$

(B) Resistance R_1: $a \rightarrow b$, resistance R_2: $d \rightarrow c$

(C) Resistance R_1: $b \rightarrow a$, resistance R_2: $c \rightarrow d$

(D) Resistance R_1: $b \rightarrow a$, resistance R_2: $d \rightarrow c$

8 A metal ring hangs from a thread whose other end is fixed. When two identical magnets (1) and (2) are moved together at a uniform velocity (v) along the axis of the ring, the ring is displaced as shown in the opposite figure. So .....



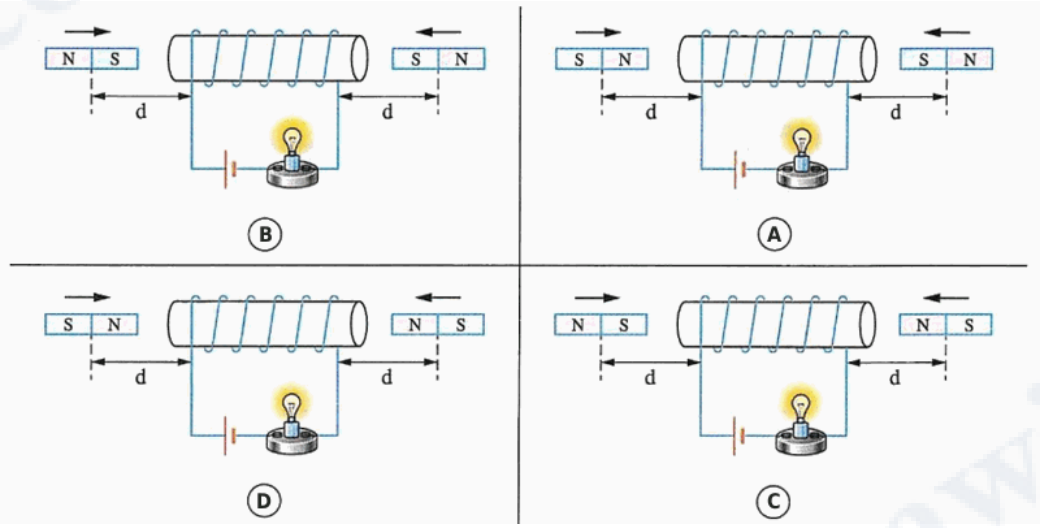
(A) magnet (1): approaches the ring, magnet (2): approaches the ring

(B) magnet (1): approaches the ring, magnet (2): moves away from the ring

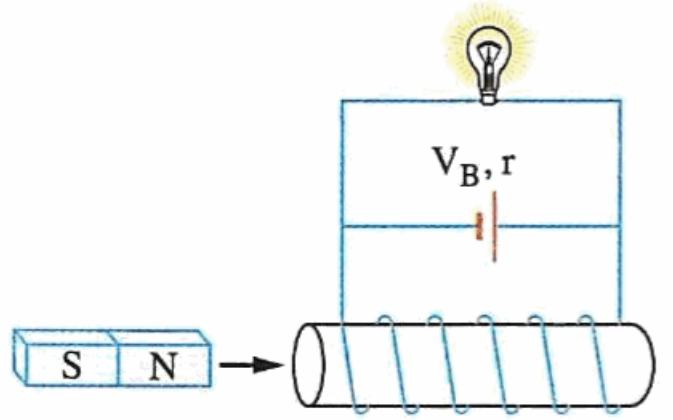
(C) magnet (1): moves away from the ring, magnet (2): approaches the ring

(D) magnet (1): moves away from the ring, magnet (2): moves away from the ring

9 Suppose two identical bar magnets approach together, at the same uniform velocity, a solenoid connected to a cell and a small lamp as shown in the following figures. In which of these figures does the brightness of the lamp increase while the two magnets cover the distance d? (Given that the resultant induced emf in the coil in all figures is less than the emf of the battery.)

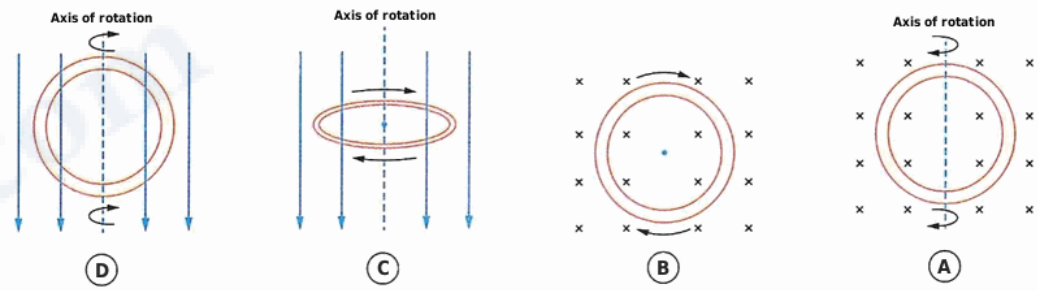


10 A battery of emf (V_B) and internal resistance (r) is connected to a lamp and a coil of resistance (R). When a magnet approaches the coil at a uniform velocity as shown in the opposite figure, an induced emf less than (V_B) is produced in the coil. What happens to the brightness of the lamp while the magnet is moving?

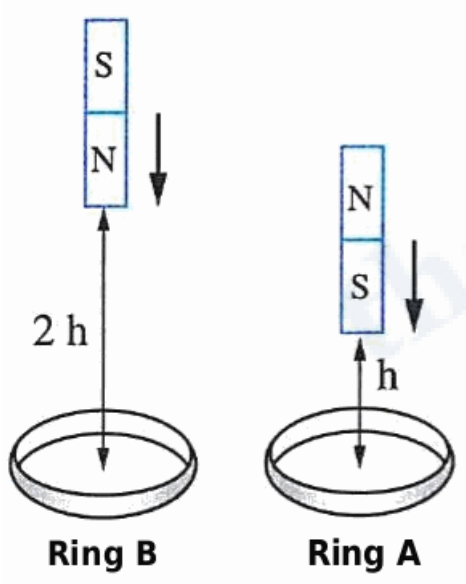


(A) It increases
(B) It decreases
(C) It does not change
(D) The answer cannot be determined

11 The suitable way of moving a metal ring in a magnetic field to produce an induced emf according to the laws of electromagnetic induction is shown in figure .....



12 The opposite figure shows two identical bar magnets falling freely from heights h and 2 h along the axes of two identical metal rings A and B respectively. Which statement describes the induced current in the two rings at the moment each magnet reaches the level of its ring?



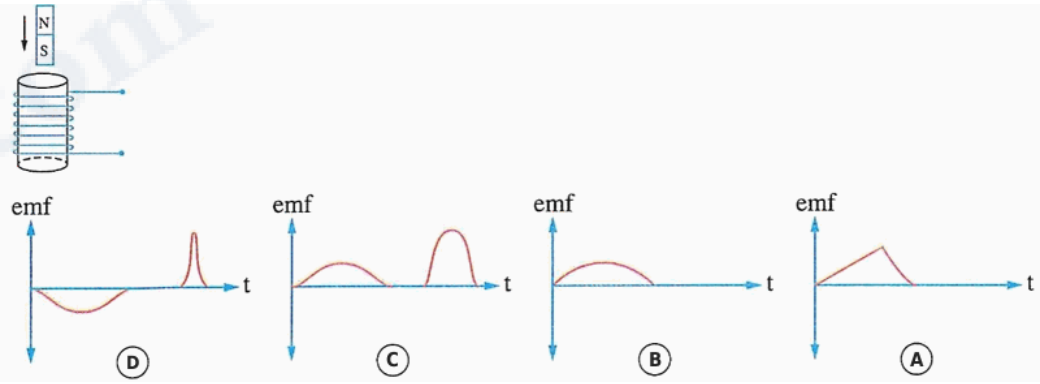
(A) The induced current in ring A is greater

(B) The induced current in ring B is greater

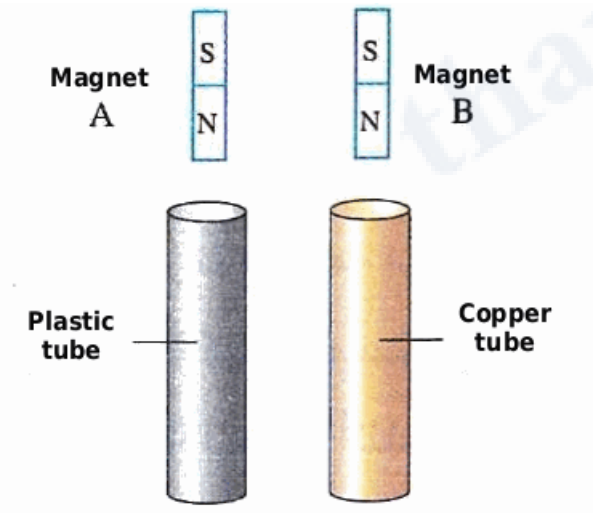
(C) The induced currents in the two rings are equal

(D) The induced current flows in the same direction in the two rings

13 Using the opposite figure, which of the following graphs represents the change of the induced emf between the ends of the coil with time (t) while the magnet falls freely through the coil until it leaves from the other end?

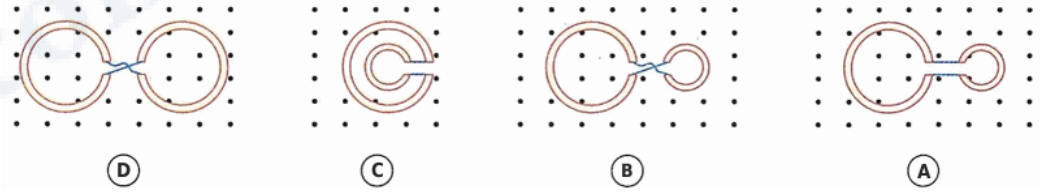


14 The opposite figure shows two small identical magnets A and B dropped from the same level at the same moment to pass through two vertical tubes of the same dimensions, one made of plastic and the other of copper, without touching the walls of the tubes. If magnet (A) takes a time (t) to pass through its tube, then magnet (B) takes a time .....

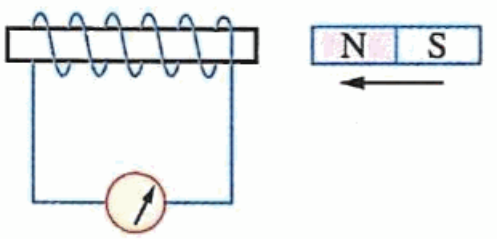


(A) greater than (t)
(B) less than (t)
(C) equal to (t)
(D) The answer cannot be determined

15 Each of the following figures shows two incomplete metal rings in one plane, connected together by two connecting wires and placed in a uniform magnetic flux perpendicular to their plane. In which of these figures does the greatest induced current flow in the rings while the magnetic flux density acting on them increases at a uniform rate?



16 If the number of turns of the coil shown in the figure is 20, and when a magnet is brought near it the flux through it increases by 0.2 Wb in 0.02 s, the average induced emf is .....



(A) 0.2 V (B) 1 V (C) 20 V (D) 200 V

17 Two rings x and y of areas 2 A and A respectively are placed perpendicular to a magnetic field whose flux density changes uniformly with time. The ratio of the induced emfs in the two rings $(((emf)_x)/((emf)_y))$ during the same time interval is .....

(A) *1/2* (B) *2/1* (C) *1/1* (D) *4/1*

18 A metal wire of uniform cross-section is used to make two rings a and b of radii r and 2 r respectively, and each ring is placed in a magnetic field perpendicular to its plane. If the magnetic flux through them changes at the same rate, the ratio between:

(1) the induced emfs in the two rings $(((emf)_a)/((emf)_b))$ equals .....

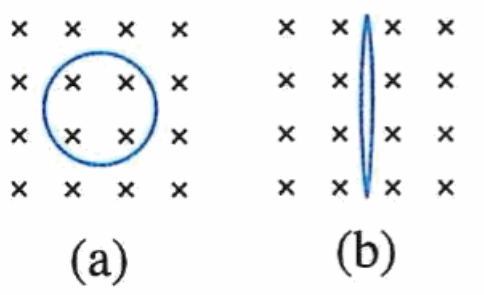
(A) *1/4* (B) *4/1* (C) *1/2* (D) *1/1*

19 A metal wire of uniform cross-section is used to make two rings a and b of radii r and 2 r respectively, and each ring is placed in a magnetic field perpendicular to its plane. If the magnetic flux through them changes at the same rate, the ratio between:

(2) the induced currents in the two rings (I_a/I_b) equals .....

(A) *1/4* (B) *2/1* (C) *1/2* (D) *1/1*

20 A loop of flexible metal wire of radius 0.12 m is perpendicular to a uniform magnetic field of flux density 0.15 T as in figure (a). If the two sides of the loop are pressed until its area becomes 3×10^{-3} m² as in figure (b) in a time of 0.2 s, the average induced emf in the loop during that time equals .....



(A) 0 (B) 1.12×10^{-3} V (C) 2.14×10^{-3} V (D) 31.7×10^{-3} V

21 A circular ring of radius 7 cm is placed perpendicular to a magnetic field of flux density 0.1 T. If the ring is folded at its middle in 2 s so that the plane of one half becomes parallel to the field, the average induced emf in the ring during that time equals .....

(A) 0.1925 mV (B) 0.385 mV (C) 0.5775 mV (D) 0.77 mV

22 The following cases show the change in flux through a circular coil of N turns. Which of them produces the greatest induced emf in the coil?

(A) The flux changes from 2 Wb to 2.1 Wb in 10^{-4} s

(B) The flux changes from 4 Wb to 0.2 Wb in 0.2 s

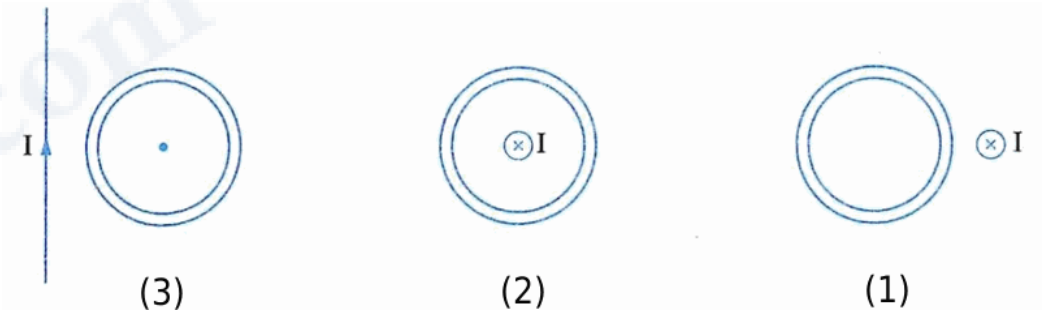
(C) The flux changes from 1 Wb to 20 Wb in 10 s

(D) The flux changes from 0.01 Wb to 0.02 Wb in 0.2 s

23 A coil of 100 turns has a magnetic flux of 0.02 Wb through it. If this flux doubles in 0.01 s, the average induced emf between the ends of the coil equals .....

(A) −400 V (B) −350 V (C) −275 V (D) −200 V

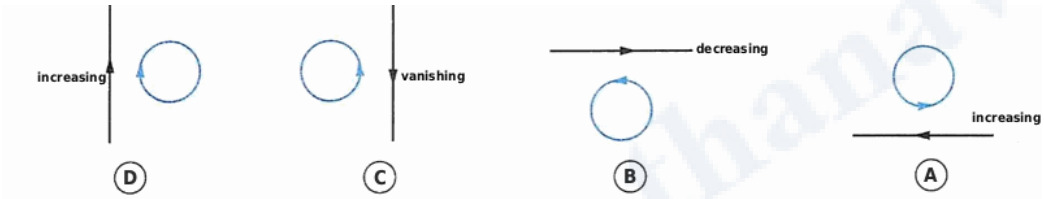
24 A straight wire carrying a current I is placed in several positions relative to a vertical metal ring as shown in the following three cases. If the current in the wire increases at a uniform rate, in which of the three cases is a current induced in the ring?



(A) Case (1) only
(B) Case (2) only
(C) Case (3) only
(D) Cases (1) and (3) only

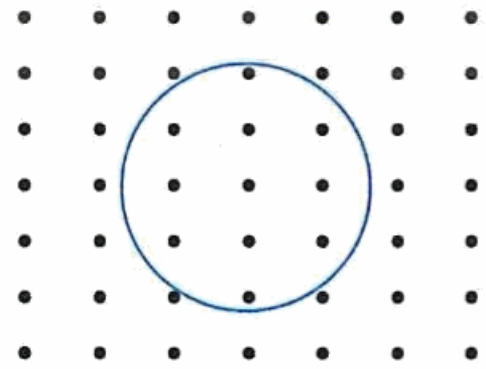
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25 Which of the following choices shows the correct direction of the induced current in the metal ring due to the change in the current in the wire shown in each figure?



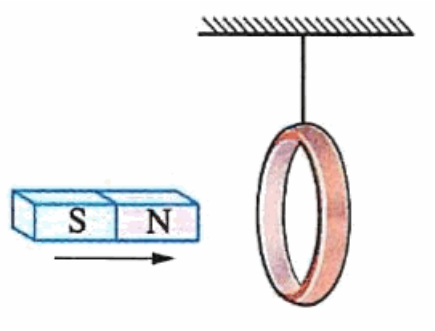
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26 The opposite figure shows a ring in the plane of the page acted on by a uniform magnetic field perpendicular to the page and outwards. Which of the following produces a clockwise induced current in the closed metal ring?



(A) Moving the ring to the right inside the magnetic field
(B) Moving the ring upwards inside the magnetic field
(C) Decreasing the magnetic flux density acting on the ring
(D) Increasing the magnetic flux density acting on the ring

27 A copper ring hangs freely from a thread. When a magnet is brought near the ring as shown in the figure .....



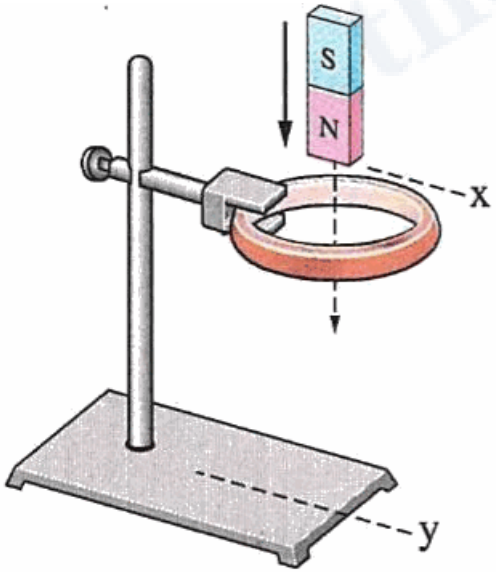
(A) the ring is attracted to the magnet

(B) the face of the ring facing the magnet becomes a north pole

(C) the face of the ring facing the magnet becomes a south pole

(D) no force acts on the ring because it is made of copper

28 If a bar magnet falls from level x to level y through an aluminium ring fixed horizontally by a stand as shown in the figure, then, looking at the ring from above, the direction of the induced current in the ring is .....



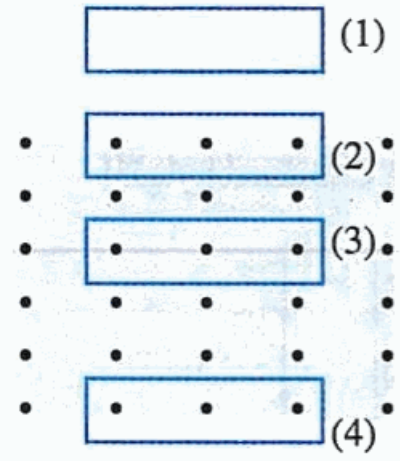
(A) always clockwise

(B) always anticlockwise

(C) clockwise, then it reverses

(D) anticlockwise, then it reverses

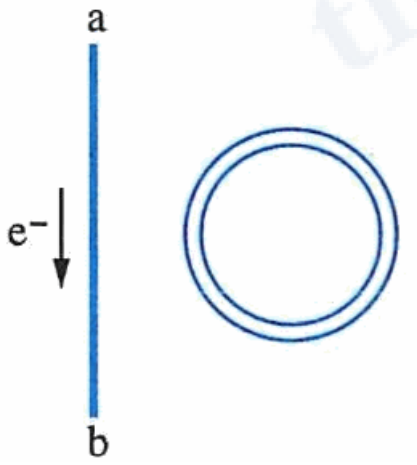
29 A rectangular metal frame in a vertical plane is left to fall through a uniform magnetic field as shown in the opposite figure. At which of the positions shown in the figure is the induced emf in the frame greatest?



(A) Position (1) (B) Position (2) (C) Position (3) (D) Position (4)

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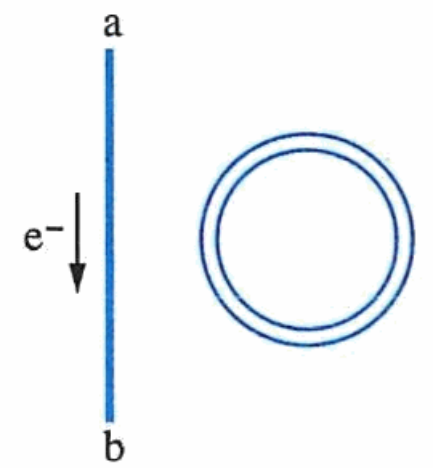
30 A fixed metal ring has, next to it and in its plane, a straight wire ab carrying a direct current as shown in the opposite figure. If the free electrons in the wire move from end a to end b:
(1) the ring, in the shown position, ...



(A) has an induced emf of constant magnitude and changing direction
(B) has an induced emf of constant magnitude and direction
(C) has an induced emf of changing magnitude and direction
(D) has no induced emf

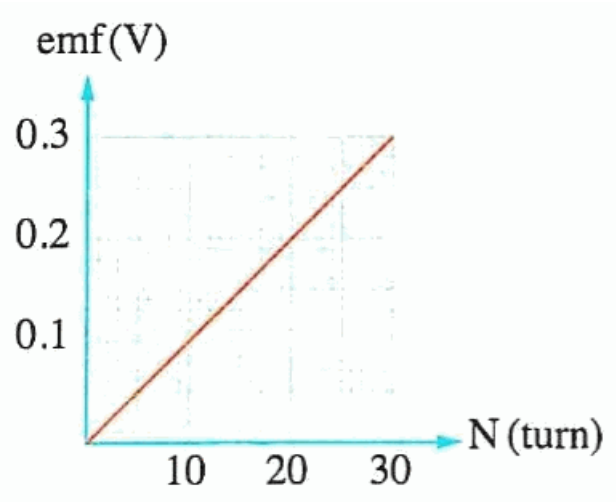
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31 A fixed metal ring has, next to it and in its plane, a straight wire ab carrying a direct current as shown in the opposite figure. If the free electrons in the wire move from end a to end b:
(2) when the wire is moved at a uniform velocity towards the centre of the ring, parallel to its plane, the ring .....



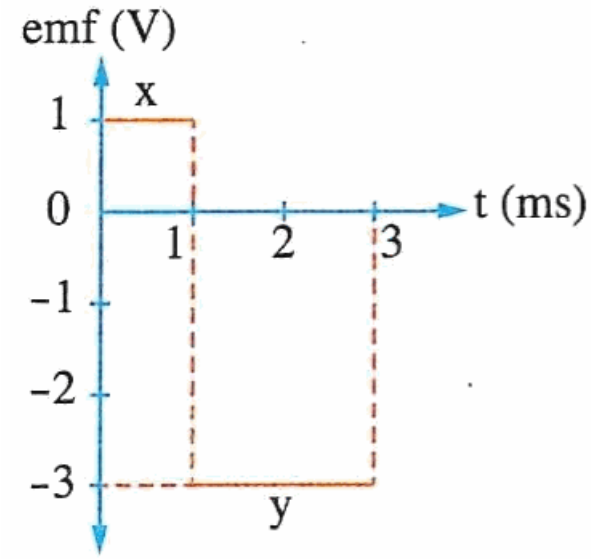
(A) has a clockwise induced current
(B) has an anticlockwise induced current
(C) has an induced current of constant magnitude and changing direction
(D) has no induced current

32 The opposite graph shows the relation between the average induced emf in several coils, through each of which the flux changes at the same uniform rate, and the number of turns of each coil (N). The rate of change of the flux through the coils is .....



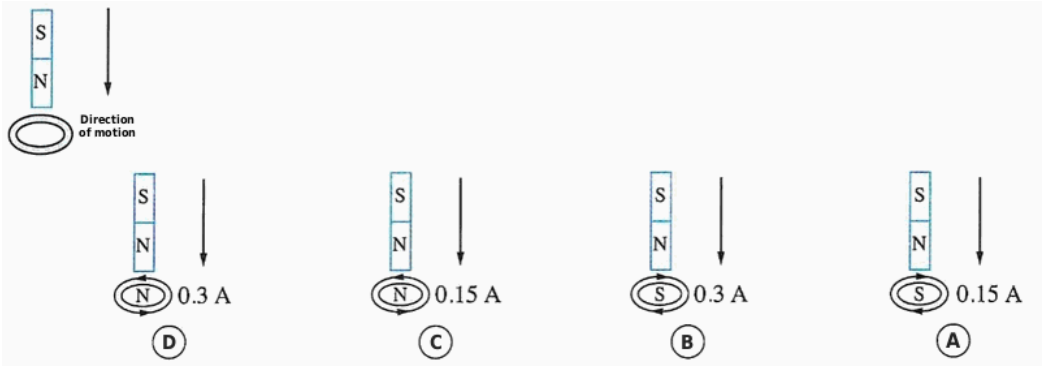
(A) 10 Wb/s (B) 1 Wb/s (C) 0.1 Wb/s (D) 0.01 Wb/s

33 The opposite graph represents the relation between the average induced emf in a metal ring and time (t). The ratio between the changes in the magnetic flux through the ring in stages (x) and (y) respectively is .....



(A) *1/3* (B) *3/1* (C) *2/3* (D) *1/6*

34 The opposite figure shows a magnet moving perpendicular to a horizontal circular coil of resistance 10 Ω and 200 turns, so the magnetic flux through the coil changes from 2.5×10^{-3} Wb to 8.5×10^{-3} Wb in 0.4 s. The figure that correctly shows the magnitude and direction of the induced current in the face of the coil facing the magnet is .....



35 A solenoid of 400 turns, each of area 4 cm², has its axis parallel to a uniform magnetic field of flux density 0.3 Tesla. The average induced emf in the coil when:

(1) the magnetic flux density increases to 0.5 Tesla in 2 ms equals .....

(A) −16 V (B) −8 V (C) 8 V (D) 16 V

36 A solenoid of 400 turns, each of area 4 cm², has its axis parallel to a uniform magnetic field of flux density 0.3 Tesla. The average induced emf in the coil when:

(2) the magnetic flux density decreases to 0.2 Tesla in 2 ms equals .....

(A) 6 V (B) 8 V (C) 10 V (D) 12 V

---

37 A coil of 400 turns, each of area 50 cm², has a perpendicular flux of density 0.2 T through it. The average induced emf between its ends if the magnetic flux through the coil vanishes in 0.01 s equals .....

(A) 20 V (B) 40 V (C) 60 V (D) 80 V

---

38 A rectangular coil of dimensions 20 cm and 10 cm has 100 turns and its plane is perpendicular to a magnetic field. If the coil is rotated *1/4* of a revolution about an axis in its own plane in 0.2 s, an induced emf of 0.4 V is produced. The magnetic flux density equals .....

(A) 0.01 T (B) 0.03 T (C) 0.04 T (D) 0.05 T

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39 A rectangular coil of 150 turns and area 75 cm² is placed in a magnetic field of flux density 0.65 T so that the plane of the coil is parallel to the field. The average induced emf in the coil if:

(1) the coil is rotated in 0.02 s until it becomes perpendicular to the field for the first time equals .....

(A) −36.56 V (B) −40.2 V (C) −50.3 V (D) 0

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40 A rectangular coil of 150 turns and area 75 cm² is placed in a magnetic field of flux density 0.65 T so that the plane of the coil is parallel to the field. The average induced emf in the coil if:

(2) the coil is turned over from the first position in 0.01 s equals .....

(A) 36.56 V (B) 40.3 V (C) 73.12 V (D) 0

---

41 A rectangular coil of 150 turns and area 75 cm² is placed in a magnetic field of flux density 0.65 T so that the plane of the coil is parallel to the field. The average induced emf in the coil if:

(3) the coil is rotated *3/4* of a revolution from the first position to become perpendicular to the field in 0.02 s equals .....

(A) 0 (B) 36.56 V (C) 50.4 V (D) 73.12 V

42 A rectangular coil of 150 turns and area 75 cm² is placed in a magnetic field of flux density 0.65 T so that the plane of the coil is parallel to the field. The average induced emf in the coil if:

(4) the coil is rotated one complete revolution in 0.02 s equals .....

(A) 0 (B) 18.28 V (C) 36.56 V (D) 73.12 V

43 A rectangular coil of 150 turns and area 75 cm² is placed in a magnetic field of flux density 0.65 T so that the plane of the coil is parallel to the field. The average induced emf in the coil if:

(5) the magnetic field vanishes in 0.1 s equals .....

(A) 0 (B) 20 V (C) 40 V (D) 60 V

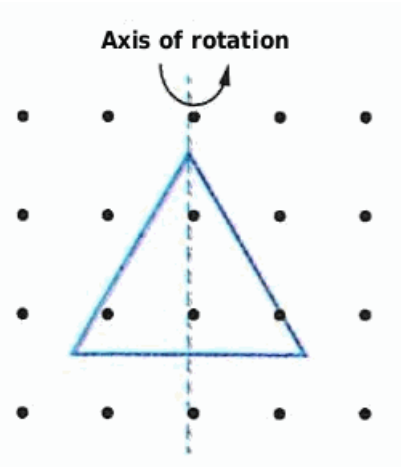
44 A coil of 25 turns and face area 1.8 cm² is wound around a hollow tube and connected to a closed circuit of resistance 3 Ω. If the coil is acted on by a uniform magnetic field parallel to its axis and the flux density increases from zero to 0.55 Tesla in 0.75 s, the induced current in the coil equals .....

(A) 1.1×10^{-3} A (B) 2.2×10^{-3} A (C) 3.3×10^{-3} A (D) 6.6×10^{-3} A

45 A coil of 100 turns, each of area 20 cm², is placed perpendicular to a uniform magnetic field of flux density 0.2 T. If the direction of the magnetic flux is reversed in 0.2 s, the average induced emf equals .....

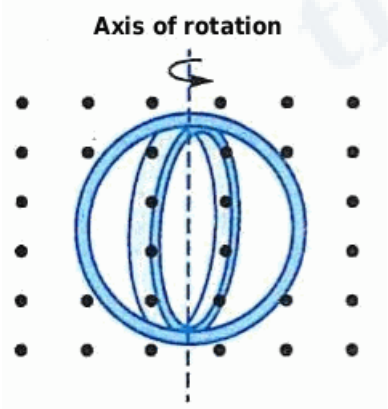
(A) 0.2 V (B) 0.4 V (C) 0.6 V (D) 0.8 V

46 A triangular frame rotates about the axis shown in the figure at 1800 rev/min in a uniform magnetic field. If the induced emf in the frame during $1/60$ s of its rotation from the perpendicular position is 4.8 V, the maximum magnetic flux through the frame equals .....



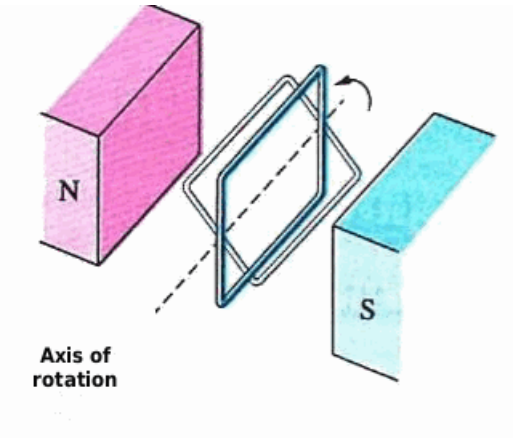
(A) 0.01 Wb (B) 0.02 Wb (C) 0.03 Wb (D) 0.04 Wb

47 The opposite figure shows a circular metal ring of area 2×10^{-3} m² whose plane is perpendicular to a uniform magnetic field of flux density 0.1 T. It rotates through 45° about an axis perpendicular to the field in 0.25 s. What is the average induced emf during this time?



(A) 2.34×10^{-4} V (B) 5.75×10^{-4} V (C) 8×10^{-4} V (D) 8.25×10^{-4} V

48 The opposite figure shows a rectangular metal frame of area 0.02 m² placed perpendicular to a uniform magnetic field of flux density 0.1 T. If the frame rotates through an angle θ about an axis perpendicular to the field in 0.25 s, an average emf of 4 mV is induced in it. Through what angle did the plane of the coil rotate?



(A) 30° (B) 45° (C) 60° (D) 75°

49 A rectangular coil of N turns, area 4 cm² and resistance 50 Ω is placed in a uniform magnetic field of flux density 0.2 T perpendicular to its plane. If the coil rotates 180° so that its position relative to the field is reversed, a charge of 1.6×10^{-3} C passes through a cross-section of the coil wire. The number of turns (N) equals .....

(A) 100 turns (B) 200 turns (C) 500 turns (D) 750 turns

50 A metal ring rotates at a constant rate about an axis in its plane in a uniform magnetic field. While the ring rotates through 60° from the position parallel to the field, an average induced current I_1 flows in it, and while it rotates through 60° from the position perpendicular to the field, an average induced current I_2 flows in it. The ratio (I_1/I_2) equals .....

(A) $1/2$ (B) $\sqrt{3}$ (C) $(\sqrt{3})/2$ (D) $1/(\sqrt{3})$

51 A circular coil of area 0.045 m² and 150 turns is connected to a closed circuit of total resistance 0.9 Ω, and its plane is perpendicular to a uniform magnetic field of flux density 8×10^{-5} T. The charge that flows through a cross-section of the coil wire if the coil is taken completely out of the field equals .....

(A) 6×10^{-4} C (B) 8×10^{-4} C (C) 9×10^{-4} C (D) 9.5×10^{-4} C

52 A fixed solenoid is connected to a centre-zero galvanometer, and next to it is a fixed bar magnet. In figure (1) the bar magnet moves at a uniform velocity (v) towards the fixed coil, and in figure (2) the coil moves towards the fixed bar magnet at the same uniform velocity (v). What do you notice about the deflection of the galvanometer pointer in figure (2) compared with figure (1)?

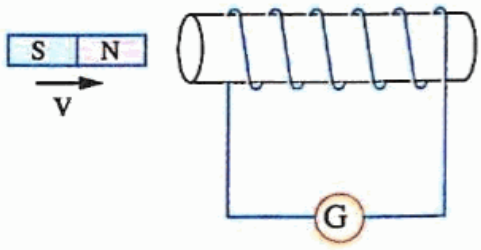


Figure (1)

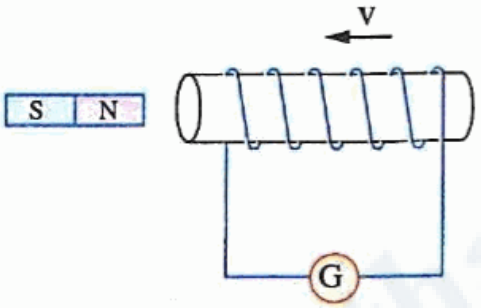


Figure (2)

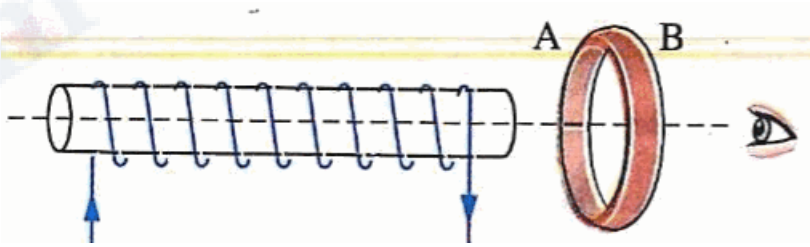
(A) The pointer does not deflect because the magnet is at rest

(B) It gives the same deflection in the opposite direction

(C) It gives a smaller deflection in the same direction

(D) It gives the same deflection in the same direction

53 The opposite figure shows a solenoid carrying a current placed next to a metal ring, with the axis of the coil perpendicular to the plane of the ring and passing through its centre. A current is induced in the ring that is anticlockwise when looking at face B when .....



(A) the current in the coil is decreased

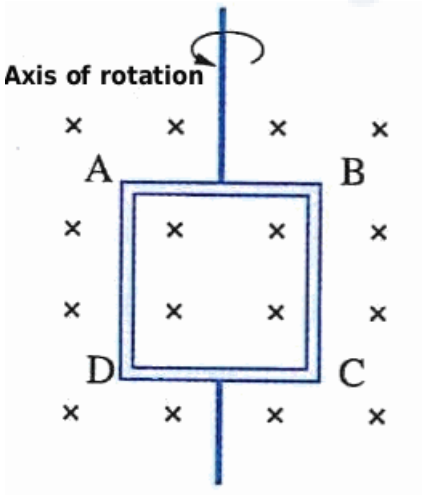
(B) the current in the coil is increased

(C) the coil is brought nearer to the ring

(D) the ring is rotated about an axis perpendicular to its plane

---

54 The opposite figure shows a square metal frame of side 20 cm placed with its plane perpendicular to a uniform magnetic field of flux density 0.4 T. When the frame rotates in the direction shown in the figure until its plane becomes parallel to the field in 0.08 s, the average induced emf in it is ..... and the direction of the induced current in one of its sides is .....



(A) 0.1 V, from A to B

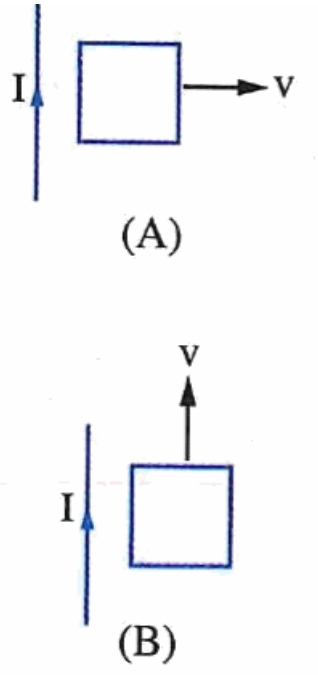
(B) 0.1 V, from A to D

(C) 0.2 V, from A to B

(D) 0.2 V, from A to D

---

55 Two coils move in the magnetic field produced by a current (I) in a very long wire as shown in figures A and B. The induced current in the coil in .....



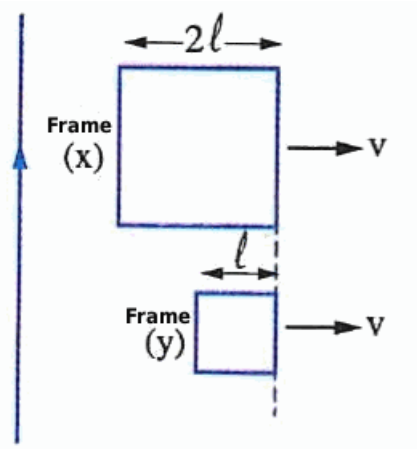
(A) figure (A): anticlockwise, figure (B): clockwise

(B) figure (A): zero, figure (B): zero

(C) figure (A): clockwise, figure (B): clockwise

(D) figure (A): clockwise, figure (B): zero

56 Two square metal frames x and y lie in one plane, and a straight wire carrying a current lies in their plane as shown in the opposite figure. If the two frames move away from the wire at a uniform velocity (v), in which frame is the greater emf induced?



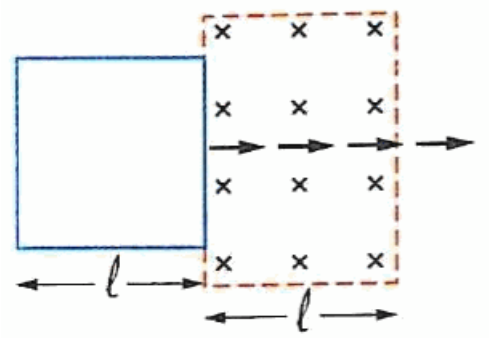
(A) Frame (x)

(B) Frame (y)

(C) It is equal in the two frames

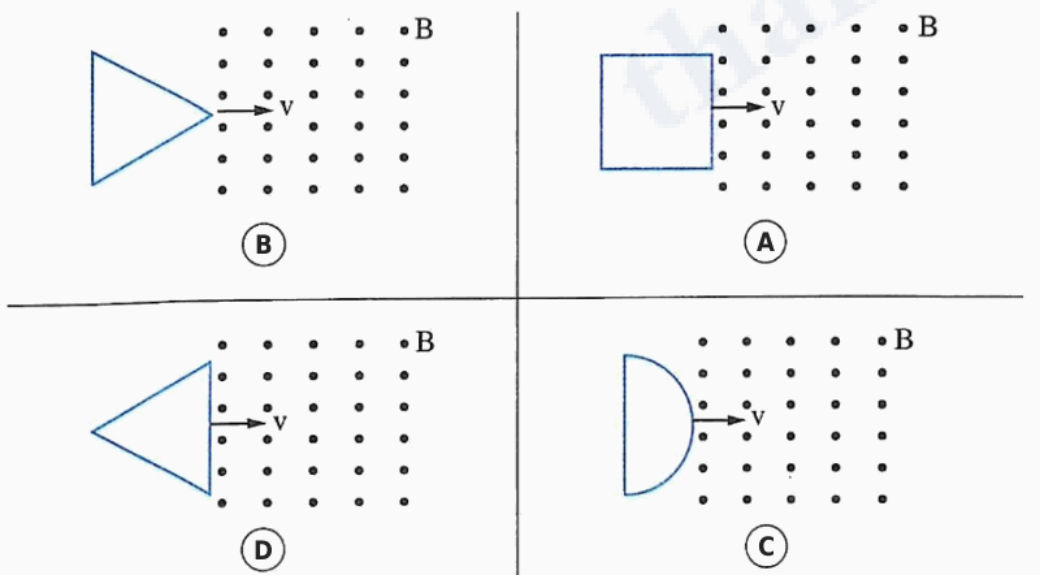
(D) No emf is induced in either frame

57 The opposite figure shows a square coil in the plane of the page moving into a region of a uniform magnetic field perpendicular to the page and inwards, until it leaves it completely. The direction of the induced current in the coil is .....

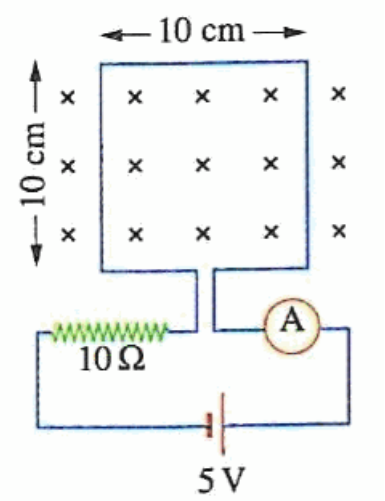


(A) always clockwise
(B) always anticlockwise
(C) clockwise, then anticlockwise
(D) anticlockwise, then clockwise

58 In each of the following figures a metal frame moves at a uniform velocity v perpendicular to a uniform magnetic field of flux density B. The frame in which the induced current decreases while it moves into the field region is .....



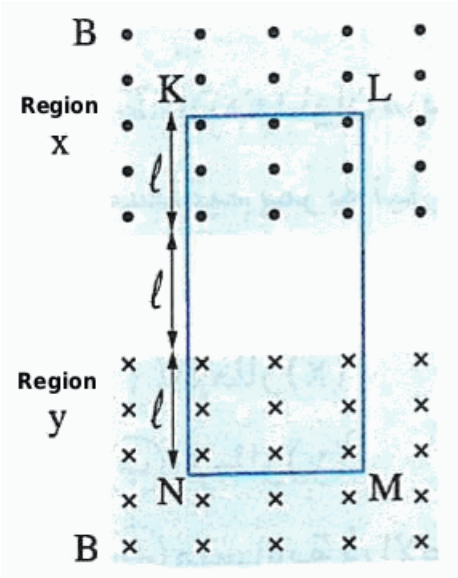
59 In the shown circuit, a one-turn coil of negligible resistance is placed in a magnetic field perpendicular to the coil and into the page. If the flux density decreases at a uniform rate of 150 T/s, the ammeter reading while the flux decreases becomes .....



(A) 0.15 A (B) 0.35 A (C) 0.5 A (D) 0.65 A

60 Two magnetic fields in opposite directions and of the same flux density act perpendicular to the plane of a rectangular coil KLMN as shown in the opposite figure. While:

(1) the flux density in region (x) increases at a certain rate and in region (y) decreases at the same rate .....



(A) no current is induced in the coil

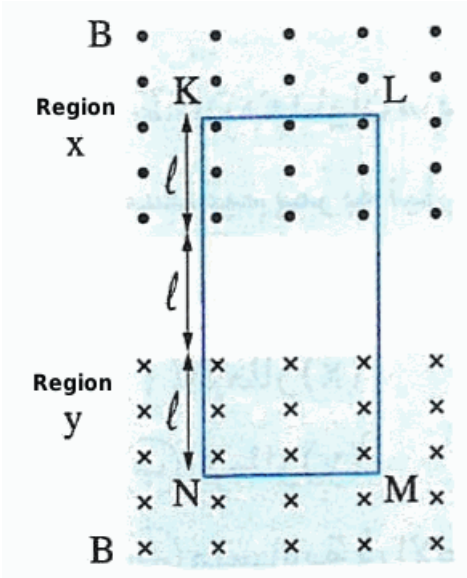
(B) an alternating induced current (changing in magnitude and direction) is induced in the coil

(C) a clockwise current is induced in the coil

(D) an anticlockwise current is induced in the coil

61 Two magnetic fields in opposite directions and of the same flux density act perpendicular to the plane of a rectangular coil KLMN as shown in the opposite figure. While:

(2) the flux density in both regions (x) and (y) increases at the same rate .....



(A) no current is induced in the coil

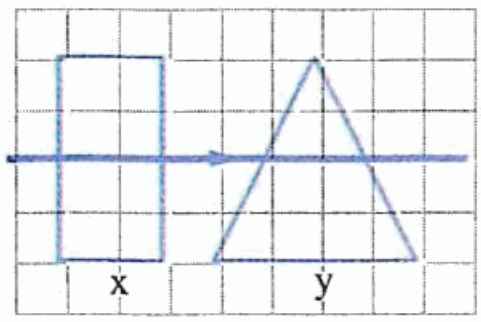
(B) an alternating induced current (changing in magnitude and direction) is induced in the coil

(C) a clockwise current is induced in the coil

(D) an anticlockwise current is induced in the coil

---

62 Two metal frames x and y lie on a horizontal table, and above them, in the same plane, is a long straight wire carrying a current that increases at a uniform rate as shown in the opposite figure. An induced emf .....



(A) is produced in frame x only

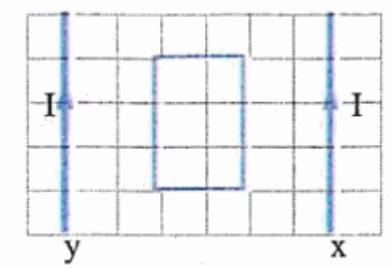
(B) is produced in frame y only

(C) is produced in both frames

(D) is not produced in either frame

---

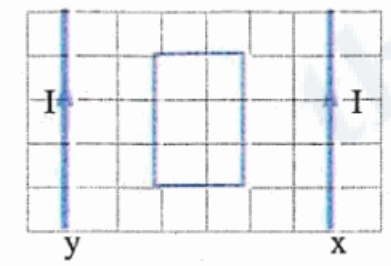
63 A rectangular metal frame is placed between two parallel straight wires x and y in its plane, each carrying a current I in the same direction as shown in the opposite figure. While:
(1) the currents in the two wires increase at the same uniform rate, the metal frame .....



(A) has a clockwise induced current
(B) has an anticlockwise induced current
(C) has an alternating induced current
(D) has no induced current

---

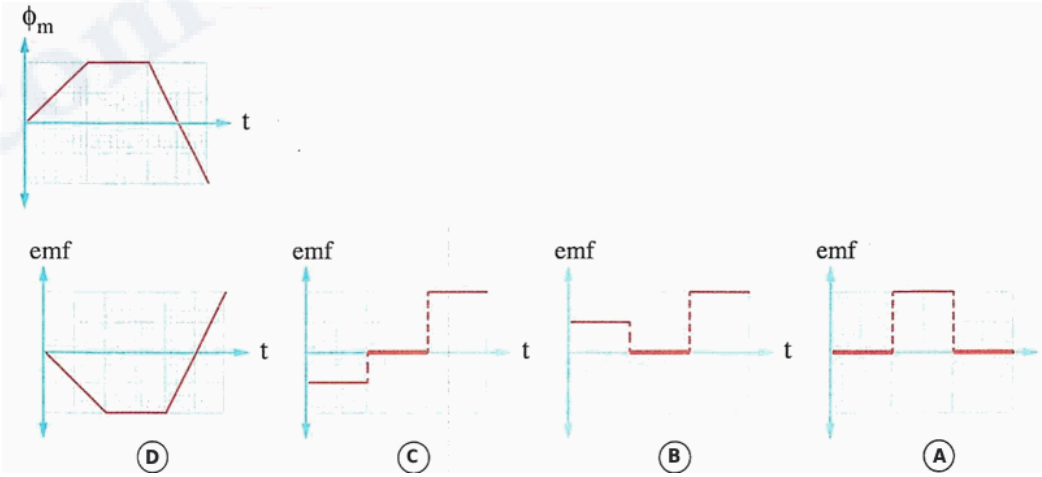
64 A rectangular metal frame is placed between two parallel straight wires x and y in its plane, each carrying a current I in the same direction as shown in the opposite figure. While:
(2) the current in wire (x) increases at a certain uniform rate and the current in wire (y) decreases at the same rate, the metal frame .....



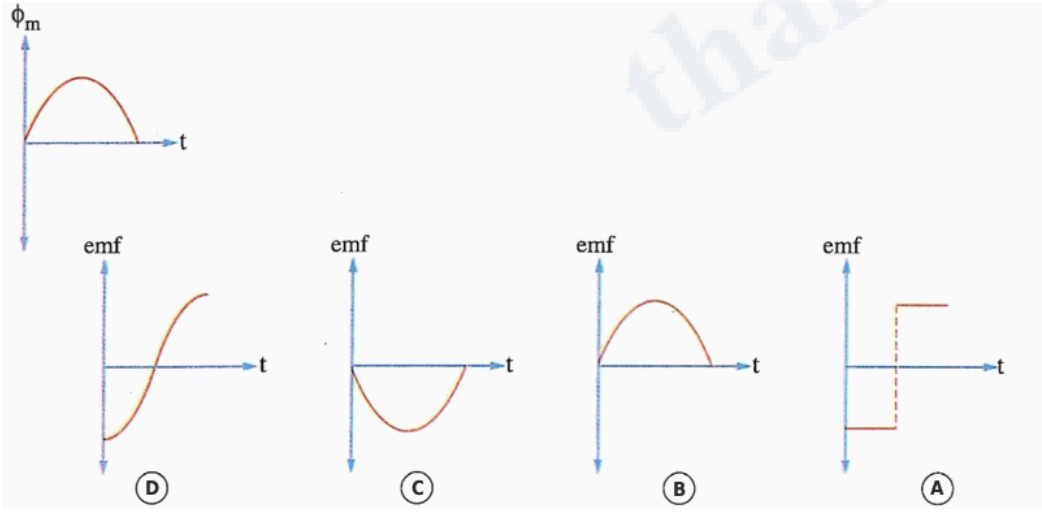
(A) has a clockwise induced current
(B) has an anticlockwise induced current
(C) has an alternating induced current
(D) has no induced current

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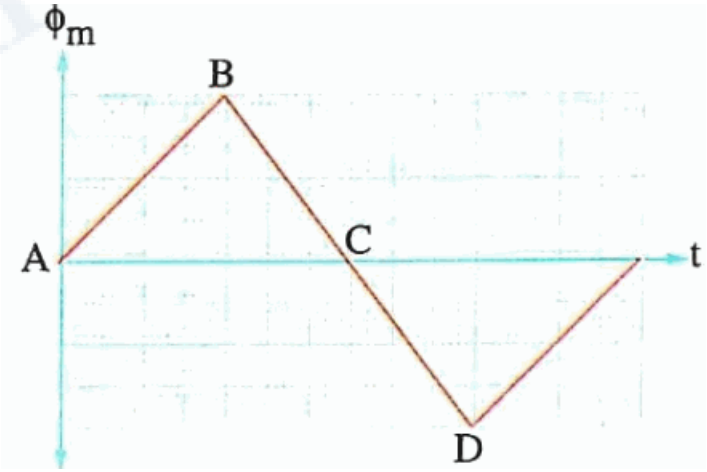
65 The opposite graph shows the relation between the magnetic flux (φ_m) through a coil and time (t). Which of the following graphs represents the induced emf in the coil during the same time?



66 A circular coil is placed parallel to the direction of a magnetic field. When the coil is turned over at a uniform speed, the flux through it changes as shown in the opposite graph. Which of the following graphs represents the induced emf in the coil during the same time?

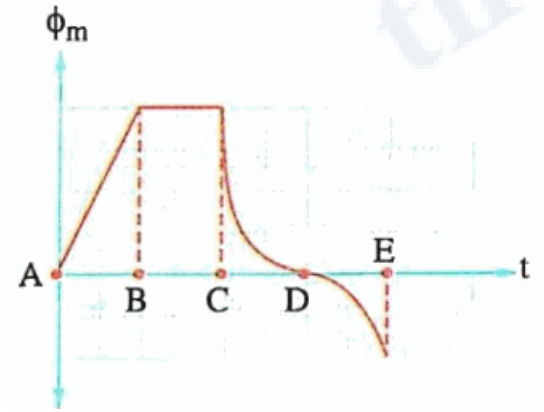


67 The opposite graph shows the relation between the magnetic flux through a circular coil in a closed circuit and time. At which two points does the direction of the induced current in the coil reverse?



(A) A, B (B) C, D (C) B, C (D) B, D

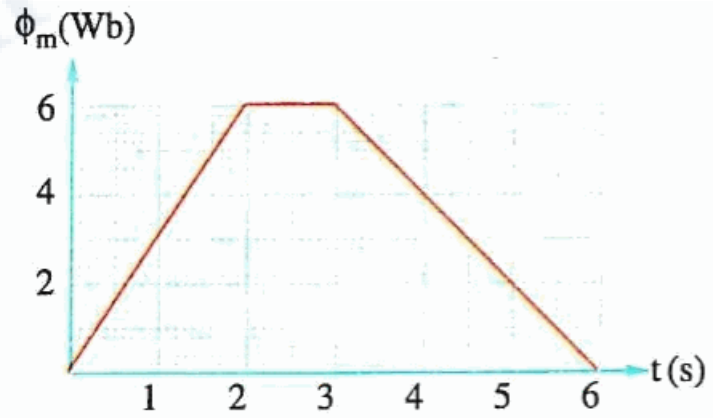
68 The opposite graph shows the change of the magnetic flux (φ_m) through a coil during four equal time intervals AB, BC, CD and DE. The interval during which the induced emf in the coil increases is .....



(A) AB (B) BC (C) CD (D) DE

69 The opposite graph shows the change of the magnetic flux through a coil of 200 turns during 6 seconds. The average induced emf during:

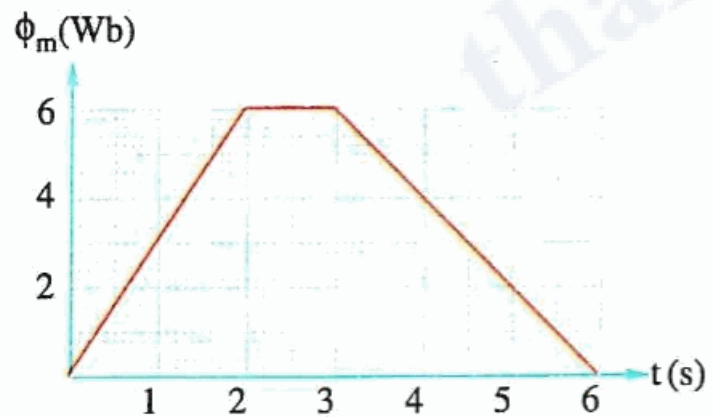
(1) the first two seconds equals .....



(A) −300 V (B) 300 V (C) −600 V (D) 600 V

70 The opposite graph shows the change of the magnetic flux through a coil of 200 turns during 6 seconds. The average induced emf during:

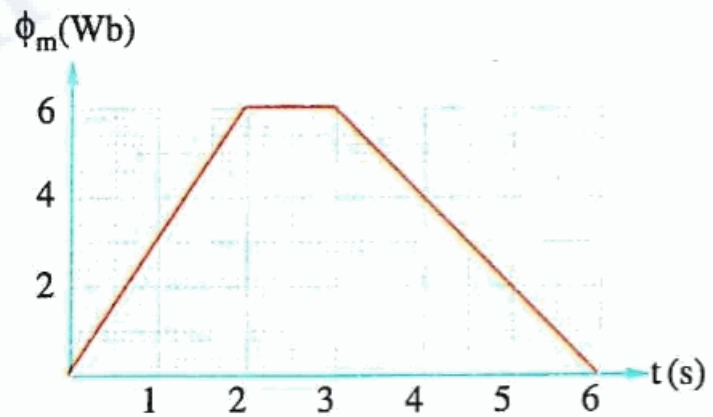
(2) the third second equals .....



(A) 1200 V (B) 600 V (C) 400 V (D) 0

71 The opposite graph shows the change of the magnetic flux through a coil of 200 turns during 6 seconds. The average induced emf during:

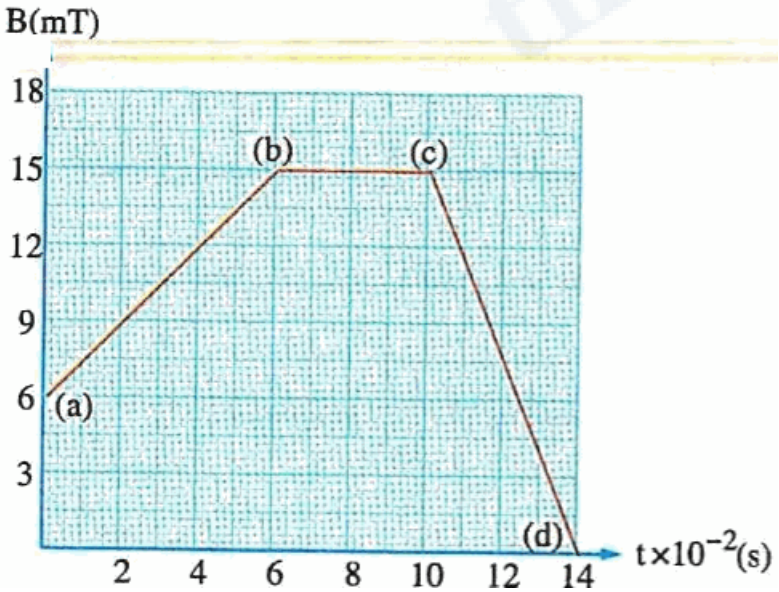
(3) the last three seconds equals .....



(A) 200 V (B) −200 V (C) 400 V (D) −400 V

72 A coil of area 0.04 m² and 150 turns has its plane perpendicular to a magnetic field whose flux density changes with time as shown in the opposite graph. So:

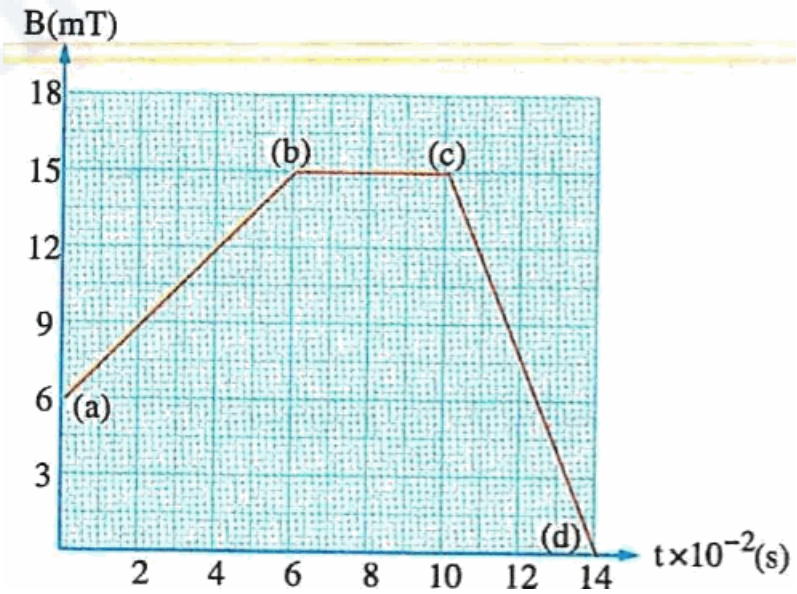
(1) the ratio between the average induced emfs in the coil in stages ab and cd respectively equals .....



(A) *2/5* (B) *5/2* (C) *1/3* (D) *3/1*

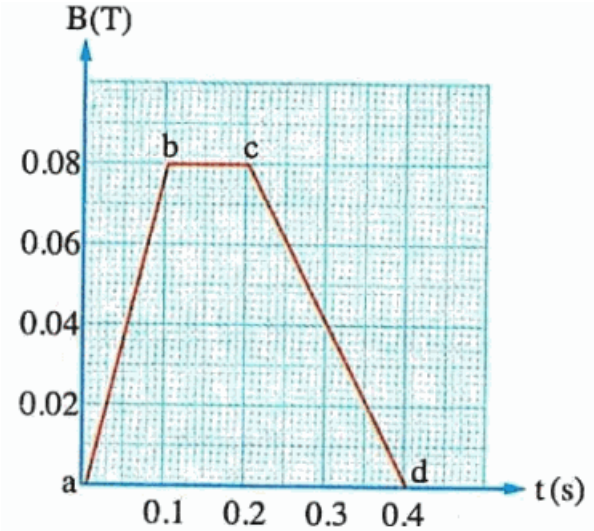
73 A coil of area 0.04 m² and 150 turns has its plane perpendicular to a magnetic field whose flux density changes with time as shown in the opposite graph. So:

(2) the average induced emf in the coil in stage bc equals .....



(A) 0 (B) 1 V (C) 1.25 V (D) 2.5 V

74 A metal ring in the plane of the page, of area 45 cm², has a magnetic flux perpendicular to the page and inwards through it, whose density changes with time as shown in the graph. The induced emf in the ring during interval ab and the direction of the induced current in the ring during interval cd are .....



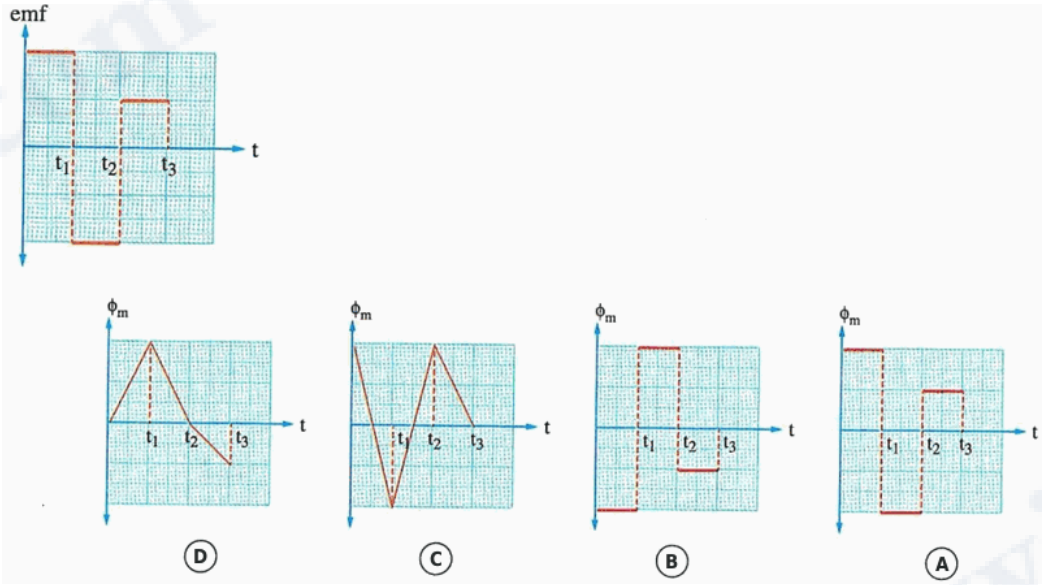
(A) emf during ab: 2.4×10^{-3} V, current during cd: clockwise

(B) emf during ab: 2.4×10^{-3} V, current during cd: anticlockwise

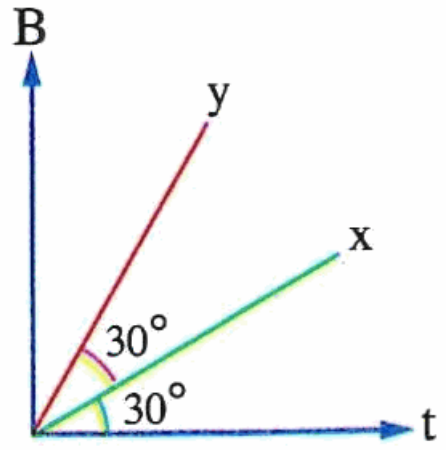
(C) emf during ab: 3.6×10^{-3} V, current during cd: clockwise

(D) emf during ab: 3.6×10^{-3} V, current during cd: anticlockwise

75 The opposite graph shows the induced emf in a coil when the magnetic flux through it changes during a certain time. Which of the following graphs represents the magnetic flux (φ_m) through the coil during that time?



76 A metal wire of uniform cross-section is made into two rings (x) and (y), which are placed perpendicular to a magnetic field of constant direction whose flux density changes with time as shown in the opposite graph. If the ratio of the induced currents in the two rings (I_x/I_y) equals $(2/3)$, the ratio of the areas of the two rings (A_x/A_y) equals .....



(A) $\sqrt{(2)}$ (B) $3/2$ (C) 2 (D) 4

77 A p.d. of 5.5×10^{-3} V is produced between the ends of the second hand of a clock in a public square because it is exposed to a magnetic field perpendicular to it. If the change in the area that cuts the flux lines when the second hand makes one complete revolution is $11/14$ m^2, the magnetic flux density equals .....

(A) 0.26 T (B) 0.42 T (C) 0.53 T (D) 0.62 T

78 The order of energy conversions in induction furnaces while operating is .....

(A) thermal, then electrical, then magnetic, then electrical

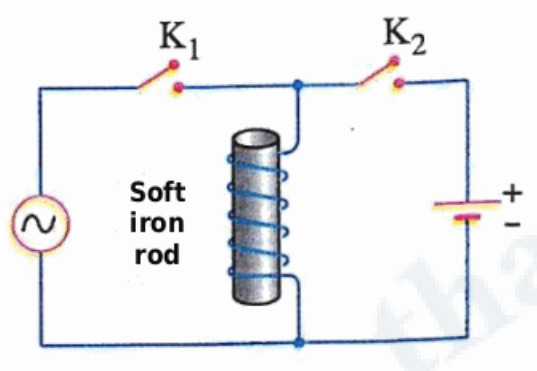
(B) electrical, then thermal, then electrical, then magnetic

(C) magnetic, then electrical, then magnetic, then thermal

(D) electrical, then magnetic, then electrical, then thermal

---

79 A soft iron rod is placed inside a solenoid and insulated from it. The coil can be connected to an alternating voltage source (changing in magnitude and direction) or to a direct voltage source through one of the two switches K_1 and K_2 as shown in the opposite figure. Which of the following choices shows what happens to the soft iron rod when each of the switches K_1 and K_2 is closed separately?



(A) Switch K_1: it is magnetized, switch K_2: it heats up

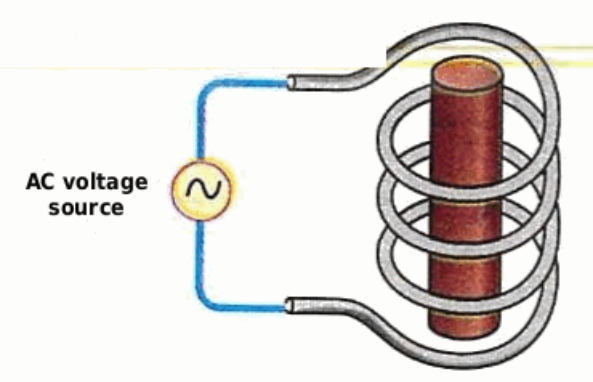
(B) Switch K_1: it is magnetized, switch K_2: it is magnetized

(C) Switch K_1: it heats up, switch K_2: it heats up

(D) Switch K_1: it heats up, switch K_2: it is magnetized

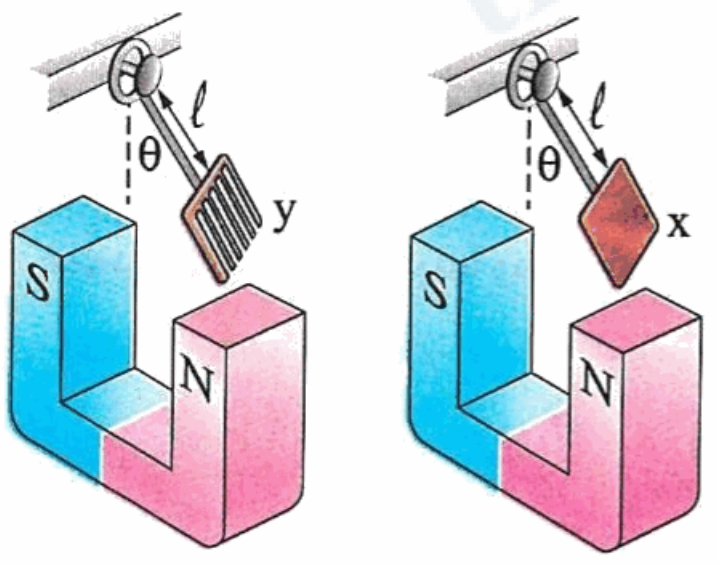
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80 The opposite figure shows a coil wound around a solid metal cylinder and connected to an alternating voltage source (changing in magnitude and direction). Given that the resistivity of aluminium is greater than that of copper, the eddy currents induced in the cylinder are greater if the cylinder is .....



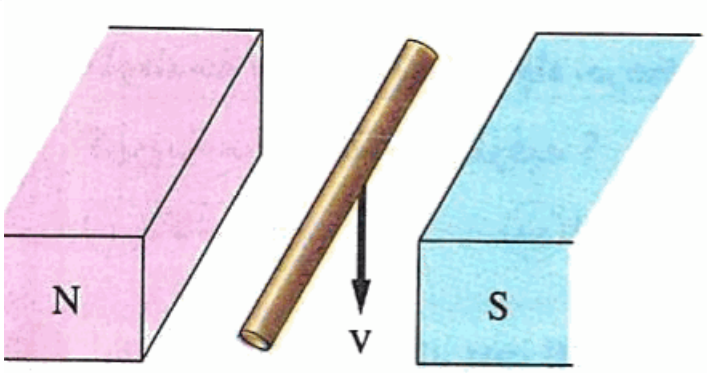
(A) thick and made of aluminium
(B) thin and made of aluminium
(C) thick and made of copper
(D) thin and made of copper

81 The opposite figure shows two aluminium plates x and y, each displaced through an angle θ from its rest position. If the two plates are released at the same moment to swing in identical magnetic fields, which plate comes to rest first?



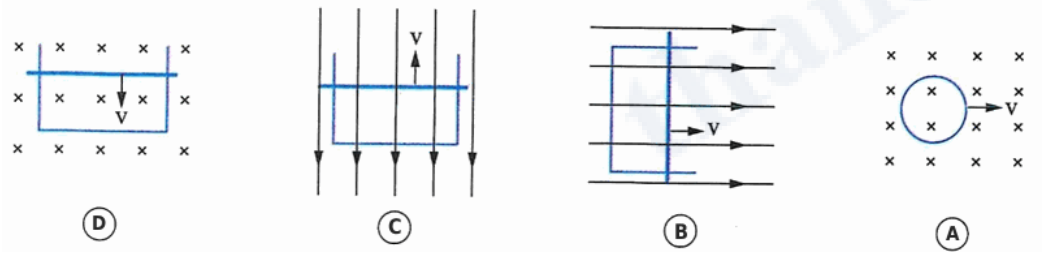
(A) Plate (x)
(B) Plate (y)
(C) Both plates come to rest together
(D) Both plates keep swinging and never come to rest

82 The opposite figure shows a metal rod of resistance R cutting the lines of a magnetic field perpendicularly at a uniform velocity v, so an induced emf is produced between its ends. If another rod of the same length and a resistance greater than R is used at the same velocity, the induced emf in this case is .....

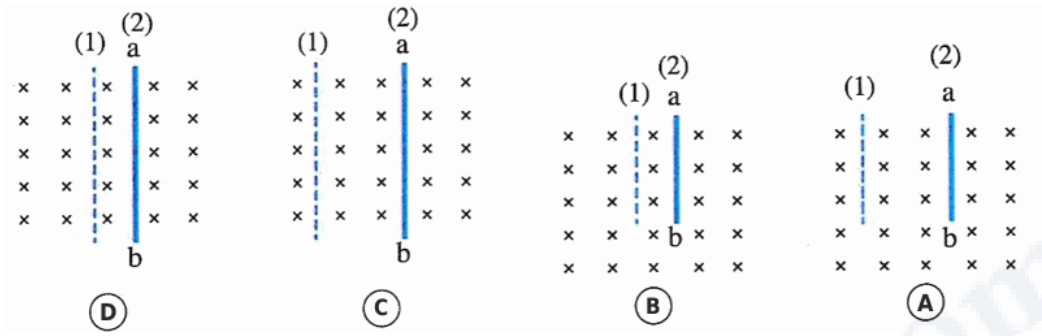


(A) greater than emf (B) smaller than emf (C) equal to emf (D) zero

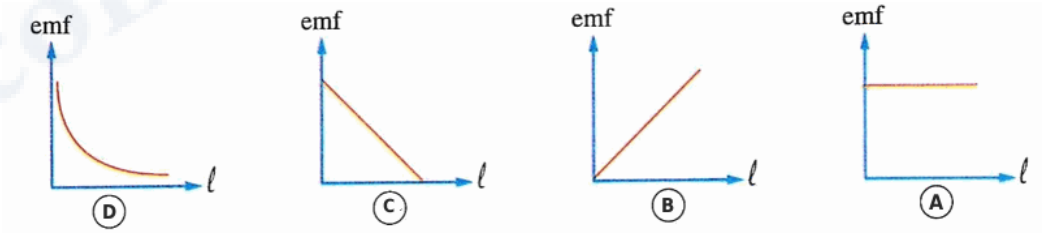
83 In which of the following figures is a current induced because of the motion of the conductor in the uniform magnetic field?



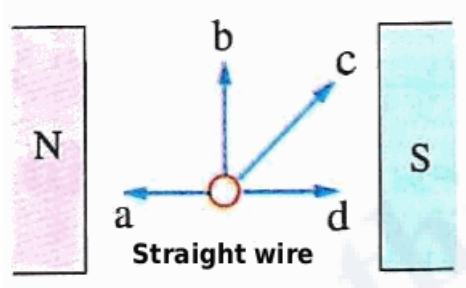
84 The following figures show four straight wires moving to the right, perpendicular to a uniform magnetic field, from position (1) to position (2) in the same time. The figure that shows the case in which the greatest induced emf is produced is .....



85 Which of the following graphs represents the relation between the induced emf between the ends of each wire of a group of wires made of the same material, with the same cross-section, moving at the same uniform velocity perpendicular to both their length and a uniform magnetic field, and the length (ℓ) of each wire?

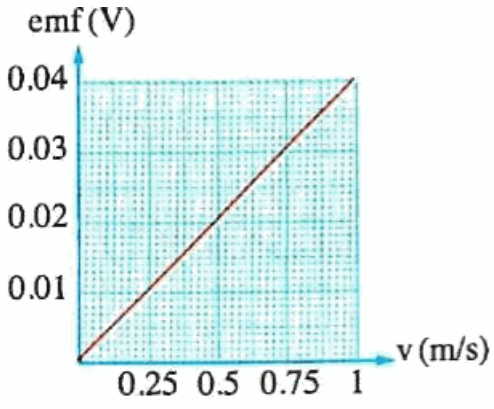


86 The opposite figure shows a straight wire perpendicular to the page moving at a uniform velocity (v) between the poles of a magnet. Which of the directions shown in the figure is the direction of motion of the wire that produces the greatest induced emf between its ends?



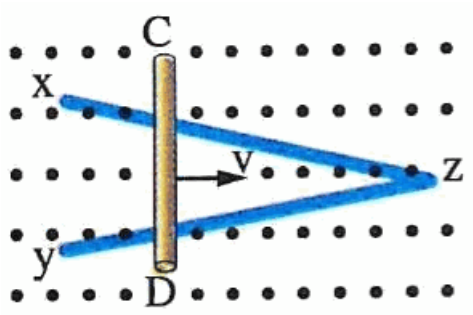
(A) Direction a (B) Direction b (C) Direction c (D) Direction d

87 A straight wire 20 cm long is moved several times perpendicular to a uniform magnetic flux at a different uniform velocity (v) each time. The opposite graph shows the relation between the induced emf in the wire and its velocity (v). The magnetic flux density equals .....



(A) 0.1 T (B) 0.2 T (C) 0.3 T (D) 0.4 T

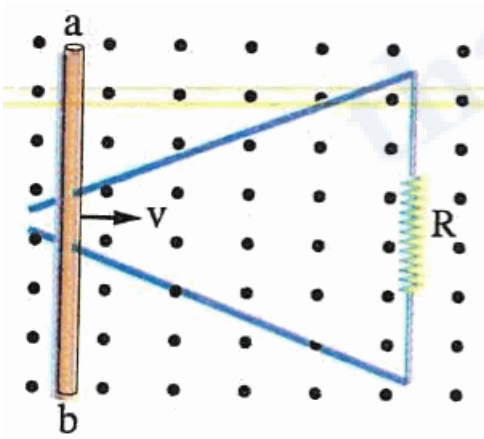
88 A metal rod (CD) of uniform cross-section and resistance R moves at a uniform velocity v perpendicular to a uniform magnetic field, touching a wire xzy of negligible resistance as shown in the opposite figure. The current in the rod while it moves .....



(A) is zero
(B) stays constant
(C) increases gradually
(D) decreases gradually

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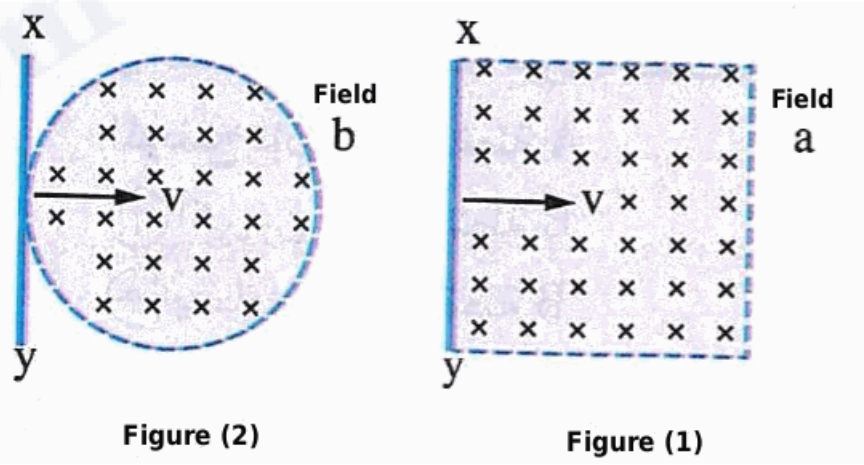
89 A metal rod (ab) of negligible resistance is placed perpendicular to a uniform magnetic field and slides at a uniform velocity (v) on two rails of negligible resistance connected by a resistance R. The induced current in the resistance (R) while the rod moves .....



(A) increases
(B) decreases
(C) does not change
(D) The answer cannot be determined

---

90 A straight wire xy passes at a uniform velocity v through two regions a and b of uniform magnetic field, with the direction of motion of the wire perpendicular to each field, as shown in the two opposite figures. The induced emf between the ends of wire xy is, in .....



(A) figure (1): constant, figure (2): constant

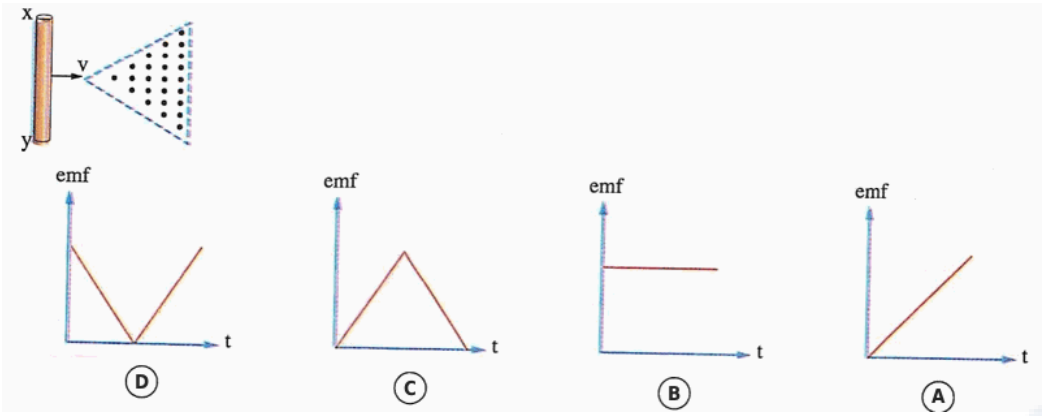
(B) figure (1): changing, figure (2): constant

(C) figure (1): constant, figure (2): changing

(D) figure (1): changing, figure (2): changing

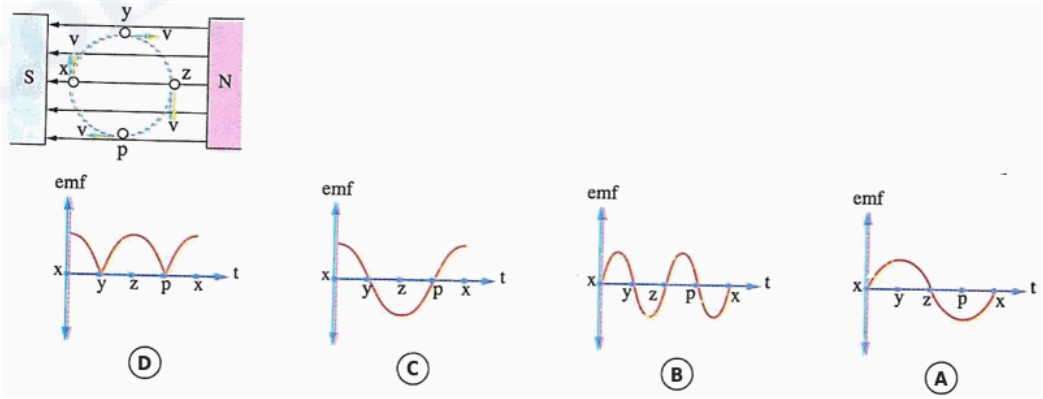
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91 A wire xy passes at a uniform velocity (v) perpendicularly through a triangular region of uniform magnetic field as shown in the opposite figure. The graph that shows the relation between the emf produced in the wire and time, from the moment it enters the field region until it reaches its end, is .....

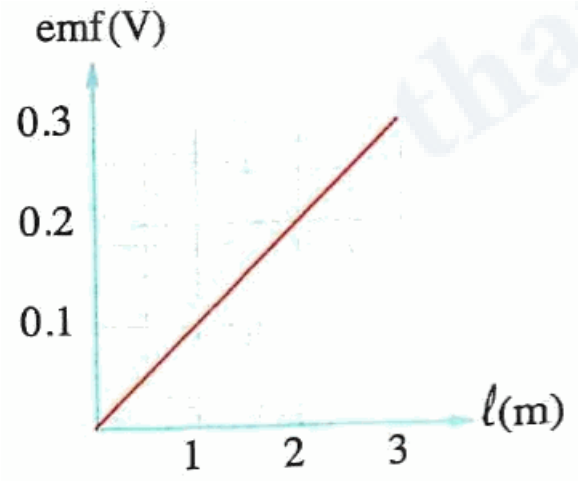


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92 In the opposite figure, a straight copper wire perpendicular to the page moves in a uniform magnetic field in the plane of the page at a uniform speed v along a circular path from point x to y to z to p and back to x. Which of the following graphs represents the induced emf between the ends of the wire during its motion against time?

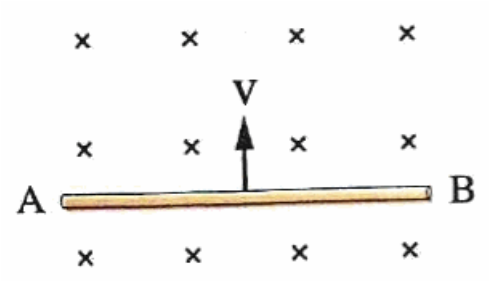


93 The opposite graph shows the relation between the induced emf in a straight wire and the length of the wire (ℓ) when it moves at a uniform velocity v perpendicular to a magnetic flux of density 0.1 T. The velocity v is .....



(A) 0.1 m/s (B) 0.2 m/s (C) 1 m/s (D) 2 m/s

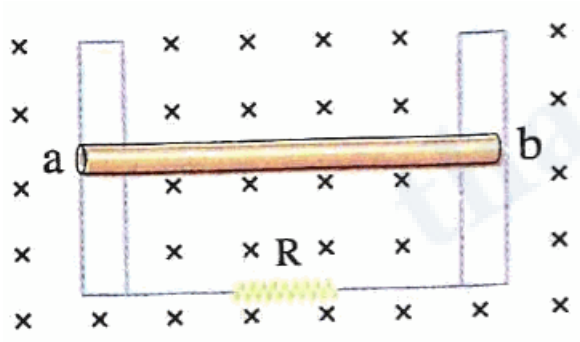
94 In the opposite figure, while the wire moves perpendicular to the flux in the shown direction, the potential of point A is .....



(A) greater than the potential of point B
(B) smaller than the potential of point B
(C) equal to the potential of point B
(D) The answer cannot be determined

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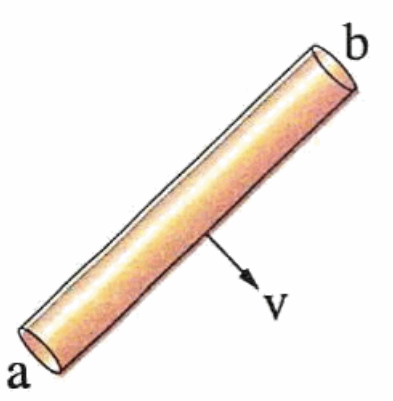
95 In the opposite figure, a straight wire ab moves in the plane of the page on two metal rails perpendicular to a magnetic field, so an induced current flows in the wire from end a to end b. So .....



(A) direction of motion of the wire: up the page, potentials of a and b: $V_a < V_b$
(B) direction of motion of the wire: up the page, potentials of a and b: $V_a > V_b$
(C) direction of motion of the wire: down the page, potentials of a and b: $V_a < V_b$
(D) direction of motion of the wire: down the page, potentials of a and b: $V_a > V_b$

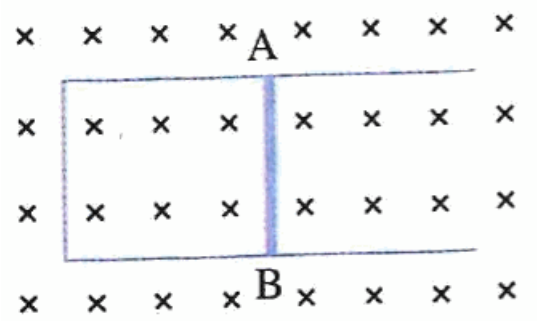
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96 The opposite figure shows a metal wire ab, 2 m long, in the plane of the page moving at a uniform velocity of 5 m/s perpendicular to a uniform magnetic field, so the potential of end a becomes greater than that of end b by 0.4 V. The magnetic flux density acting on the wire and its direction are .....



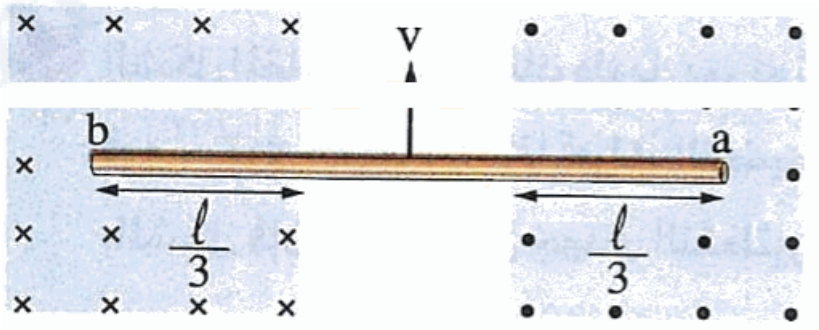
(A) 0.02 T, into the page
(B) 0.02 T, out of the page
(C) 0.04 T, into the page
(D) 0.04 T, out of the page

97 The opposite figure shows a metal wire AB, 0.15 m long, moved at a uniform velocity (v) perpendicular to a magnetic flux of density 0.4 Tesla, so an induced emf of 0.03 V is produced between its ends, making a current flow in the wire from end A to end B. The magnitude and direction of the velocity of the wire are .....



(A) 0.5 m/s, to the right of the page
(B) 0.5 m/s, to the left of the page
(C) 1 m/s, to the right of the page
(D) 1 m/s, to the left of the page

98 A cylindrical metal rod ab of length ℓ moves at a uniform velocity (v) so that a part of it at each end passes perpendicularly through a different magnetic field of flux density B as shown in the opposite figure. Which end of the rod has the higher potential?



(A) End a
(B) End b
(C) The two ends have the same potential
(D) The answer cannot be determined

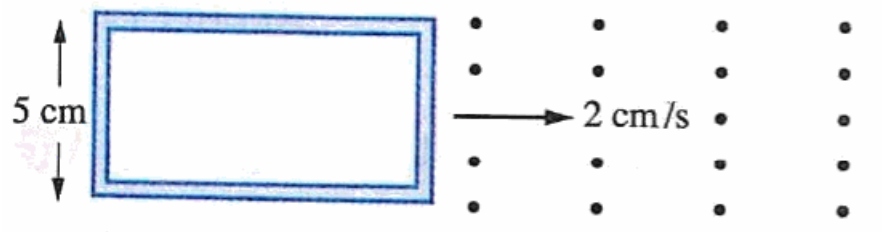
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99 A copper rod 30 cm long moves at 0.5 m/s in a magnetic field of flux density 0.8 T. The induced emf between the ends of the rod if it moves .....

(A) perpendicular to the field: 0.12 V, parallel to the field: 0.12 V
(B) perpendicular to the field: 0.12 V, parallel to the field: 0
(C) perpendicular to the field: 0, parallel to the field: 0.12 V
(D) perpendicular to the field: 0, parallel to the field: 0

---

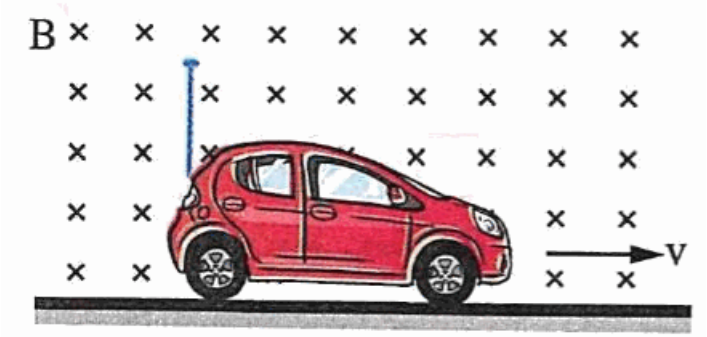
100 In the opposite figure, a rectangular metal frame of width 5 cm and resistance 1 Ω enters, at a uniform speed of 2 cm/s, a region of a magnetic field perpendicular to the plane of the frame with flux density 0.5 T. The induced current in the frame while it enters the field equals .....



(A) 0.5 mA
(B) 1 mA
(C) 2 mA
(D) 5 mA

---

101 In the opposite figure, a car with a 1 m antenna moves at a uniform speed of 80 km/h so that the motion of the antenna is perpendicular to the horizontal component of the Earth's magnetic field, and an induced emf of 4×10^{-4} V is produced between the ends of the antenna. The horizontal component of the Earth's magnetic field equals .....

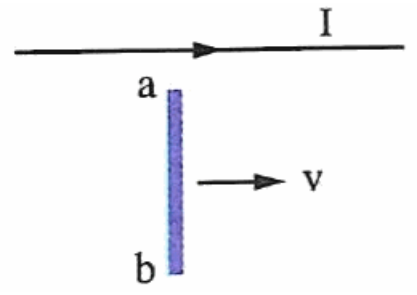


(A) 12×10^{-6} T (B) 14×10^{-6} T (C) 16×10^{-6} T (D) 18×10^{-6} T

102 A wire 0.5 m long moves in a uniform magnetic field of flux density 0.4 T at 2 m/s in a direction perpendicular to its length, so an induced emf of 0.336 V is produced between its ends. The angle between the direction of the velocity of the wire and the magnetic field is about .....

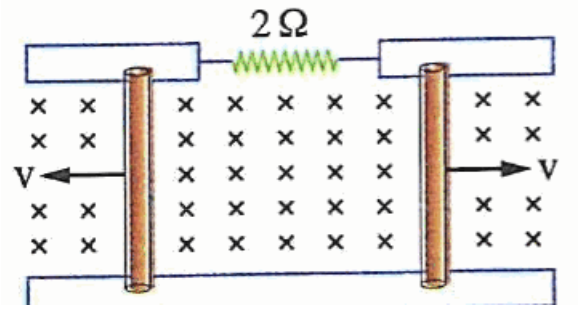
(A) 36° (B) 57° (C) 64° (D) 82°

103 The opposite figure shows a long wire carrying a current and a metal rod ab, both in the plane of the page. If the rod moves at a uniform velocity v in the direction shown in the figure, the relation between the potentials of points a and b is .....



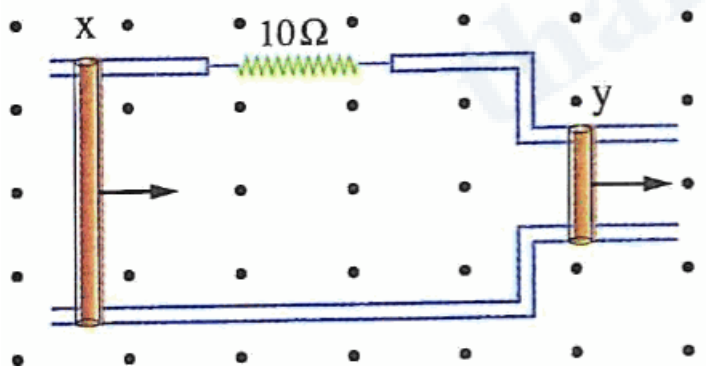
(A) $V_b = V_a = 0$ (B) $V_a > V_b$ (C) $V_a < V_b$ (D) $V_a = V_b \neq 0$

104 The opposite figure shows two cylindrical conductors of negligible resistance, each 20 cm long, moving on a metal track of negligible resistance at a constant speed of 5 m/s perpendicular to a uniform magnetic field of flux density 0.4 T. The induced current in the 2 Ω resistance equals .....



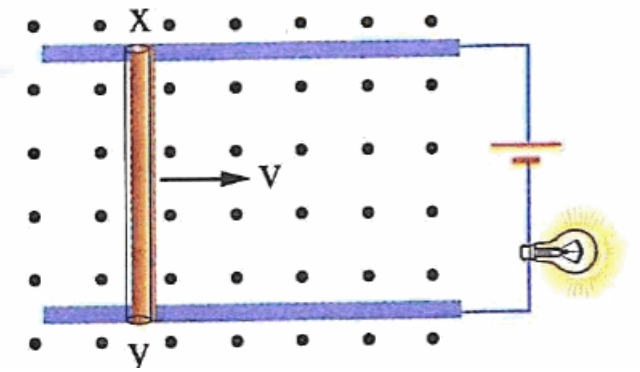
(A) zero (B) 0.8 A (C) 0.6 A (D) 0.4 A

105 In the opposite figure, two conductors (x) and (y) move in the same direction at a uniform speed of 0.5 m/s on two metal rails of negligible resistance, perpendicular to a uniform magnetic field of flux density 0.2 T. If the induced current in the 10 Ω resistance is 2.5 mA, conductor (x) is longer than conductor (y) by .....



(A) 10 cm (B) 15 cm (C) 25 cm (D) 35 cm

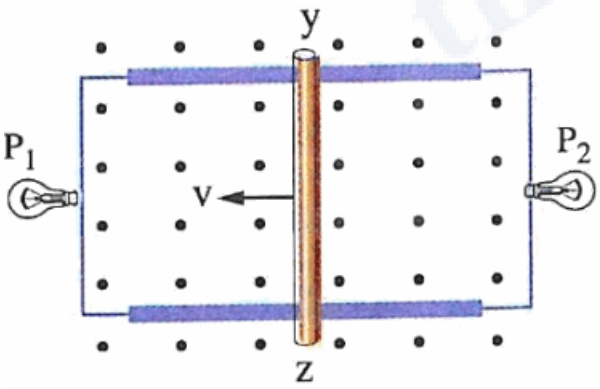
106 In the opposite figure, what happens to the brightness of the lamp while rod xy moves at a uniform velocity (v) in the shown direction?



(A) It does not change
(B) It becomes zero
(C) It decreases but does not become zero
(D) It increases

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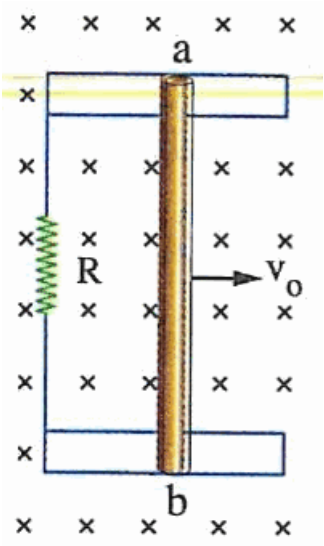
107 The opposite figure shows a metal rod (yz) of resistance R placed on two smooth rails, each of resistance 2 R, and two identical lamps P_1 and P_2 are connected to the ends of the rails on each side. The whole arrangement is perpendicular to a uniform magnetic flux of density B. What happens to the brightness of each lamp while the rod moves at a uniform velocity (v) in the shown direction?



(A) Brightness of P_1: decreases, brightness of P_2: decreases
(B) Brightness of P_1: decreases, brightness of P_2: increases
(C) Brightness of P_1: increases, brightness of P_2: decreases
(D) Brightness of P_1: increases, brightness of P_2: increases

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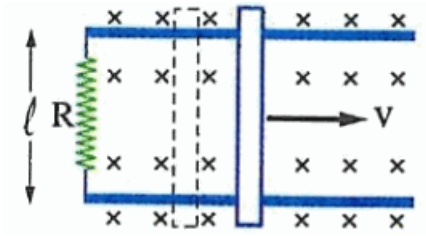
108 A conductor ab of negligible resistance moves horizontally at a uniform velocity (v_o) perpendicular to a uniform magnetic field, touching two metal rails of negligible resistance connected by a resistance (R) as shown in the opposite figure. If the electric power consumed in the resistance (R) while the conductor moves is $(P_w)_o$, the force (F) needed to pull the conductor at its uniform velocity (v_o) equals .....



(A) $((P_w)_o)/v_o$ (B) $(P_w)_o\, v_o$ (C) $((P_w)_o^2)/v_o$ (D) $(P_w)_o^2\, v_o$

109 In the opposite figure, if ℓ = 15 cm, R = 25 Ω, B = 0.6 T and v = 8 m/s, and assuming the resistance of the sliding copper rod and the rails is negligible:

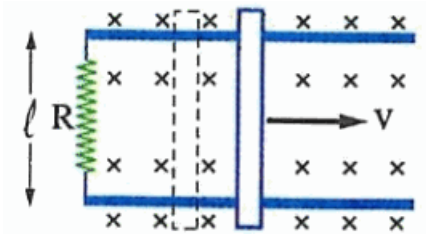
(1) the induced emf in the rod equals .....



(A) 0.72 V (B) 0.85 V (C) 1.44 V (D) 2.82 V

110 In the opposite figure, if ℓ = 15 cm, R = 25 Ω, B = 0.6 T and v = 8 m/s, and assuming the resistance of the sliding copper rod and the rails is negligible:

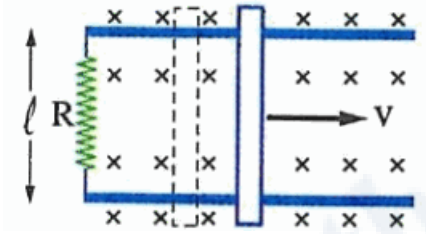
(2) the current in the resistance (R) equals .....



(A) 0.0288 A (B) 0.0576 A (C) 0.0864 A (D) 0.1152 A

111 In the opposite figure, if ℓ = 15 cm, R = 25 Ω, B = 0.6 T and v = 8 m/s, and assuming the resistance of the sliding copper rod and the rails is negligible:

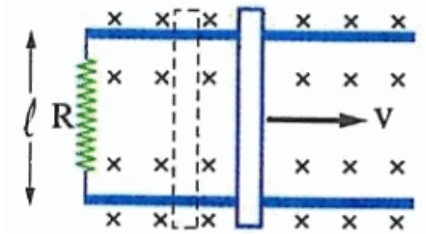
(3) the force needed to keep the rod moving at the same uniform velocity v equals .....



(A) 1.43×10^{-3} N (B) 1.87×10^{-3} N (C) 2.59×10^{-3} N (D) 4.32×10^{-3} N

112 In the opposite figure, if ℓ = 15 cm, R = 25 Ω, B = 0.6 T and v = 8 m/s, and assuming the resistance of the sliding copper rod and the rails is negligible:

(4) the power consumed in the resistance (R) while the rod moves equals .....

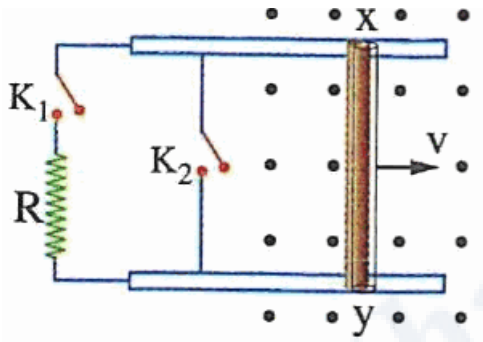


(A) 0.72 W (B) 0.88 W (C) 15.6×10^{-3} W (D) 20.7×10^{-3} W

113 An electric circuit consists of two thick parallel wires 50 cm apart with a 3 Ω resistance connected across their ends. A metal rod is placed perpendicular to the two parallel wires so that it closes the circuit. If the area between the two wires is perpendicular to a magnetic flux of density 0.15 T, the force needed to move the metal rod at a uniform speed of 200 cm/s equals .....

(A) 1.87×10^{-3} N (B) 2.55×10^{-3} N (C) 3.75×10^{-3} N (D) 7.5×10^{-3} N

114 A cylindrical rod xy of resistance R is placed in a uniform magnetic field and slides on two smooth rails as shown in the opposite figure. The force needed to pull rod xy so that it moves along the two parallel rails at a uniform velocity (v), perpendicular to the magnetic field, is smaller but not zero when .....



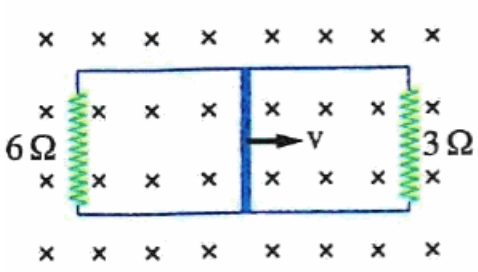
(A) switches K_1 and K_2 are open

(B) switches K_1 and K_2 are closed

(C) switch K_1 is open and switch K_2 is closed

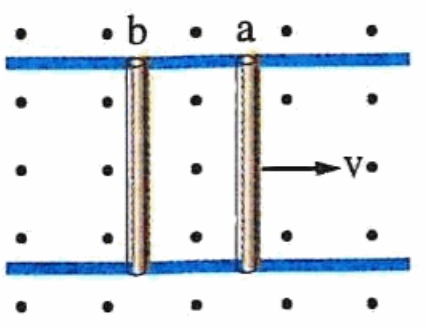
(D) switch K_1 is closed and switch K_2 is open

115 In the opposite figure, a closed rectangular circuit has a conductor 1 m long sliding on it. If the circuit is in a uniform magnetic field of flux density 2 T perpendicular to its plane and the resistance of the conductor is 2 Ω, the force needed to slide the conductor at a constant speed of 2 m/s equals .....



(A) 2 N (B) 4 N (C) 6 N (D) 8 N

116 The opposite figure shows two identical cylindrical metal rods a and b that can move on two smooth metal rails in the plane of the page, with a uniform magnetic field perpendicular to the page acting on the arrangement. When rod a is pulled at a uniform velocity v to the right of the page, the direction of the force acting on rod b due to the external magnetic field is .....



(A) in the plane of the page and to the right

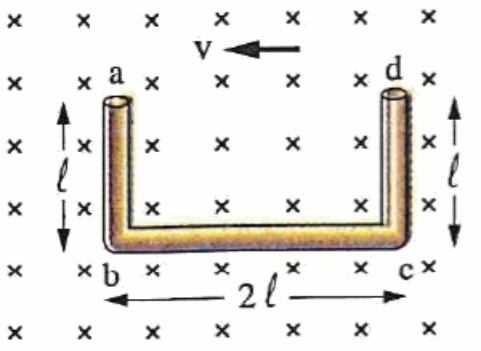
(B) in the plane of the page and to the left

(C) perpendicular to the page and inwards

(D) perpendicular to the page and outwards

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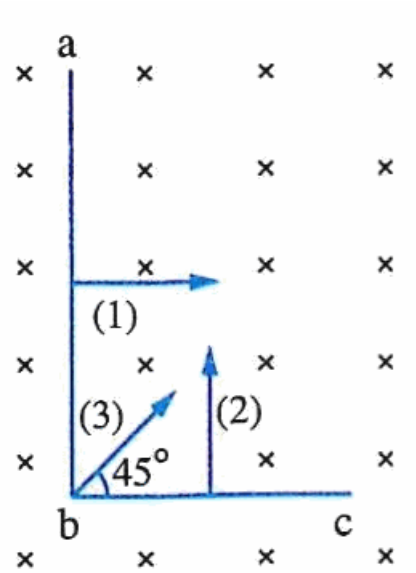
117 A wire abcd is bent in the shape of the letter U, where the length of ab is ℓ and the length of bc is $2\ \ell$. If the wire moves at a uniform velocity v in the direction shown in the figure inside a uniform magnetic field of flux density B perpendicular to the plane of the wire, the induced emf between its ends a and d equals .....



(A) 0 (B) B ℓ v (C) 2 B ℓ v (D) 4 B ℓ v

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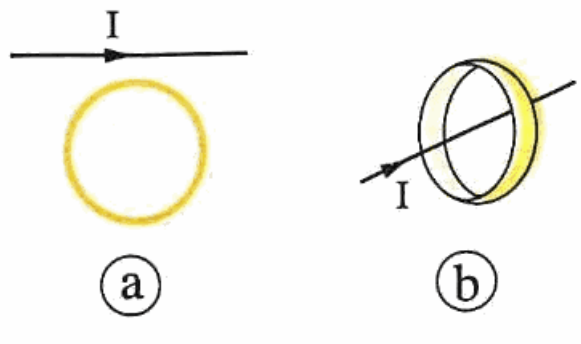
118 A wire abc bent in the shape of the letter (L), with parts of lengths ℓ and $2\ \ell$, is placed with its plane perpendicular to a uniform magnetic field as shown in the opposite figure. When the wire moves at a uniform velocity (v) in each of the shown directions (1), (2) and (3) separately, the p.d. between the ends of the wire is V_1, V_2 and V_3 respectively. Which of the following relations is correct?



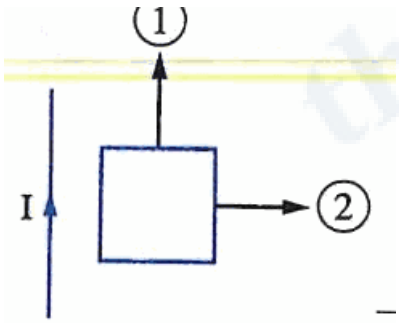
(A) $V_1 = V_2 = V_3$ (B) $V_3 > V_1 > V_2$ (C) $V_1 > V_3 > V_2$ (D) $V_3 > V_2 > V_1$

Essay questions — 19 questions

1 Figure (a) shows a copper wire carrying a current (I) placed in the plane of a copper ring, and figure (b) shows the wire placed along the axis of the ring. In which case does an induced current flow in the ring while the current in the wire increases? Explain your answer.



2 A square metal frame lies in the same plane as a long straight wire carrying a current. State, giving the reason, the direction of the induced current in the frame (if any) when the frame is moved once in direction (1) and once in direction (2) as shown in the opposite figure.

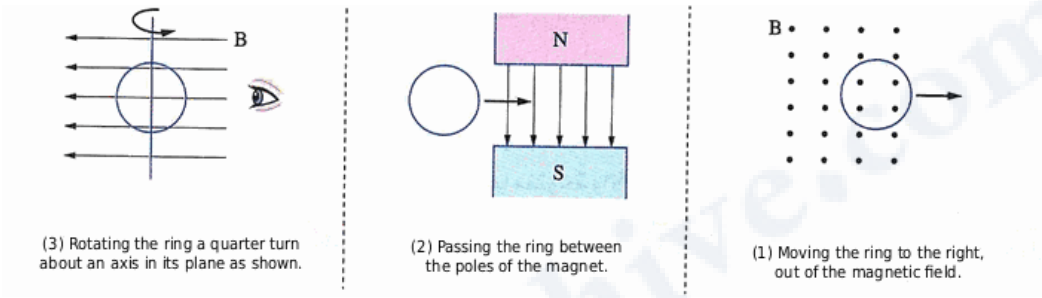


3 State, with explanation, the direction of the induced current in the shown face of the ring in each case, if any:

(1) Moving the ring to the right of the page out of the magnetic field.

(2) Passing the ring between the poles of the magnet.

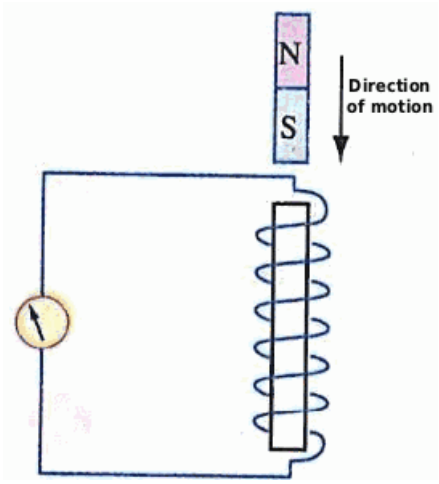
(3) Rotating the ring a quarter of a revolution about an axis in its plane in the shown direction.



4 In the opposite figure, a magnet is brought near a solenoid, and the galvanometer pointer deflects momentarily:

(1) Show on the figure the direction of the induced current in the coil and the polarity of the coil. What rule is used for this?

(2) What is the effect of placing a soft iron cylinder inside the coil on the momentary deflection of the galvanometer pointer? Explain.



5 A student moved a magnet at a uniform velocity (v_1) for a certain distance along the axis of a solenoid whose ends are connected to a centre-zero galvanometer, then moved the magnet again at a uniform velocity (v_2) for the same distance. The maximum deflections of the galvanometer pointer seen by the student in the two cases are shown in the following figure. Compare, with explanation, the magnitudes and directions of the velocity of the magnet in the two cases.

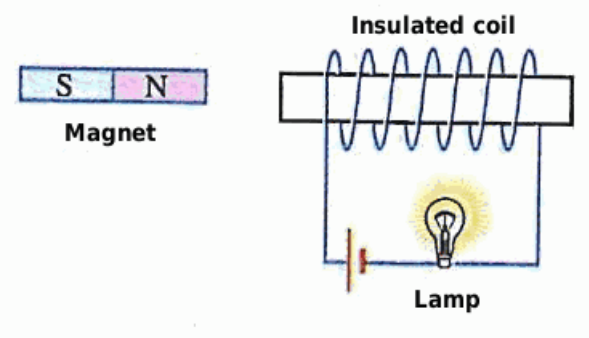


6 In the opposite figure, if the induced emf, when produced, is less than the emf of the battery, what happens to the brightness of the lamp while:

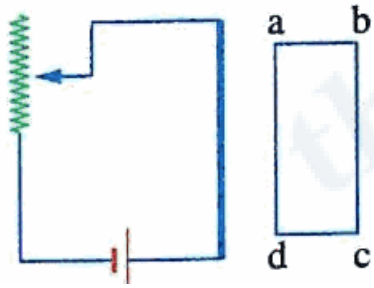
(1) the magnet is brought towards the coil?

(2) the magnet is at rest inside the coil?

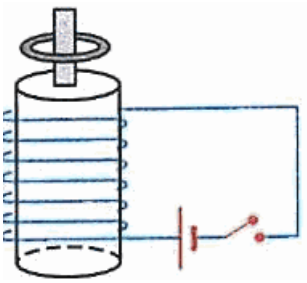
(3) the magnet is moved away from the coil?



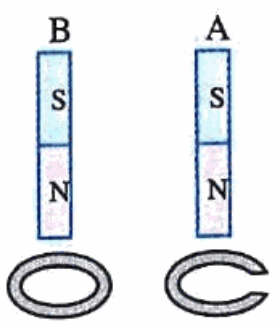
7 In the opposite figure, while the resistance taken from the rheostat is gradually increased, what is the direction of the induced current in coil abcd? Explain your answer.



8 When an aluminium ring is placed around the projecting part of the core of a strong electromagnet and the circuit is closed, the ring is seen to jump upwards. Explain.



9 In the opposite figure, two identical magnets A and B fall freely from the same height through two copper rings, one open and the other closed. Which magnet reaches the ground first? Explain your answer.

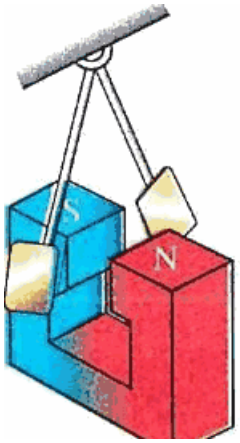


10 A circular coil of radius 10 cm has N turns, and the resistance of each turn is 1 Ω. It is placed perpendicular to a magnetic flux of density 0.1 T. If that flux vanishes in 0.01 s, calculate the average induced current in the coil.

11 A ring of radius 22 cm is placed perpendicular to a uniform magnetic field of flux density 0.05 T. If the ring is rotated through 80° in 0.25 s about an axis in its plane, calculate the average emf induced in the ring.

12 A metal ring of resistance R has a magnetic flux ϕm through it. If the flux vanishes in a time t, prove that the charge that flows through a cross-section of the ring wire is given by: $Q = \phi m / R$

13 A copper plate oscillates as a pendulum. Explain why its oscillation is damped (dies out) faster when it is surrounded by the poles of a strong magnet as shown in the figure.

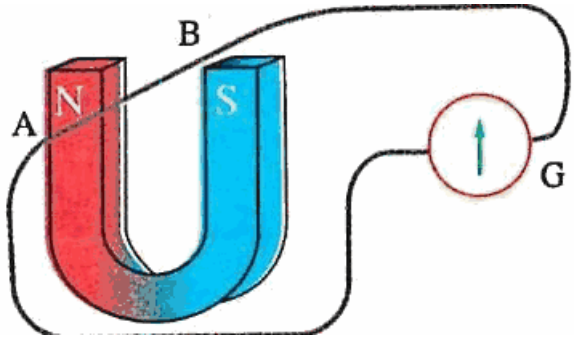


14 In the opposite figure, wire AB moves downwards at a uniform velocity between the poles of the magnet:

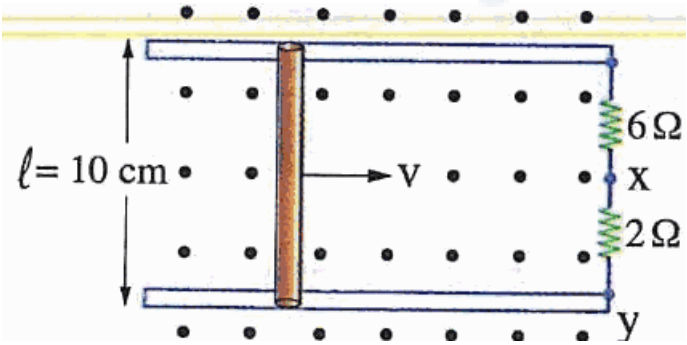
(1) What happens to the pointer of the sensitive galvanometer?

(2) What change happens to the galvanometer pointer if wire AB moves upwards at a uniform velocity?

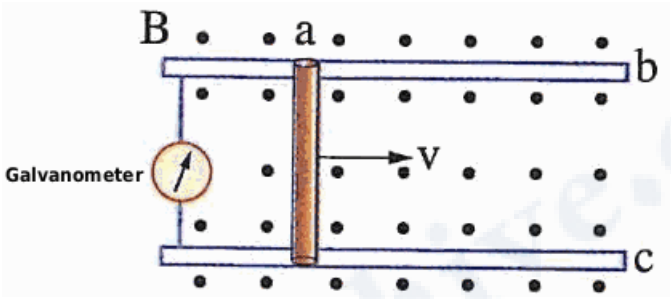
(3) How should wire AB move in the magnetic field so that the galvanometer pointer does not deflect?



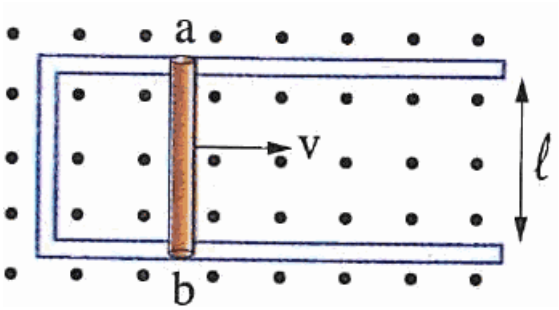
15 The opposite figure shows a cylindrical rod 10 cm long, of negligible resistance, moving at a uniform speed of 4 m/s while touching two parallel metal rails of negligible resistance, perpendicular to a uniform magnetic field of flux density 1 T. Calculate the p.d. between points x and y while the rod moves.



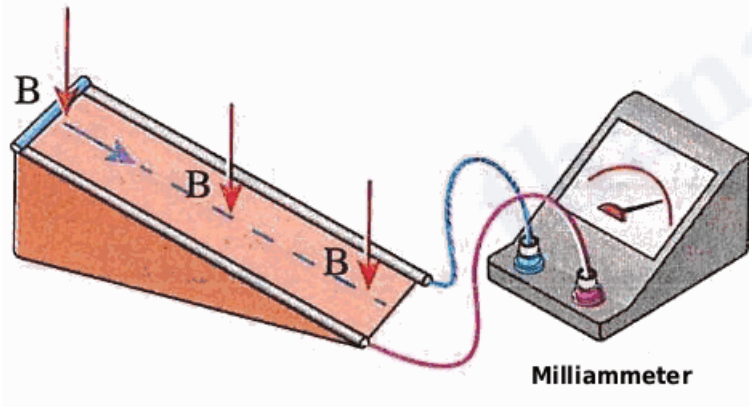
16 A metal rod (a) moves perpendicular to a magnetic field B at a uniform velocity (v) along two metal rods (b) and (c), each of resistance (R). Explain the change in the galvanometer reading while rod a moves in the direction shown in the opposite figure.



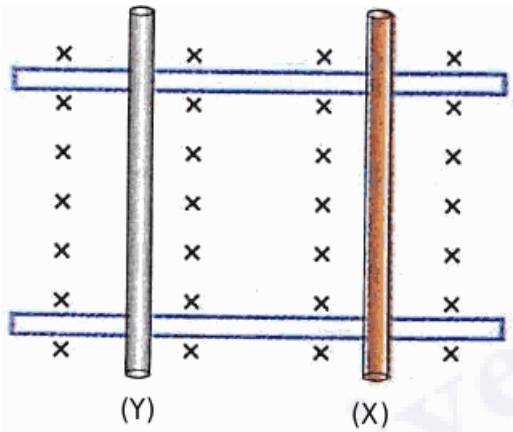
17 The opposite figure shows a rod ab of length ℓ and resistance R pulled at a uniform velocity (v) perpendicular to a uniform magnetic field of flux density B. Prove that the force needed to pull rod ab so that it keeps moving at the same uniform velocity (v) is given by: $F = B^2\ell^2v / R$



18 A cylindrical metal rod of resistance R slides freely down an inclined plane in a vertical magnetic field (B), touching two smooth rails of negligible resistance connected to a milliammeter as shown in the opposite figure. Explain why the milliammeter reading is not constant while the rod slides.

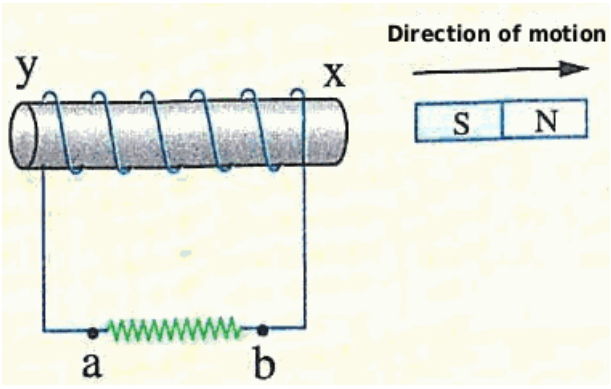


19 In the opposite figure, the two metal rods (X) and (Y) can slide on two parallel wires perpendicular to a uniform magnetic field. If the magnetic field starts to decrease gradually, describe, with explanation, how the two rods move.



Past exam questions — 83 questions

1 In the opposite figure, when the magnet moves in the shown direction, which of the following choices is correct? (Trial exam / May 2021)



(A) End (y) of the coil is a north pole and point (a) has a negative potential

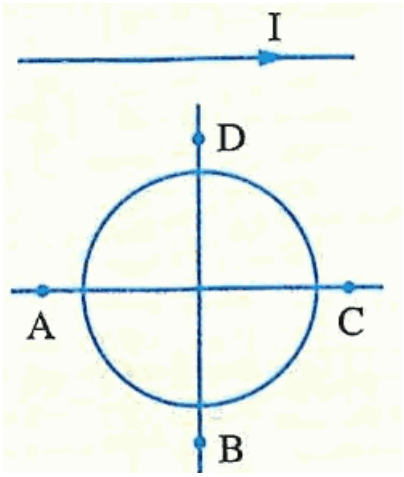
(B) End (x) of the coil is a north pole and point (b) has a positive potential

(C) End (x) of the coil is a south pole and point (a) has a positive potential

(D) End (y) of the coil is a south pole and point (b) has a negative potential

---

2 A straight wire carrying a current I lies in the same plane as a metal ring as shown in the figure. When the ring is moved in a certain direction, an anticlockwise current is induced in it. The ring was moved towards point ..... (Trial exam / May 2021)



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3 A magnetic flux whose density changes at a constant rate acts perpendicular to a circular coil, so an induced emf (E) is produced in the coil. If the number of turns of the coil is doubled, its area is halved and the flux density changes at the same rate, the induced emf in the coil equals ..... (Trial exam / June 2021)

(A) E (B) 4E (C) ½E (D) ¼E

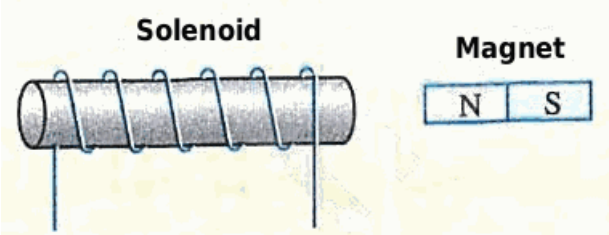
4 A student carried out the following steps using the apparatus shown in the figure: (Trial exam / June 2021)

Step (I): moving the magnet towards the solenoid while keeping the solenoid at rest.

Step (II): moving both the magnet and the solenoid at the same speed in the same direction.

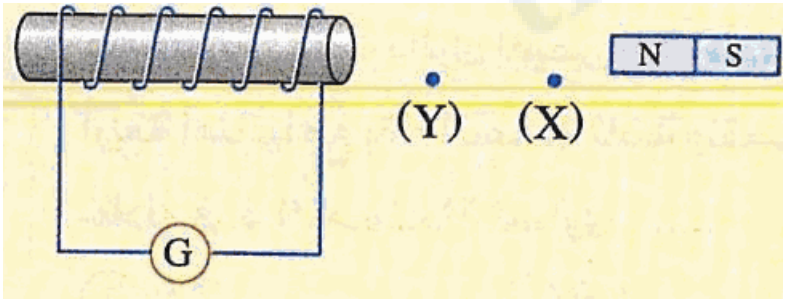
Step (III): moving both the magnet and the solenoid at the same speed towards each other.

Which of these steps does not produce an induced emf in the coil when carried out?



(A) Step (I) only (B) Step (II) only (C) Step (III) only (D) All the steps

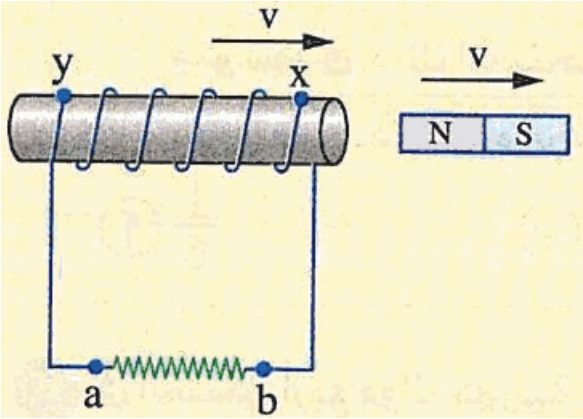
5 In the opposite figure, when the magnet moves towards the coil at a speed v from point (X) to point (Y), the galvanometer pointer deflects two divisions to the right of zero. If the experiment is repeated with the south pole facing the coil and the magnet moved at a speed 2v from point (X) to point (Y), the galvanometer pointer deflects ..... (Trial exam / June 2021)



(A) 4 divisions to the left (B) 4 divisions to the right

(C) 2 divisions to the left (D) 2 divisions to the right

6 The magnet and the coil shown in the figure move at the same speed in the same direction, so ..... (1st session 2021)



(A) the potential of point (a) is greater than that of point (b)

(B) the potential of point (x) is less than that of point (y)

(C) the potential of point (x) is greater than that of point (y)

(D) the potential of point (a) equals that of point (b)

---

7 Two circular coils (1) and (2) of areas A_1 and A_2 respectively have the same number of turns and are placed in a magnetic flux perpendicular to their planes. When the flux density through them changes at the same rate, the average induced emf in coil (1) is found to be twice that in coil (2). So ..... (1st session 2021)

(A) $A_1 = 2A_2$ (B) $A_1 = 4A_2$ (C) $A_1 = 1/2A_2$ (D) $A_1 = 1/4A_2$

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8 Two coils (x) and (y), where the area of coil (x) is twice that of coil (y), are placed in a magnetic field of flux density B so that the plane of each coil is perpendicular to the field lines. When the direction of the field acting on the two coils is reversed in 2 ms, the ratio of the average induced emf in coil x to that in coil y is *3/1*. The ratio of the number of turns of coil x to that of coil y equals ..... (1st session 2021)

(A) *3/4* (B) *2/3* (C) *3/2* (D) *4/3*

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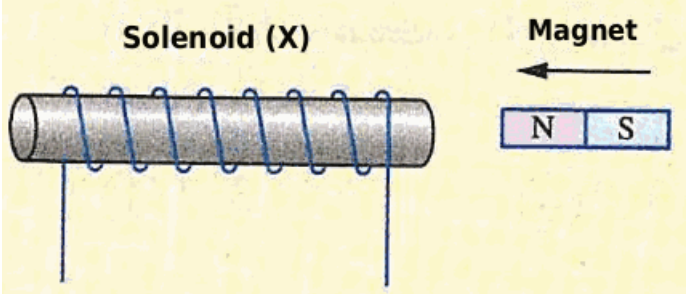
9 A student carried out Faraday's experiment to produce an induced emf in a coil as shown in the opposite figure, and took the following actions to increase the average induced emf in coil (X): (2nd session 2021)

Action (I): replacing the coil with another of larger area.

Action (II): replacing the coil with another of more turns.

Action (III): increasing the time of motion of the magnet.

Which actions actually achieve the student's aim?



(A) I , III (B) I , II (C) II , III (D) I , II , III

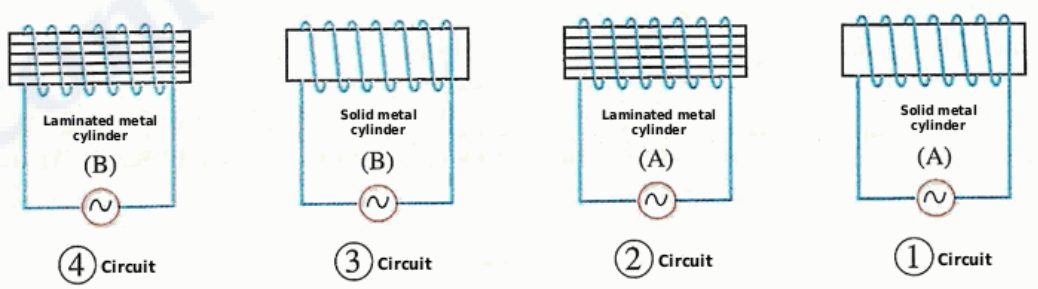
10 When a circular coil is exposed to a changing magnetic flux, an induced emf (E) is produced in it. When the number of turns of the coil is increased to four times with the area kept constant and the rate of change of the flux through the coil is decreased to half, the induced emf produced equals ..... (2nd session 2021)

(A) 2E (B) 4E (C) ½E (D) ¼E

11 Two coils (x) and (y): the area of coil (y) is twice that of coil (x), and the number of turns of coil (x) is *1/3* that of coil (y). When the two coils are placed in a magnetic field with their planes perpendicular to the field and the flux density acting on them changes at the same rate, an emf is induced in each coil. The ratio of the average induced emf of coil (x) to that of coil (y) = ... (1st session 2022)

(A) *1/6* (B) *3/4* (C) *2/3* (D) *2/5*

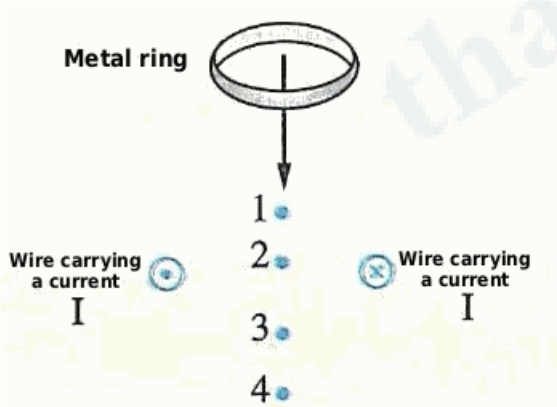
12 The figure shows four AC circuits with identical sources and coils. Given that the resistivity of metal A is greater than that of metal B, (1st session 2022)
in which of these circuits are greater eddy currents induced in the metal cylinder?



(A) Circuit (3) (B) Circuit (1) (C) Circuit (2) (D) Circuit (4)

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13 The figure shows two wires, each carrying a current I, placed perpendicular to the plane of the page, and a metal ring moving downwards so that it cuts the magnetic field produced by the currents in the two wires. At which two of the points 1, 2, 3 and 4 is a current induced in the ring that produces a field opposite to the original field at the midpoint between the two wires? (1st session 2022)



(A) 1 , 3 (B) 2 , 3 (C) 1 , 2 (D) 1 , 4

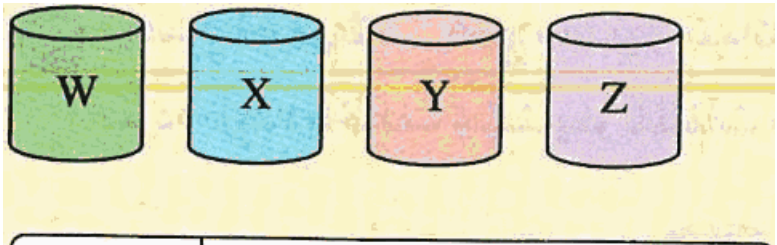
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14 Two circular coils (1) and (2) have N_1 and N_2 turns respectively and the same area, and are placed in a magnetic flux perpendicular to their planes. When the flux density through them changes at the same rate, the average induced emf in coil (2) is found to be a quarter of that in coil (1). So ..... (2nd session 2022)

(A) $N_1 = 1/4N_2$ (B) $N_1 = 8N_2$ (C) $N_1 = 4N_2$ (D) $N_1 = 1/8N_2$

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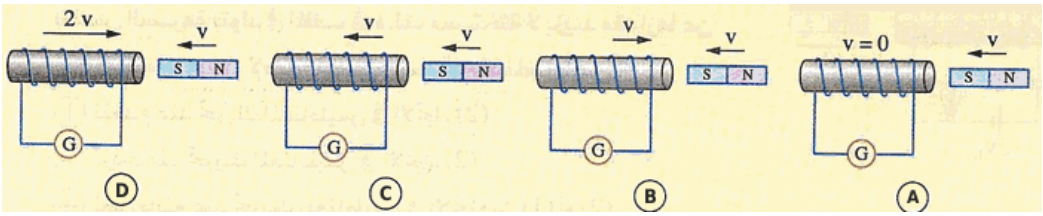
15 Here are four metal pieces of identical dimensions made of different metals, and the opposite table gives the electrical conductivities of these metals. When the pieces are exposed to the same changing magnetic flux produced by an AC source, and neglecting the differences in the magnetic permeability of these metals, the piece in which the least thermal energy is produced by eddy currents is the piece made of metal ..... (2nd session 2022)



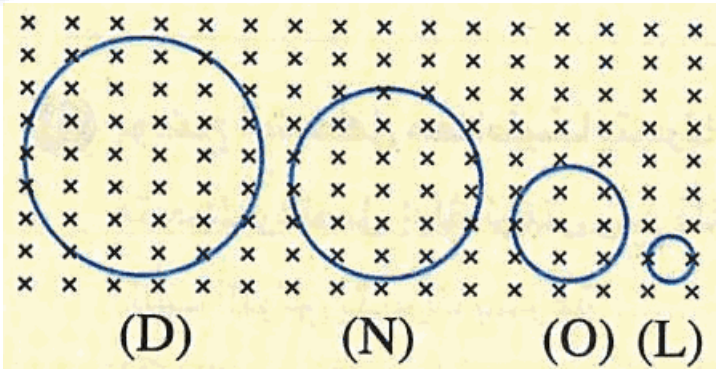
Metal	Electrical conductivity
W	$5.96 \times 10^7\ \Omega^{-1}.m^{-1}$
X	$3.5 \times 10^7\ \Omega^{-1}.m^{-1}$
Y	$2.98 \times 10^7\ \Omega^{-1}.m^{-1}$
Z	$0.217 \times 10^7\ \Omega^{-1}.m^{-1}$

(A) W (B) X (C) Y (D) Z

16 A magnet, a solenoid and a galvanometer were used to verify Faraday's law of electromagnetic induction, and the experiment was carried out four times, moving the magnet and the coil at the velocities shown in the four figures. The galvanometer pointer has the greatest deflection in experiment ..... (2nd session 2022)



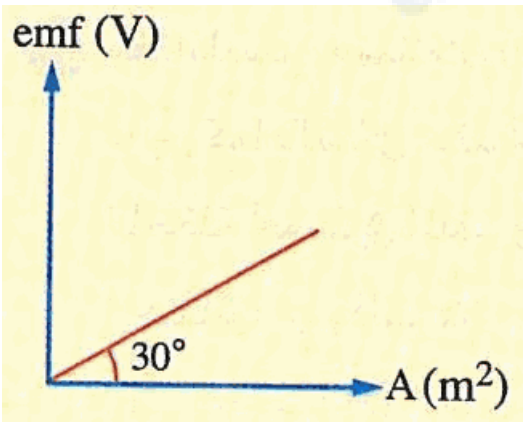
17 A copper wire of uniform cross-section is made into four rings D, N, O and L of different diameters, all lying in the plane of the page and exposed to a uniform magnetic flux as shown in the figure. If the magnetic flux vanishes, in which ring is the greatest current induced? (Trial exam 2023)



(A) D (B) L (C) O (D) N

18 A group of coils of different areas, each of 100 turns, are placed in one plane perpendicular to a magnetic flux of changing density for the same time. The graph shows the relation between the average induced emf in each coil and the face area of the coil (A). The rate of change of the magnetic flux density is ..... (Trial exam 2023)

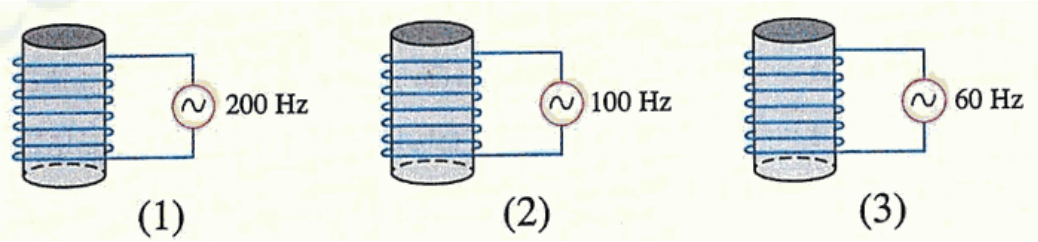
(Given that: both quantities are plotted on the two axes with the same scale)



(A) 5.77×10^{-4} T/s (B) 5.77×10^{-2} T/s (C) 0.577 T/s (D) 5.77×10^{-3} T/s

19 The figure shows three identical metal pieces placed inside three identical coils, each connected to an AC source of a different frequency so that the same effective current flows in the coils, which raised the temperature of each piece. (Trial exam 2023)

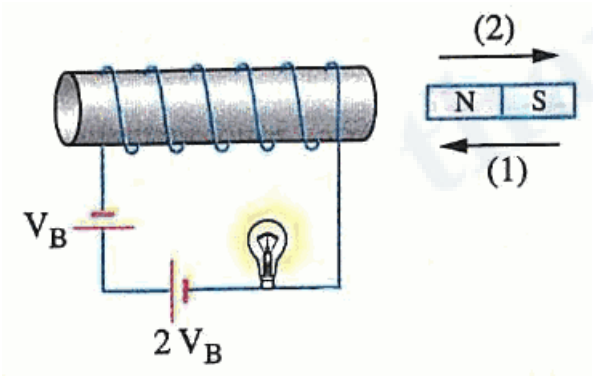
Which of the following choices gives the order of the temperatures of the three metal pieces after passing the current in each coil for the same time?



(A) $T_1 > T_2 > T_3$ (B) $T_2 > T_1 > T_3$ (C) $T_2 > T_3 > T_1$ (D) $T_3 > T_1 > T_2$

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20 In the opposite figure, while the magnet is moved in each of the two directions (1) and (2) at the same speed, an induced emf not greater than $0.5\ V_B$ is produced in the coil. What happens to the brightness of the lamp while the magnet is moving? (1st session 2023)



(A) It becomes zero when the magnet is moved in direction (2)

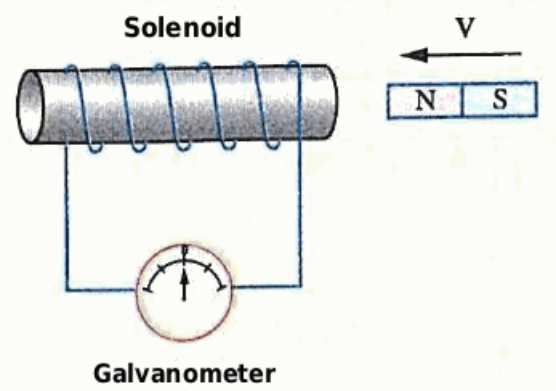
(B) It increases when the magnet is moved in direction (2)

(C) It stays constant when the magnet is moved in direction (1) or (2)

(D) It increases when the magnet is moved in direction (1)

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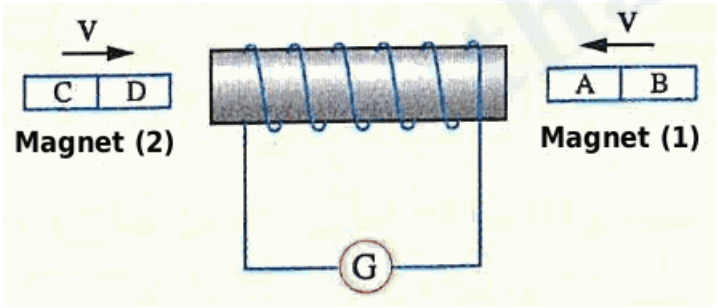
21 The figure shows a magnet moving at a speed (v) to the left towards a moving solenoid connected to a galvanometer, yet no current is induced in the coil, because the solenoid moves at ..... (1st session 2023)



(A) (v) to the left (B) (2v) to the left (C) (v) to the right (D) (2v) to the right

---

22 Two identical magnets (1) and (2) are placed at the same distance from a solenoid as shown in the figure. When the two magnets are moved at the same speed and at the same moment towards the two ends of the coil along its axis, the galvanometer pointer does not deflect. This is because ..... (2nd session 2023)

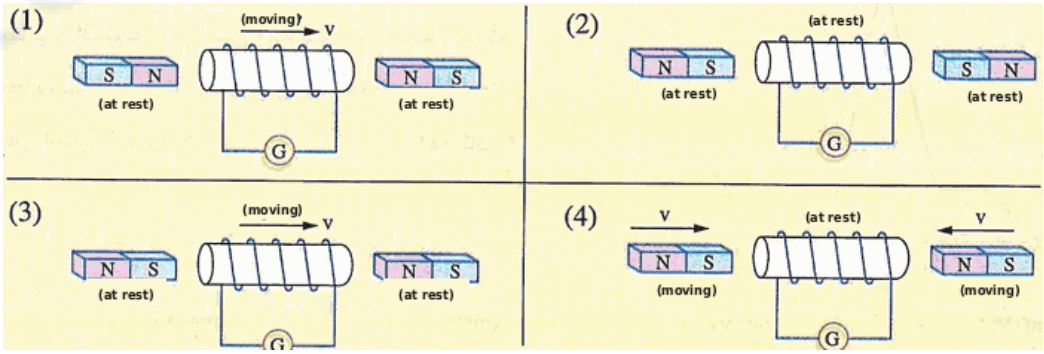


(A) pole (A) is north and pole (D) is north (B) pole (A) is north and pole (D) is south
(C) pole (A) is south and pole (D) is north (D) pole (B) is south and pole (D) is south

---

23 Each of the following figures shows a coil connected to a galvanometer, with a magnet placed near each of its ends. If the coils are identical and the magnets are identical and at equal distances from the coil, (1st session 2024)

what is the correct order of the induced emf in each coil according to the state of motion shown in each figure?



(A) $(emf)_2 = (emf)_4 > (emf)_1 = (emf)_3$ (B) $(emf)_1 = (emf)_4 > (emf)_2 = (emf)_3$

(C) $(emf)_4 = (emf)_2 > (emf)_1 > (emf)_3$ (D) $(emf)_1 = (emf)_3 > (emf)_2 = (emf)_4$

---

24 The following table lists several possibilities for getting an induced current in the coil by moving the magnet shown in the figure: (1st session 2024)

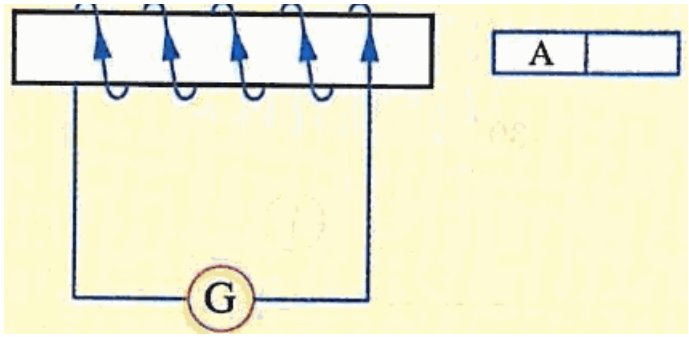
Possibility 1: pole A is south, the magnet approaches the coil.

Possibility 2: pole A is south, the magnet moves away from the coil.

Possibility 3: pole A is north, the magnet approaches the coil.

Possibility 4: pole A is north, the magnet moves away from the coil.

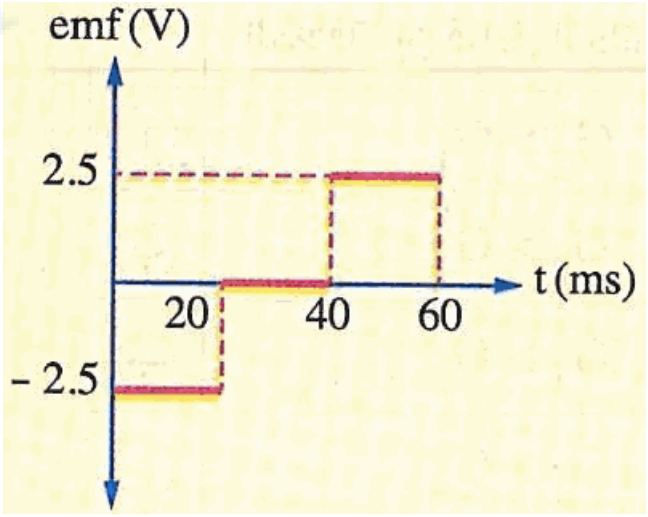
Which two possibilities produced a current in the direction shown in the figure?



(A) 1 , 2 (B) 1 , 4 (C) 3 , 4 (D) 2 , 3

---

25 The opposite graph shows the relation between the induced emf in a square metal frame that enters, at a uniform velocity, a region of uniform magnetic flux of density 0.2 T until it leaves it, and time (t). The area of the metal frame equals ..... (1st session 2024)

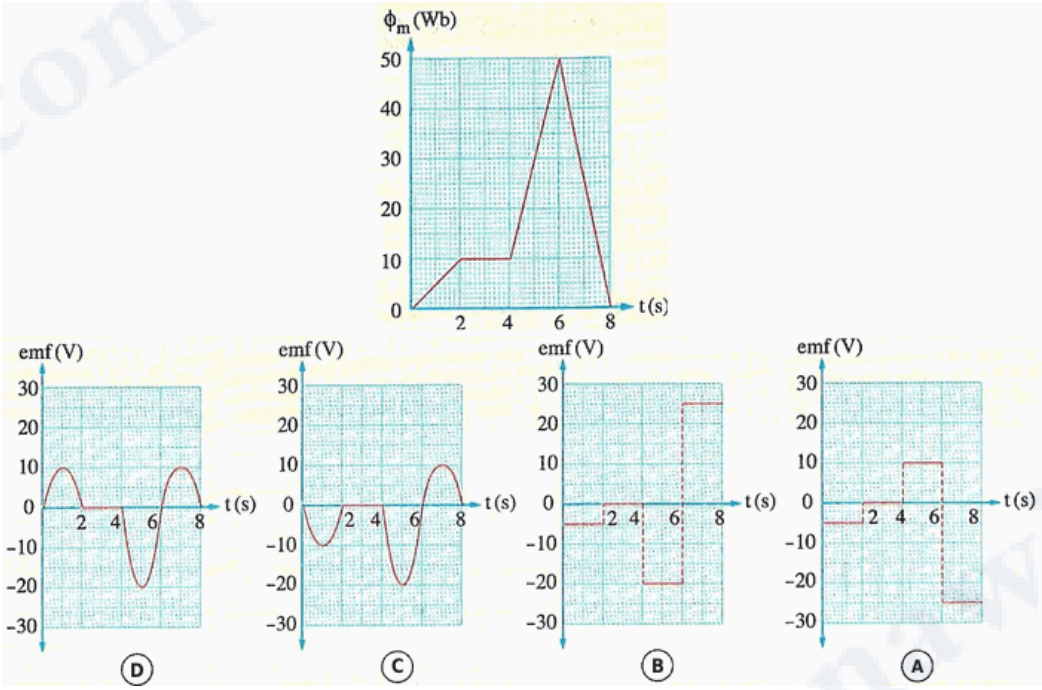


(A) $0.5\ cm^2$ (B) $0.5\ m^2$ (C) $0.25\ cm^2$ (D) $0.25\ m^2$

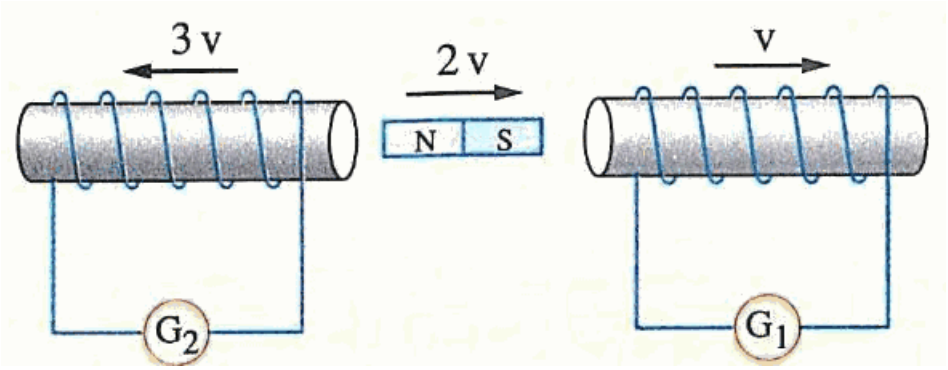
26 A circular coil of 60 turns and face area $36\ cm^2$ has a magnetic flux perpendicular to its plane of density $10^{-6}\ T$ through it. The average induced emf in the coil while it rotates $1/2$ a revolution from the position perpendicular to the field in 400 ms equals ..... (1st session 2024)

(A) 1.08 nV (B) 0.54 μV (C) 1.08 μV (D) 0.54 nV

27 The opposite graph shows the change of the magnetic flux through a one-turn circular coil. Which of the following graphs shows the relation between the induced emf in the coil and time (t) during the same time? (2nd session 2024)



28 Two identical galvanometers are connected to two identical coils, and a magnet is placed midway between the two coils. If the magnet and the two coils move at the velocities shown in the opposite figure, then ..... (2nd session 2024)



(A) $G_2 > G_1$, the two currents are in the same direction

(B) $G_2 > G_1$, the two currents are in opposite directions

(C) $G_1 > G_2$, the two currents are in opposite directions

(D) $G_1 > G_2$, the two currents are in the same direction

29 A magnetic flux passes through a coil of 10 turns. If the flux decreases by 0.3 mWb in 0.02 s, the induced emf in the coil equals ..... (2nd session 2024)

(A) 0.15 V (B) 15 V (C) 150 V (D) 1.5 V

---

30 A circular coil of 200 turns and face area $5\ cm^2$ rotates in a magnetic flux of density $6 \times 10^{-4}\ T$ about a fixed axis perpendicular to the flux, so an average induced emf of 0.3 mV is produced in 400 ms. Which of the following choices produces that induced emf? (2nd session 2024)

(A) The coil rotates ½ a revolution from the position perpendicular to the flux

(B) The coil rotates ¼ of a revolution from the position perpendicular to the flux

(C) The coil rotates ½ a revolution from the position parallel to the flux

(D) The coil rotates ¾ of a revolution from the position parallel to the flux

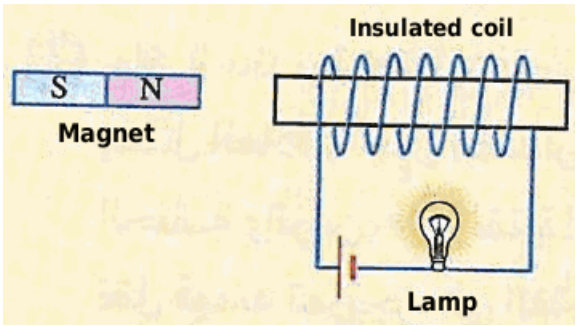
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31 Two circular coils: the area of the first is twice that of the second, and the number of turns of the first is twice that of the second. They are placed perpendicular to a magnetic flux whose density changes at the same rate. The ratio of the emf produced in the first coil to that produced in the second coil equals ..... (Sample exam 2025)

(A) *1/2* (B) *2/1* (C) *1/4* (D) *4/1*

---

32 In the opposite figure, if the induced emf, when produced, is less than the emf of the battery, what happens to the brightness of the lamp while the magnet is brought towards the coil? (Sample exam 2025)



(A) The lamp becomes brighter

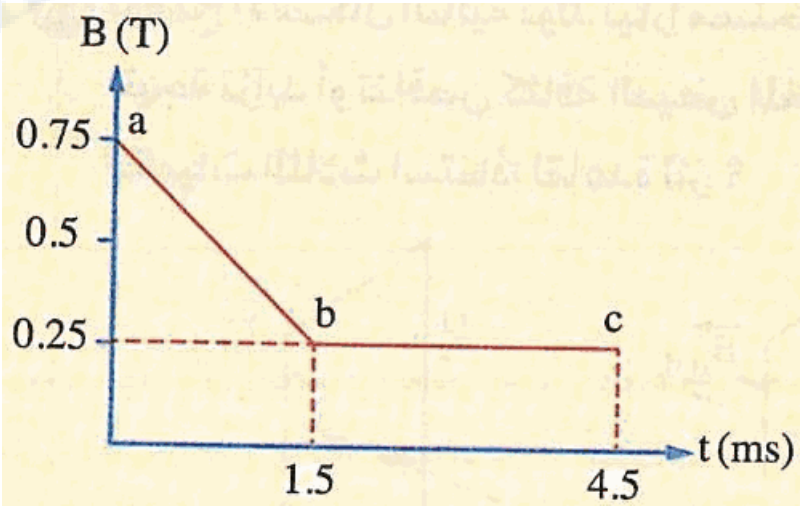
(B) The lamp becomes dimmer

(C) The brightness of the lamp does not change

(D) The lamp goes out

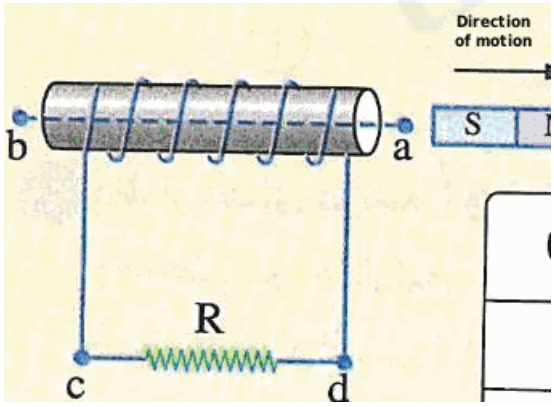
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33 The opposite graph shows the relation between the magnetic flux density (B) in which a coil of 200 turns, each of cross-sectional area $30\ cm^2$, is placed and time (t). If the magnetic field is parallel to the axis of the coil, the average induced emf in the coil during interval (bc) equals ..... (Sample exam 2025)



(A) 0 (B) 25 V (C) 35 V (D) 50 V

34 In the opposite figure, when the magnet is moved away from the coil ..... (Sample exam 2025)



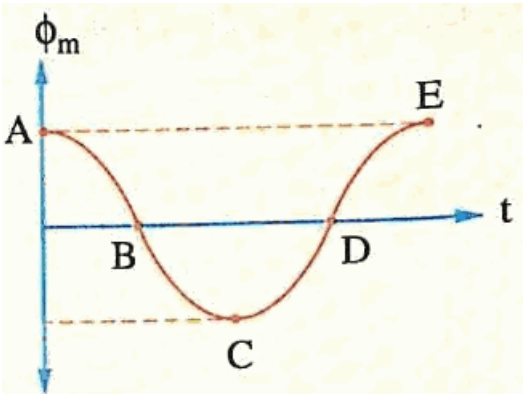
(A) the field inside the coil is b → a, the current in R is c → d

(B) the field inside the coil is a → b, the current in R is d → c

(C) the field inside the coil is b → a, the current in R is d → c

(D) the field inside the coil is a → b, the current in R is c → d

35 The opposite figure shows the change of the magnetic flux through a coil during a certain time. The induced emf in the coil is maximum at ..... (Sample exam 2025)

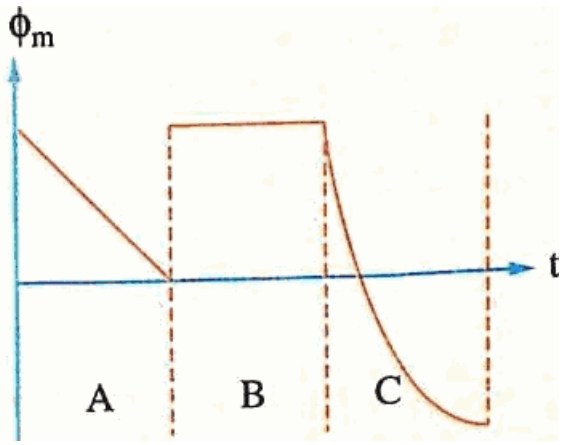


(A) points A and E
(B) points C and D
(C) points B and D
(D) points A, E and C

36 Which of the following actions does not produce an induced emf in a coil placed perpendicularly in a magnetic field? (Sample exam 2025)

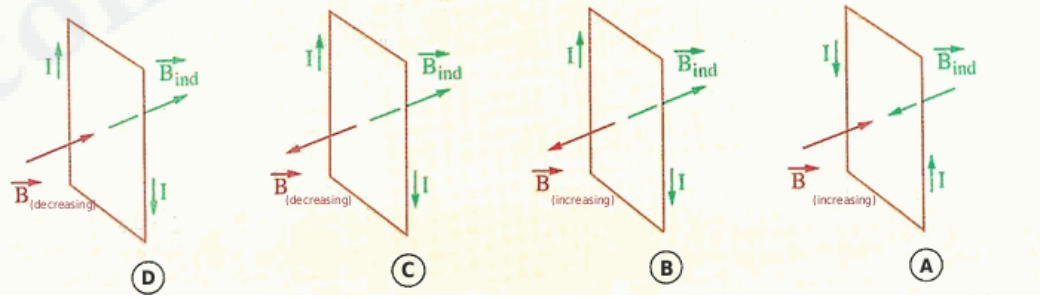
(A) Changing the area of the coil exposed to the magnetic field
(B) Leaving the coil at rest in a changing magnetic field
(C) Leaving the coil at rest in a uniform magnetic field
(D) Changing the angle between the plane of the coil and the magnetic field

37 A metal ring has a changing flux through it, and the opposite graph shows the relation between the magnetic flux through the ring and time. The interval during which a current that gradually decreases flows in the ring is interval ..... (Sample exam 2025)

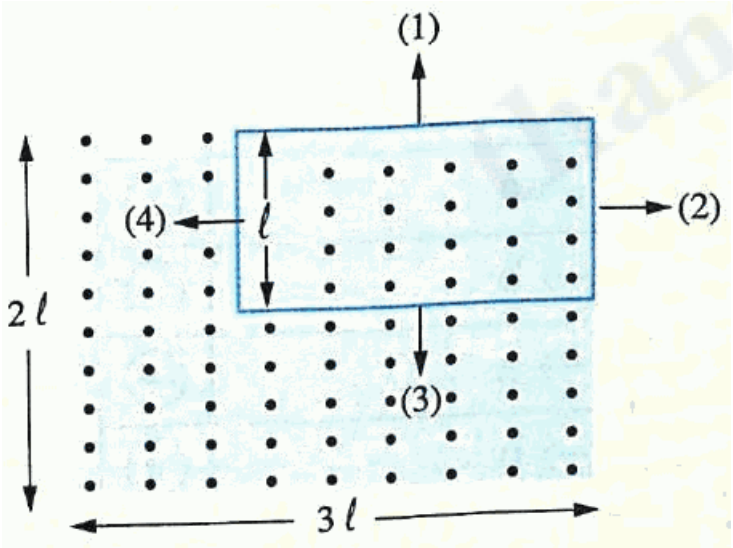


(A) A
(B) B
(C) C
(D) A , B

38 The following figures show an induced current (I) in a coil, which produces a magnetic flux of density (B_{ind}) at the centre, as a result of an increase or decrease of the external magnetic flux density (B) acting on the coil. Which figure does not show the directions of these three quantities according to Lenz's rule? (Sample exam 2025)

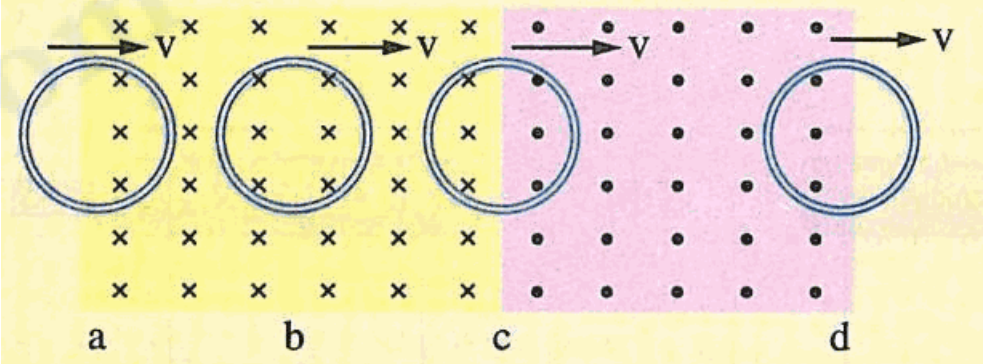


39 A metal frame of width ℓ and length 2ℓ is placed perpendicular to a uniform magnetic flux limited to the region shown in the figure. The direction in which the frame should move a distance ℓ in a time t to produce the greatest average induced emf is ..... (Sample exam 2025)

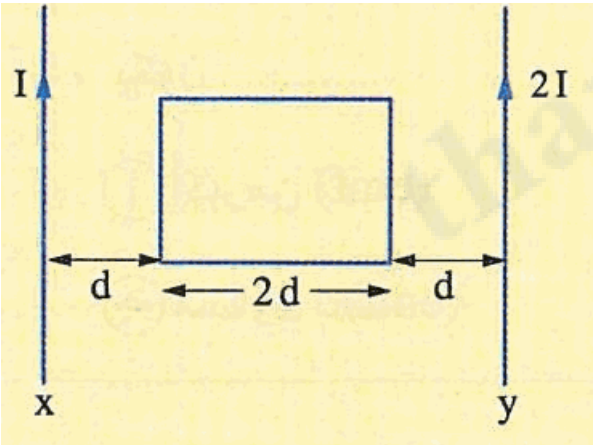


(A) Direction (1) (B) Direction (2) (C) Direction (3) (D) Direction (4)

40 A metal ring moves at a uniform velocity (v) in the direction shown in the following figure. A clockwise current is induced at the moment the ring passes position ..... (Sample exam 2025)



41 In the shown figure, a metal frame and two long straight wires (x) and (y), each carrying a current, all lie in the same plane. The direction of the induced current in the metal frame if, during a time (t), the current vanishes in ..... (Sample exam 2025)



(A) wire (x): clockwise, wire (y): clockwise

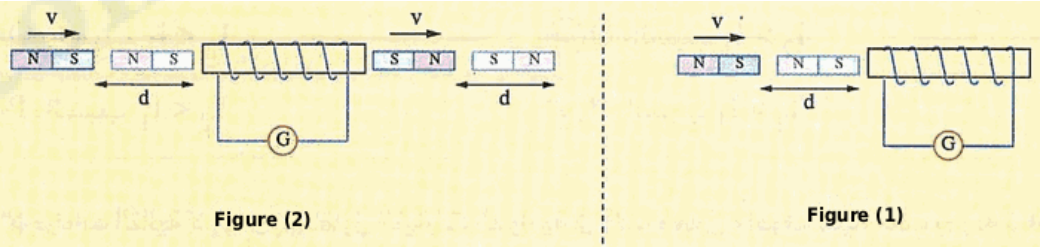
(B) wire (x): anticlockwise, wire (y): anticlockwise

(C) wire (x): clockwise, wire (y): anticlockwise

(D) wire (x): anticlockwise, wire (y): clockwise

42 In figure (1), while a magnet approaches a solenoid, the galvanometer pointer deflects through an angle (θ) in a certain direction. In figure (2) the experiment is repeated using two identical magnets, identical to the magnet in figure (1). (Sample exam 2025)

Which of the following choices is correct?



(A) The galvanometer pointer deflects through (2θ) in the opposite direction

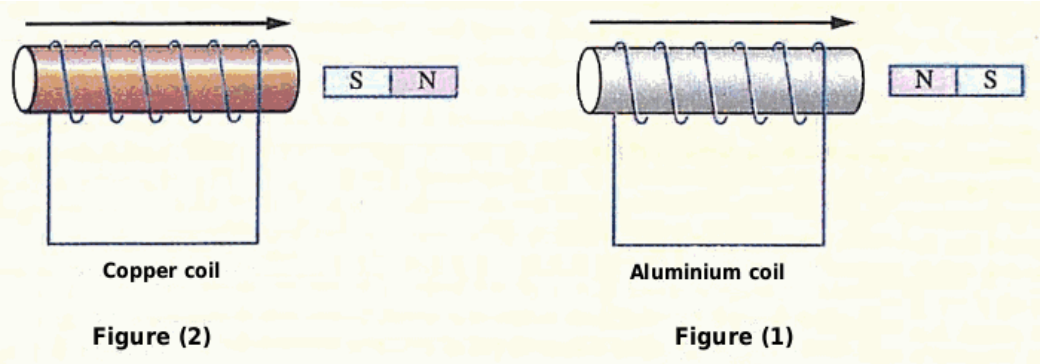
(B) The galvanometer pointer deflects through (2θ) in the same direction

(C) The galvanometer pointer does not deflect

(D) The galvanometer pointer deflects through (θ) in the same direction

---

43 In figure (1), an aluminium solenoid is moved towards a strong magnet, so an induced emf (emf) is produced between the ends of the coil. If the aluminium coil is replaced with a copper one of the same number of turns and cross-sectional area, and the experiment is repeated at the same speed as in figure (2), the induced emf in the copper coil is ..... (Sample exam 2025)



(A) greater than (emf)

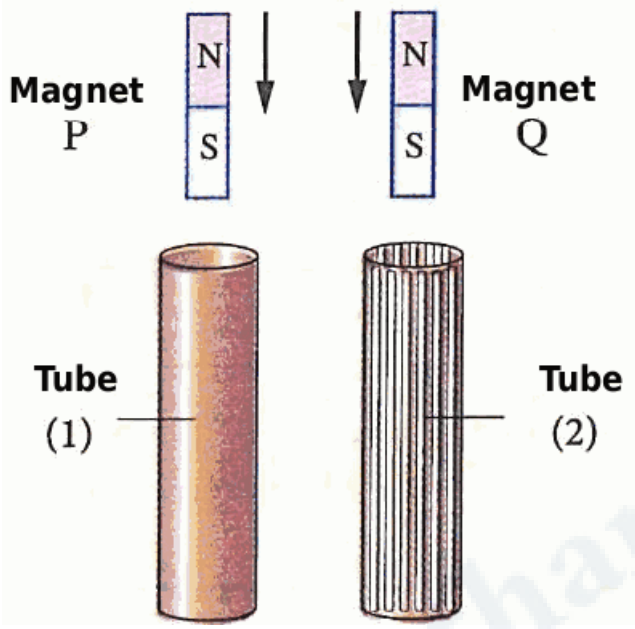
(B) less than (emf)

(C) equal to (emf)

(D) equal to zero

---

44 Two identical magnets P and Q hang vertically at the same height above two tubes (1) and (2) respectively. Both tubes are made of copper, and tube (2) is divided into insulated lengthwise strips as shown in the opposite figure. If the two magnets are dropped at the same moment to pass through the tubes without touching them, induced currents I_1 and I_2 are produced respectively. Which magnet leaves its tube completely first, and why? (Sample exam 2025)



(A) Q, because $I_2 < I_1$

(B) Q, because $I_2 > I_1$

(C) P, because $I_2 < I_1$

(D) P, because $I_2 > I_1$

---

45 Which of the following actions does not reduce the eddy currents in a metal core around which a coil carrying an alternating current is wound? (Sample exam 2025)

(A) Making the metal core of laminations insulated from each other

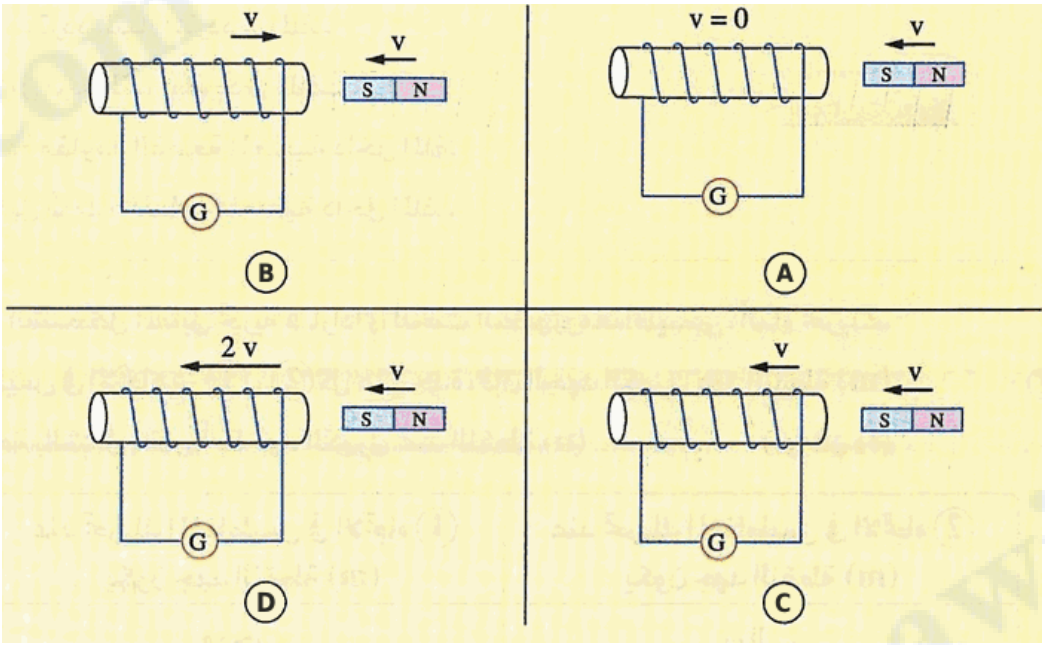
(B) Making the metal core of a material of high electrical conductivity

(C) Using a low-frequency current

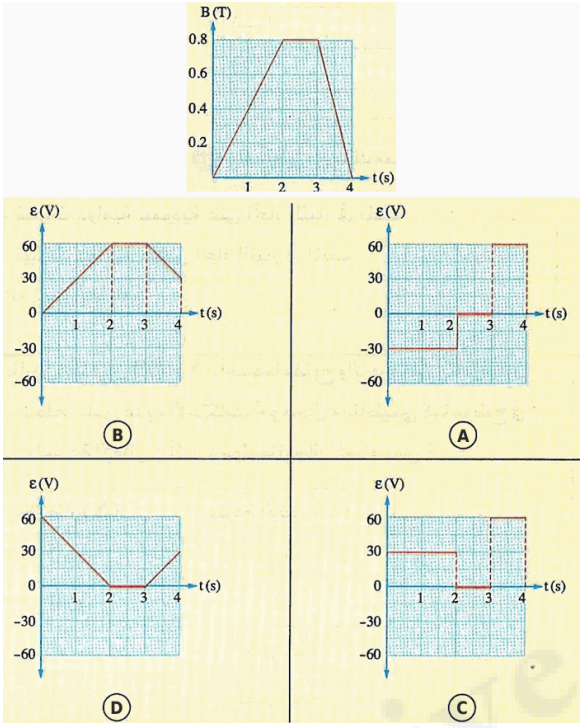
(D) Making the metal core of a material of high resistivity

---

46 Each of the following figures shows the relative motion during a certain time between a magnet and a coil connected to a galvanometer. Which figure shows the case in which the greatest average emf is induced in the coil? (1st session 2025)



47 A circular coil of 100 turns, each of cross-sectional area $0.75\ m^2$, is placed perpendicular to a magnetic field whose density can be changed, and the graph shows the relation between the magnetic flux density (B) and time (t). Which of the following graphs represents the relation between the induced emf (ε) in the coil and time (t)? (1st session 2025)



48 A thick metal piece is placed in the core of a solenoid, insulated from it, which carries an alternating current. The eddy currents induced in the metal piece increase ..... (1st session 2025)

(A) by increasing the frequency of the alternating current in the coil

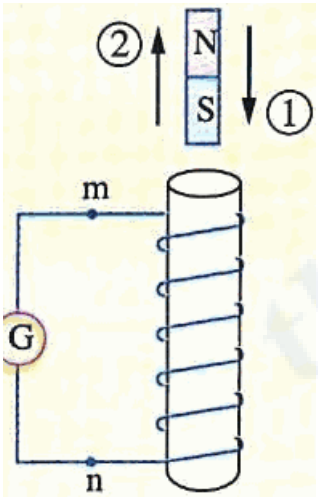
(B) by decreasing the frequency of the alternating current in the coil

(C) by increasing the resistance of the metal piece inside the coil

(D) by decreasing the thickness of the metal piece inside the coil

---

49 The opposite figure shows Faraday's experiment of electromagnetic induction. While the magnet is moved in each of the directions (1) and (2) separately, the potential at point (m) shown in the figure compared with the potential at point (n) is ..... (2nd session 2025)



(A) direction (1): positive, direction (2): negative

(B) direction (1): positive, direction (2): positive

(C) direction (1): negative, direction (2): positive

(D) direction (1): negative, direction (2): negative

---

50 A solenoid of insulated wire is wound around a metal core. While a direct current flows in the coil, the metal core ..... (2nd session 2025)

(A) has eddy currents induced in it in the same direction as the current in the coil

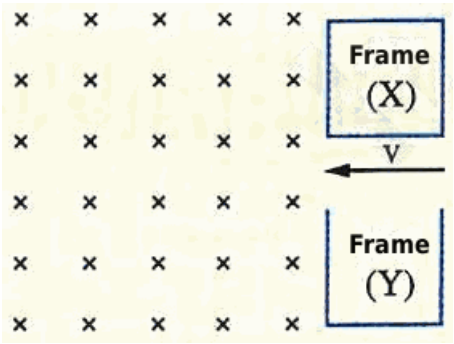
(B) has eddy currents induced in it perpendicular to the current in the coil

(C) has eddy currents induced in it opposite to the current in the coil

(D) has no eddy currents induced in it

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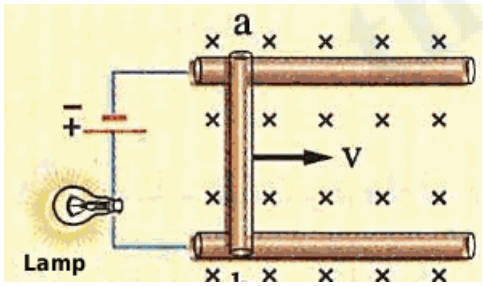
51 The figure shows two metal frames (X) and (Y), one open and the other closed, moving at a speed (v) on a smooth frictionless surface towards a magnetic field as shown in the figure. What happens to the speed of the two frames while they enter the magnetic field? (Sample exam 2026)



(A) (X) stays constant, (Y) increases
(B) (X) stays constant, (Y) decreases
(C) (X) increases, (Y) stays constant
(D) (X) decreases, (Y) stays constant

---

52 In the shown figure, while rod ab is moved to the right at a uniform velocity (v), the brightness of the lamp ..... (Trial exam / May 2021)
(Given that: the ohmic resistance of the rod and the rails is negligible)



(A) becomes zero
(B) increases
(C) does not change
(D) decreases

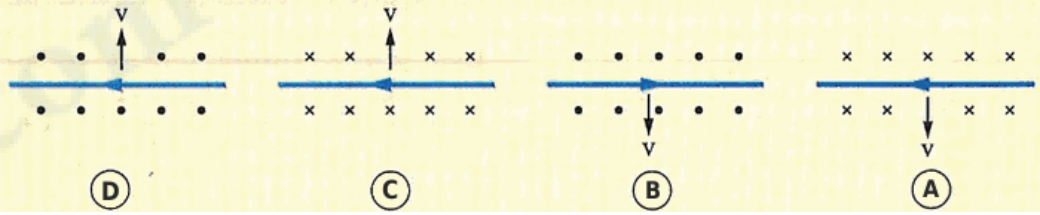
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53 A straight wire of unit length moves perpendicular to both its length and a magnetic field of flux density 0.4 T, so an induced emf of 0.2 V is produced between its ends. The speed of the wire equals ..... (Trial exam / June 2021)

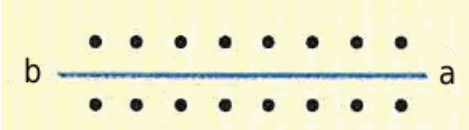
(A) 0.5 m/s
(B) 1 m/s
(C) 1.5 m/s
(D) 2 m/s

---

54 The following figures show four straight wires, each connected to a closed circuit and moving at a velocity v in a uniform magnetic field. In which of these figures is the direction of the induced current in the wire correct? (Trial exam / June 2021)

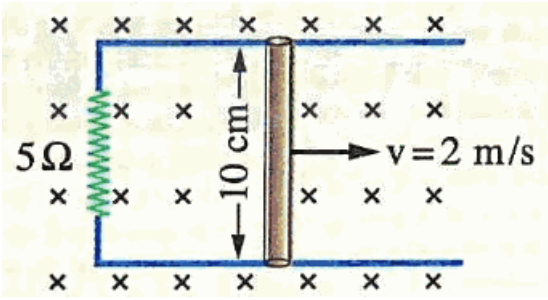


55 The opposite figure shows a straight wire (ab) placed in a uniform magnetic field perpendicular to the page and outwards. For an induced emf to be produced in the wire so that the potential of point (a) is greater than that of point (b), the wire must move ..... (1st session 2021)



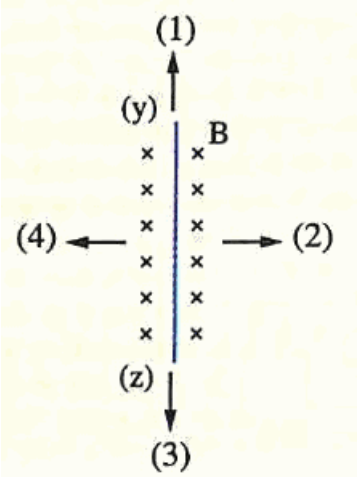
(A) down the page
(B) up the page
(C) to the right of the page
(D) to the left of the page

56 The opposite figure shows a wire moving perpendicular to a magnetic field of flux density 0.2 T. The current in the resistance equals ..... (1st session 2021)
(Given that: the ohmic resistance of both the wire and the frame is negligible)



(A) 4 mA
(B) 6 mA
(C) 8 mA
(D) 2 mA

57 The figure shows a straight wire (zy) in a closed circuit placed in a uniform magnetic field (B). For an induced current to flow in the wire from (z) to (y), in which direction (1), (2), (3) or (4) must wire (zy) be moved? (2nd session 2021)



(A) (1) (B) (2) (C) (3) (D) (4)

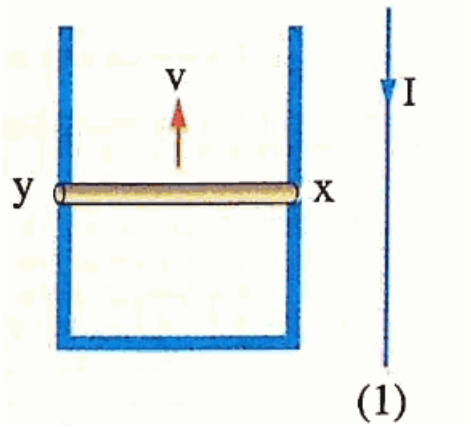
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58 A straight wire 20 cm long moves at 0.5 m/s in a direction perpendicular to its length, making an angle (θ) with the direction of a magnetic field of flux density 0.4 T, so an induced emf of 20 mV is produced between its ends. The angle (θ) equals ..... (2nd session 2021)

(A) 60° (B) 30° (C) 45° (D) 90°

---

59 The figure shows a wire (xy) of resistance (R) moving upwards on a metal frame of negligible resistance at a uniform velocity (v) in the magnetic field produced by a current (I) in wire (1), so an induced current flows in wire xy from x to y. To reduce the induced current to half, ... (1st session 2022)



(A) the speed of wire (xy) must be doubled

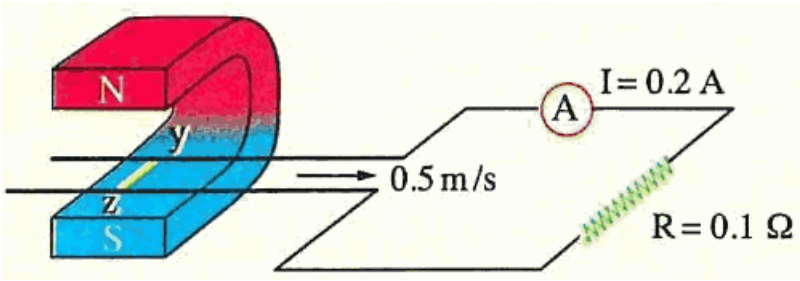
(B) the current in wire (1) must be reduced to a quarter

(C) the speed of wire (xy) must be increased four times

(D) the current in wire (1) must be reduced to half

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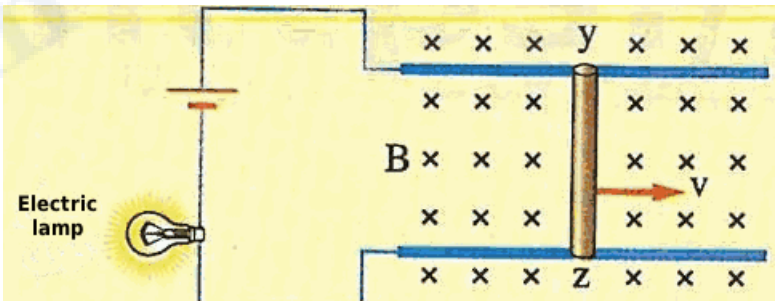
60 The figure shows a metal wire yz of negligible resistance sliding on two metal rails of negligible resistance at 0.5 m/s, perpendicular to a magnetic field of flux density 2 T. If the ammeter reading is 0.2 A, the length of wire zy equals ..... (1st session 2022)



(A) 0.04 m (B) 0.02 m (C) 0.01 m (D) 0.03 m

---

61 If wire zy is moved to the right perpendicular to a magnetic field B directed into the page as shown in the figure, and the induced emf in the wire is less than the emf of the battery, then ..... (1st session 2022)



(A) the lamp becomes brighter, and the potential of z is greater than that of y

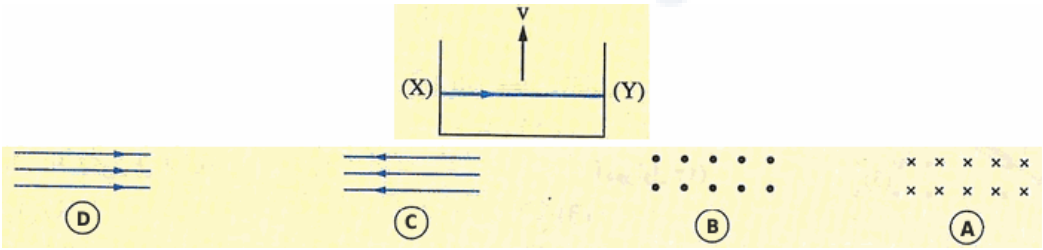
(B) the lamp becomes brighter, and the potential of z is less than that of y

(C) the lamp becomes dimmer, and the potential of z is less than that of y

(D) the lamp becomes dimmer, and the potential of z is greater than that of y

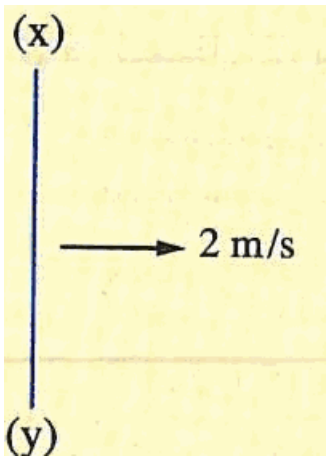
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62 The figure shows a straight wire (YX) in the plane of the page moving upwards at a velocity v, so an induced current flows in it from (X) to (Y). Which of the following figures shows the direction of the magnetic flux acting on the wire relative to the plane of the page? (2nd session 2022)



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63 The figure shows a straight wire (xy) 20 cm long moving perpendicular to a uniform magnetic flux at 2 m/s, so an induced emf of 0.02 V is produced between its ends, and the potential of point (x) becomes greater than that of point (y). The magnitude and direction of the magnetic flux density are ..... (2nd session 2022)



(A) 0.05 T, perpendicular to the page and inwards

(B) 0.5 T, perpendicular to the page and inwards

(C) 0.05 T, perpendicular to the page and outwards

(D) 0.5 T, perpendicular to the page and outwards

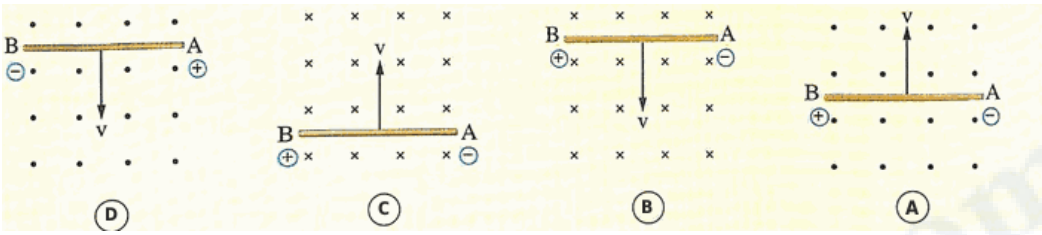
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64 A wire 0.2 m long moves at a uniform speed of 2 m/s in a direction perpendicular to its length, making an angle of 30° with the lines of a magnetic flux of density 0.4 T. The induced emf in the wire is ..... (Trial exam 2023)

(A) 0.16 V (B) 0.32 V (C) 0.08 V (D) 0.24 V

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65 A copper wire AB of length ℓ moves in the plane of the paper perpendicular to a uniform magnetic flux. Which of the following figures correctly shows the polarity of the ends of the wire? (Trial exam 2023)

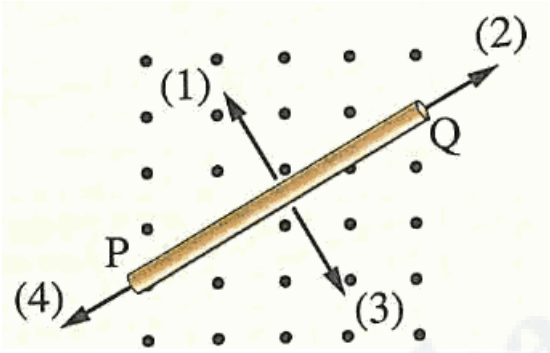


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66 A copper wire of length ℓ has its ends connected to a galvanometer. When the wire moves at a uniform velocity v perpendicular to both its length and a magnetic flux of density B, the galvanometer pointer deflects through an angle θ. When both the speed of the wire is increased to 2v and the flux density to 2B, the galvanometer pointer deflects through an angle ..... (Trial exam 2023)

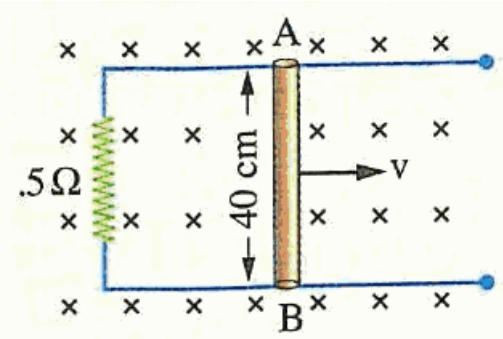
(A) 2θ (B) 4θ (C) 6θ (D) θ

67 The opposite figure shows a uniform magnetic field acting on a wire (PQ) in the plane of the page that is part of a closed electric circuit. If the induced current in the wire flows from point (Q) to point (P), the wire moves in direction ..... (1st session 2023)



(A) (1) (B) (3) (C) (2) (D) (4)

68 The opposite figure shows a wire AB of resistance 0.5 Ω moving perpendicular to a magnetic field of flux density 0.2 T. For the current produced in the circuit during the motion to be 0.1 A, the wire must move at a speed of ..... (1st session 2023)
(Neglecting the resistance of the connecting wires)



(A) 1.5 m/s (B) 1.875 m/s (C) 2.5 m/s (D) 0.625 m/s

69 A straight wire of length (ℓ) moves at a velocity (v) in a direction perpendicular to its length and inclined at 30° to the direction of a uniform magnetic field of flux density (B), so an induced emf (emf) is produced between its ends. To double the induced emf in the wire, ... (2nd session 2023)

(A) the wire must be replaced with another of length (4ℓ)

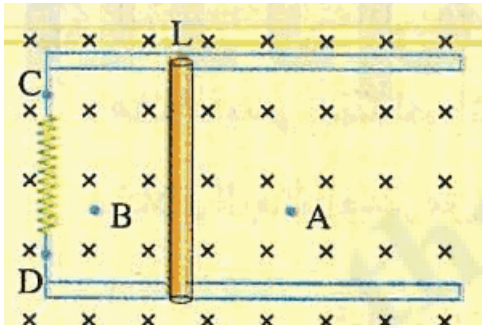
(B) the wire must be moved at a velocity (3v)

(C) the wire must be moved in a magnetic flux of density $(1/2$ B)

(D) the wire must be moved perpendicular to the magnetic field (B)

---

70 In the opposite figure, wire (L) can move in the plane of the page in a magnetic field perpendicular to the page and inwards. Which of the following choices is correct? (2nd session 2023)



(A) If the wire moves towards point A, the potential of point C is greater than that of point D

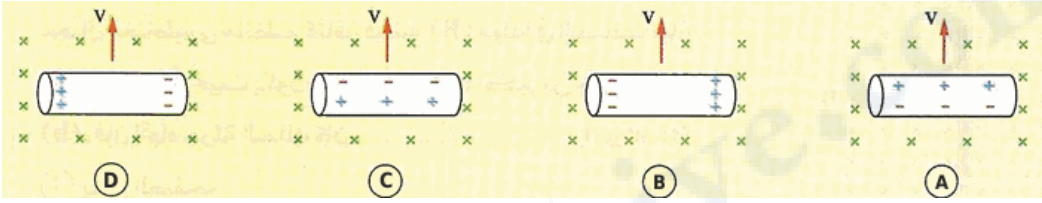
(B) If the wire moves towards point A, the potential of point C is less than that of point D

(C) If the wire moves towards point B, the potential of point C is greater than that of point D

(D) If the wire moves towards point B, the potential of point C equals that of point D

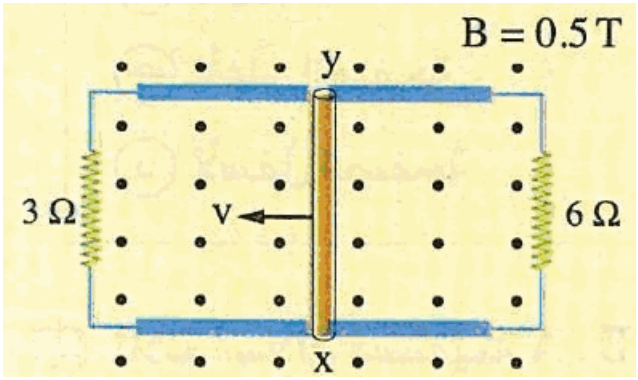
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71 A metal wire in the plane of the page moves upwards at a constant velocity (v) and is acted on by a uniform magnetic field perpendicular to the page and inwards. Which of the following figures shows the displacement of the electric charges inside the wire during its motion? (2nd session 2023)



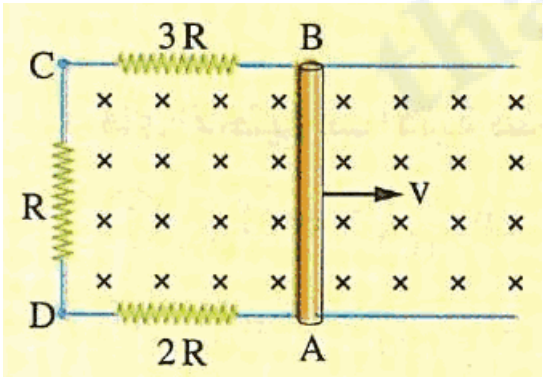
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72 A metal wire (yx) 0.2 m long with a resistance of 1 Ω moves to the left at a constant speed of 3 m/s perpendicular to a uniform magnetic field of flux density 0.5 T, along two metal rails of negligible resistance connected to the 6 Ω and 3 Ω resistances as shown in the figure. The p.d. across the 3 Ω resistance while the wire moves equals ..... (2nd session 2023)



(A) 0.2 V (B) 0.3 V (C) 0.1 V (D) 0.4 V

73 The opposite figure shows a conductor AB moved to the right perpendicular to a uniform magnetic field. Which of the following statements is correct while conductor (AB) moves? (1st session 2024)



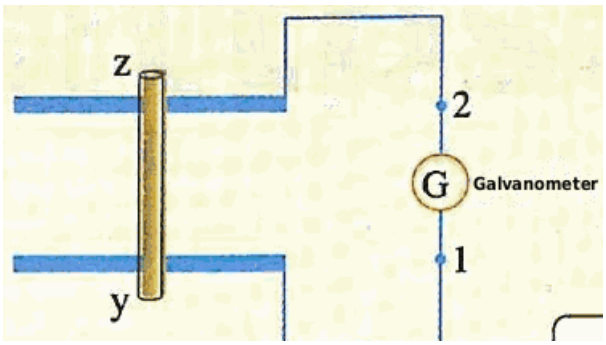
(A) The potential of (C) equals that of (D)

(B) The potential of (A) equals that of (B)

(C) The potential of (C) is less than that of (D)

(D) The potential of (C) is greater than that of (D)

74 The opposite figure shows a movable wire zy acted on by a uniform magnetic field. Which of the following is correct for a current to flow through the galvanometer from point (1) to point (2)? (1st session 2024)



(A) The wire moves to the left of the page, and the field is perpendicular to the page and outwards

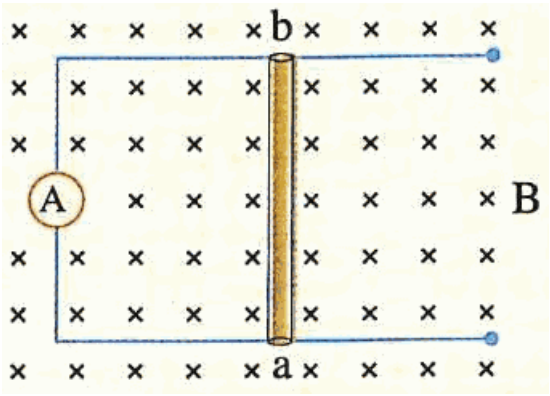
(B) The wire moves to the right of the page, and the field is perpendicular to the page and outwards

(C) The wire moves to the right of the page, and the field is in the plane of the page and to the left

(D) The wire moves to the left of the page, and the field is in the plane of the page and to the right

---

75 The figure in front of you shows a metal wire (ab) moving perpendicular to a uniform magnetic field of flux density (B), producing an induced current in the wire so that the potential of point (a) is greater than that of point (b). The wire was moving ..... (2nd session 2024)



(A) to the left of the page

(B) to the right of the page

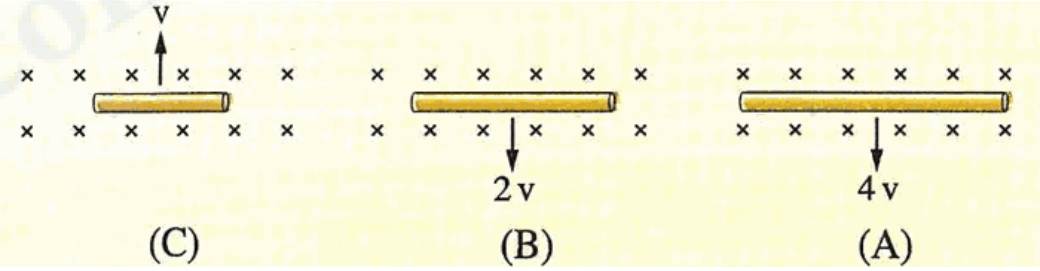
(C) up the page

(D) down the page

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76 Three straight wires A, B and C of lengths 2ℓ, 1.5ℓ and ℓ respectively move at velocities 4v, 2v and v respectively, perpendicular to a magnetic flux of density (B) directed into the page, as shown in the following figures. (2nd session 2024)

Which of the following choices is correct?



(A) $emf_{(C)} > emf_{(B)}$

(B) $emf_{(A)} > emf_{(C)}$

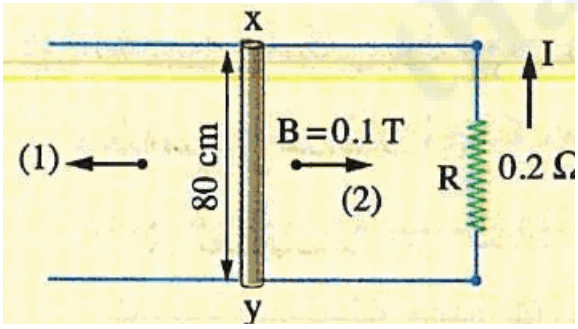
(C) $emf_{(B)} > emf_{(A)}$

(D) $emf_{(C)} > emf_{(A)}$

---

77 Using the data in the opposite figure, and neglecting the resistance of both conductor xy and the connecting wires it slides on, the two conditions for an induced current of 2 A to flow in the resistance R in the direction shown in the figure are ..... (Sample exam 2025)

(Assuming the magnetic flux covers the whole figure and is directed into the page)



(A) direction (1), 5 m/s

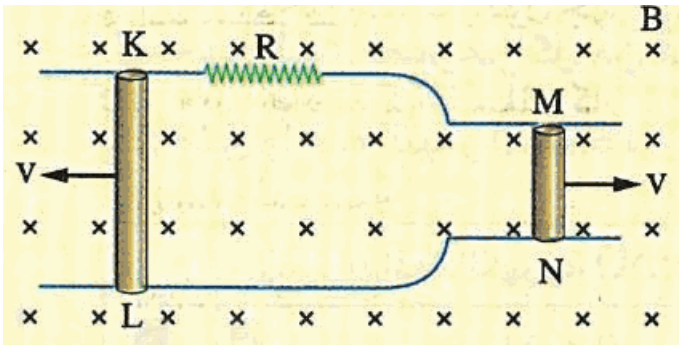
(B) direction (2), 10 m/s

(C) direction (1), 10 m/s

(D) direction (2), 5 m/s

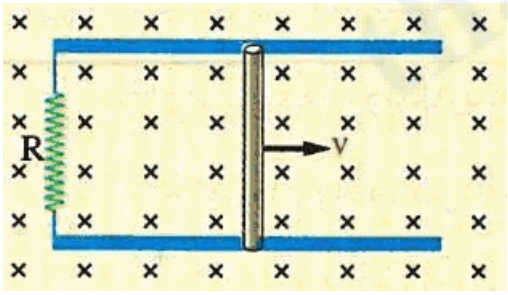
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78 Two copper conductors MN and KL have the same cross-sectional area and negligible resistance. The length of MN is ℓ and the length of KL is 2ℓ, and the two conductors move on a metal frame of negligible resistance at a speed v in the direction shown in the opposite figure. The induced current in the resistance R equals ..... (Sample exam 2025)



(A) $(3B\ell v)/R$ (B) $(B\ell v)/R$ (C) $(2B\ell v)/R$ (D) $(4B\ell v)/R$

79 A straight metal rod of resistance (r) moves, touching a frame of negligible resistance, at a constant velocity (v) perpendicular to a uniform magnetic flux of density (B) in the direction shown in the figure. Which of the following actions increases the p.d. across the resistance (R)? (1st session 2025)



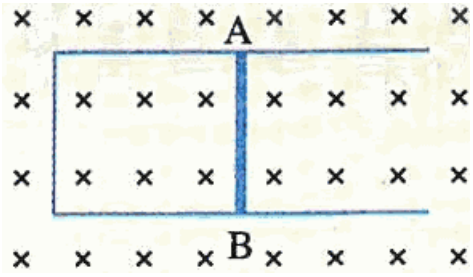
(A) Increasing the angle between the direction of motion of the rod and the magnetic field by 30°

(B) Moving the rod in the direction opposite to the magnetic field

(C) Moving the rod towards the resistance (R) at a uniform velocity (v)

(D) Moving the rod in the same direction at a speed greater than (v)

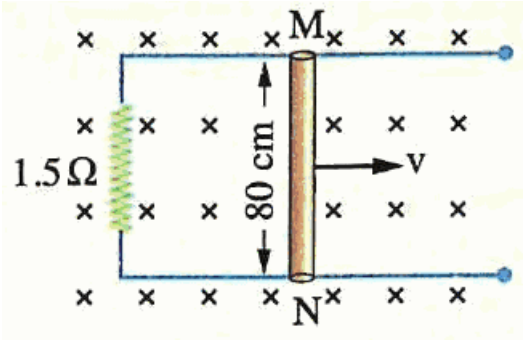
80 The figure shows a metal rod AB 0.15 m long sliding while touching a metal frame of electrical resistance (R). If the motion of the rod is perpendicular to a uniform magnetic field of density 0.4 T, an induced emf of 0.03 V is produced between its ends and an induced current flows inside the rod from end B to end A. The magnitude and direction of the uniform velocity of the rod are ..... (2nd session 2025)



(A) 0.5 m/s, to the left of the page
(B) 0.5 m/s, to the right of the page
(C) 2 m/s, to the right of the page
(D) 2 m/s, to the left of the page

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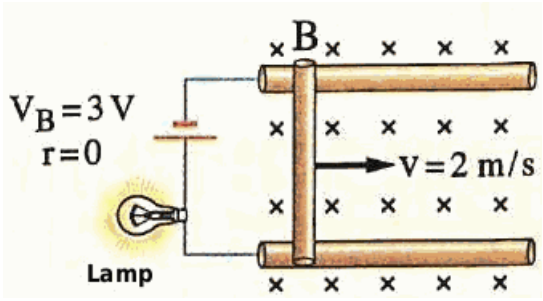
81 A metal conductor (MN) 80 cm long with a resistance of 0.5 Ω moves, touching two wires of negligible resistance, in the direction shown in the figure at a uniform velocity (v) perpendicular to a uniform magnetic field of flux density 0.5 T. If the magnetic force acting on the conductor during its motion is 0.16 N, the correct choice for both the induced emf in the conductor and the direction of the induced current in the circuit is ..... (Sample exam 2026)



(A) 0.6 V, clockwise
(B) 0.8 V, clockwise
(C) 0.6 V, anticlockwise
(D) 0.8 V, anticlockwise

---

82 Two smooth metal rails of negligible resistance are connected to a lamp of resistance 3 Ω and a battery of emf 3 V with negligible internal resistance, and the rails touch a conductor 40 cm long with a resistance of 1 Ω. If this conductor moves at a uniform speed of 2 m/s perpendicular to a uniform magnetic field of flux density (B) as shown in the figure, the power consumed in the lamp while the conductor moves is 1.92 W. The value of (B) equals ..... (Sample exam 2026)

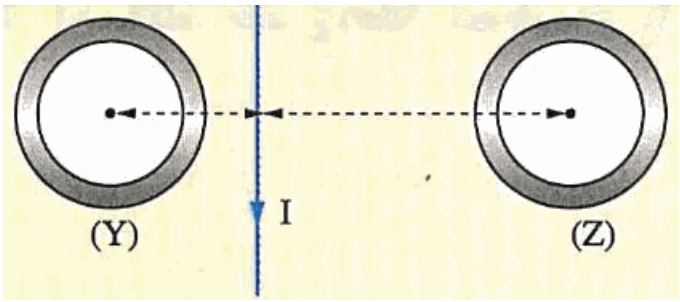


(A) 0.2 T (B) 0.25 T (C) 0.3 T (D) 0.35 T

83 The figure shows part of a straight wire carrying a current, placed between two identical metal rings, all in one vertical plane: (2nd session 2025)

(1) Which ring, (Y) or (Z), has the greater magnetic flux through it?

(2) When the current in the wire increases uniformly, state the direction of the induced current in: (a) ring (Y). (b) ring (Z).



Answer key and solutions

Multiple choice questions

1 B	2 D	3 D	4 A	5 B	6 B	7 C	8 B	9 A	10 B
11 A	12 B	13 D	14 A	15 A	16 D	17 B	18 D	19 B	20 D
21 B	22 A	23 D	24 C	25 A	26 D	27 B	28 D	29 D	30 D
31 B	32 D	33 D	34 D	35 A	36 B	37 B	38 C	39 A	40 D
41 B	42 A	43 A	44 A	45 B	46 D	47 A	48 C	49 C	50 B
51 A	52 D	53 A	54 C	55 D	56 A	57 D	58 D	59 B	60 C
61 A	62 B	63 D	64 A	65 C	66 D	67 D	68 D	69 C	70 D
71 C	72 A	73 A	74 C	75 C	76 D	77 B	78 D	79 D	80 C
81 A	82 C	83 D	84 C	85 B	86 B	87 B	88 B	89 A	90 C
91 A	92 C	93 C	94 A	95 C	96 D	97 B	98 C	99 B	100 A
101 D	102 B	103 B	104 D	105 C	106 D	107 C	108 A	109 A	110 A
111 C	112 D	113 C	114 D	115 A	116 A	117 A	118 B		

1 **Answer (B)**

$emf = N\,(\Delta\varphi_m)/(\Delta\, t)$, so it is directly proportional to N (a straight line through the origin).

2 **Answer (D)**

The ring is open, so no induced current flows in it, and no magnetic force is produced in either case.

3 **Answer (D)**

The N pole approaches end B, so a north pole forms there to repel it (Lenz's rule), and a south pole forms at A.

The current in the galvanometer flows from 1 to 2, according to the winding direction of the coil.

4 **Answer (A)**

The oscillating magnet changes the flux by approaching and moving away in turn, so an alternating current is induced and the pointer oscillates right and left.

5 **Answer (B)**

The magnet moving away decreases the flux, so an induced emf is produced that opposes the decrease. It is in the same direction as the battery emf, so the brightness increases momentarily.

6 **Answer (B)**

$emf \propto$ the relative velocity between the magnet and the coil

(2): $v + 2v = 3v$, (1): $2v$, (3): $2v - v = v$, (4): $v - v = 0$

Descending order: $(2) > (1) > (3) > (4)$

7 **Answer (C)**

The magnet moves away from x, so a north pole forms at its right end (to attract it), and the magnet's N pole approaches y, so a north pole forms at its left end (to repel it).

The coils are identical, so the current flows in R_1 from b to a and in R_2 from c to d.

8 **Answer (B)**

The two magnets move together and the ring is displaced towards magnet (2), so magnet (1) approaches and repels the ring, and magnet (2) moves away and attracts it (Lenz's rule).

9 **Answer (A)**

If the poles facing the two ends of the coil are unlike, their effects add up and an induced emf is produced; if they are alike, their effects cancel.

The brightness increases when the induced emf is in the same direction as the battery emf: figure (A).

10 **Answer (B)**

The coil is connected in parallel with the battery and the lamp, and the induced emf opposes the battery emf, so the battery current increases.

$V = V_B - Ir$, so the p.d. across the lamp decreases and its brightness decreases.

11 **Answer (A)**

An emf is produced when the flux $\varphi_m = BA\cos\theta$ changes during rotation. This happens in figure (A) (the axis of rotation is in the plane of the ring and perpendicular to the field).

In the other figures the flux stays constant (rotation about an axis parallel to the field or perpendicular to the ring).

12 **Answer (B)**

The speed of the magnet on arrival $v = \sqrt{(2gh)}$ is greater at B (falling from $2h$).

So the rate of change of flux and $emf = (N\Delta\varphi_m)/(\Delta t)$ are greater in ring B, and the current in it is greater.

13 **Answer (D)**

The magnet enters the coil, so an emf is induced in one direction, then it leaves, so an emf is induced in the opposite direction.

Its speed when leaving is greater (free fall), so the emf is greater and lasts a shorter time.

14 **Answer (A)**

Magnet B falls inside a copper tube, so eddy currents are induced that oppose its motion (Lenz's rule), while A falls freely in the plastic tube.

So the time for B is greater than t.

15 **Answer (A)**

16 **Answer (D)**

$emf = N(\Delta\varphi_m)/(\Delta t) = 20 \times 0.2/0.02 = 200$ V

17 **Answer (B)**

$emf = (\Delta B)/(\Delta t)\, A$, so it is proportional to the area: $((emf)_x)/((emf)_y) = 2A/A = 2/1$

18 **Answer (D)**

$emf = N(\Delta\varphi_m)/(\Delta t)$, and each has one turn and the same rate of change of flux, so the ratio is $1/1$

19 **Answer (B)**

$I = emf/R$ and the emfs are equal, while the resistance $R \propto$ length $\propto$ radius

$I_a/I_b = R_b/R_a = 2r/r = 2/1$

20 **Answer (D)**

$A_1 = \pi r^2 = 3.14 \times (0.12)^2 = 0.0452\ m^2$ and $\Delta A = 0.0452 - 0.003 = 0.0422\ m^2$

$emf = (B \Delta A)/(\Delta t) = (0.15 \times 0.0422)/0.2 = 31.7 \times 10^{-3}$ V

21 **Answer (B)**

$A = \pi r^2 = 22/7 \times (0.07)^2 = 0.0154\ m^2$, and the flux decreases to half: $\Delta\varphi_m = BA/2$

$emf = (0.1 \times 0.0154/2)/2 = 0.385$ mV

22 **Answer (A)**

$emf = N (\Delta\varphi_m)/(\Delta t)$, so the greatest is the one with the greatest $(\Delta\varphi_m)/(\Delta t)$

In (A): $0.1/(10^{-4}) = 1000$ Wb/s, which is the greatest.

23 **Answer (D)**

$emf = -N (\Delta\varphi_m)/(\Delta t) = -100 \times (0.04 - 0.02)/0.01 = -200$ V

24 **Answer (C)**

A current is induced when the field of the wire passes through the ring and its flux through the ring changes.

In (1) and (2) the field lines are circles in the plane of the ring, so there is no flux through it; in (3) the field lines are perpendicular to the plane of the ring, so the flux changes.

25 **Answer (A)**

In figure (A) the current in the wire is to the left and increasing, and the field at the ring (above the wire) is into the page and increasing, so the flux increases.

So the induced current produces a field out of the page (Lenz's rule), that is anticlockwise.

26 **Answer (D)**

The field is out of the page, and a clockwise current produces a field into the page, that is, it opposes an increase of the outward flux.

So the flux density acting on the ring must be increased.

27 **Answer (B)**

The magnet approaches with its *N* pole, so the ring repels it (Lenz's rule) and the face of the ring facing it becomes a north pole.

28 **Answer (D)**

As the N pole approaches, an anticlockwise current is induced in the ring (its upper face is N and repels).

After the magnet passes, the flux decreases, so the current reverses to clockwise.

29 **Answer (D)**

An *emf* is produced when the frame enters the field (2) or leaves it (4); at (3) the whole frame is inside the field and the flux is constant.

The speed at (4) is greater (free fall), so the *emf* is greater.

30 **Answer (D)**

The current in the wire is direct, so the field and the flux through the ring are constant, and no emf is induced.

31 **Answer (B)**

The electrons move from a to b, so the conventional current is upwards, and the field at the ring is into the page.

Approaching increases the flux, so a field out of the page is induced, that is, an anticlockwise current.

32 **Answer (D)**

$emf = N\,(\Delta\varphi_m)/(\Delta t)$, so the slope of the line $= (\Delta\varphi_m)/(\Delta t) = 0.3/30 = 0.01$ Wb/s

33 **Answer (D)**

$\Delta\varphi_m = emf \times \Delta t$: x: $1 \times 1 = 1$, y: $3 \times 2 = 6$

$(\Delta\varphi_x)/(\Delta\varphi_y) = 1/6$

34 **Answer (D)**

$emf = N\,(\Delta\varphi_m)/(\Delta t) = 200 \times ((8.5\text{-}2.5) \times 10^{-3})/0.4 = 3$ V and $I = emf/R = 3/10 = 0.3$ A

The magnet approaches with its N pole, so the face of the coil facing it becomes north (repels).

35 **Answer (A)**

$emf = -N\,A\,(\Delta B)/(\Delta t) = -400 \times 4 \times 10^{-4} \times (0.5\text{-}0.3)/(2 \times 10^{-3}) = -16$ V

36 **Answer (B)**

$emf = -N\,A\,(\Delta B)/(\Delta t) = -400 \times 4 \times 10^{-4} \times (0.2\text{-}0.3)/(2 \times 10^{-3}) = 8$ V

37 **Answer (B)**

$emf = N\,BA/(\Delta t) = 400 \times (0.2 \times 50 \times 10^{-4})/0.01 = 40$ V

38 **Answer (C)**

A quarter revolution about an axis in its plane: the flux changes from BA to zero.

$emf = N\,BA/(\Delta t) \Rightarrow 0.4 = (100 \times B \times 0.02)/0.2 \Rightarrow B = 0.04$ T

39 **Answer (A)**

$emf = -N\,BA/(\Delta t) = -150 \times (0.65 \times 75 \times 10^{-4})/0.02 = -36.56$ V

40 **Answer (D)**

After turning the coil half a revolution, its plane is parallel to the field again, so $\Delta\varphi_m = 0$ and the average emf is zero.

41 **Answer (B)**

The flux changes from 0 to $-BA$, so the magnitude is $NBA/(\Delta t) = 36.56$ V

42 **Answer (A)**

One complete revolution: the flux returns to its first value, $\Delta\varphi_m = 0$, so the average emf is zero.

43 **Answer (A)**

The plane of the coil is parallel to the field, so the flux through it is zero before and after the field vanishes: $\Delta\varphi_m = 0$ and $emf = 0$

44 **Answer (A)**

$emf = N\,A\,(\Delta B)/(\Delta t) = 25 \times 1.8 \times 10^{-4} \times 0.55/0.75 = 3.3 \times 10^{-3}$ V

$I = emf/R = (3.3 \times 10^{-3})/3 = 1.1 \times 10^{-3}$ A

45 **Answer (B)**

Reversing the field makes $\Delta B = 2B = 0.4$ T

$emf = N\,A\,(\Delta B)/(\Delta t) = 100 \times 20 \times 10^{-4} \times 0.4/0.2 = 0.4$ V

46 **Answer (D)**

$T = 1/30$ s, so $1/60$ s is half a revolution, and the flux changes from φ_{max} to $-\varphi_{max}$, that is by $2\varphi_{max}$

$emf = (2\varphi_{max})/(\Delta t) \Rightarrow 4.8 = 2\varphi_{max} \times 60 \Rightarrow \varphi_{max} = 0.04$ Wb

47 **Answer (A)**

$\Delta\varphi_m = BA(1 - \cos 45^\circ) = 0.1 \times 2 \times 10^{-3} \times 0.293$

$emf = (\Delta\varphi_m)/(\Delta t) = (5.86 \times 10^{-5})/0.25 = 2.34 \times 10^{-4}$ V

48 **Answer (C)**

$emf = (BA(1-\cos\theta))/(\Delta t) \Rightarrow 4 \times 10^{-3} = (0.1 \times 0.02\ (1-\cos\theta))/0.25$

$1 - \cos\theta = 0.5 \Rightarrow \theta = 60^\circ$

49 **Answer (C)**

$Q = (N\ \Delta\varphi_m)/R$, and a rotation of 180° makes $\Delta\varphi_m = 2BA$

$1.6 \times 10^{-3} = (N \times 2 \times 0.2 \times 4 \times 10^{-4})/50 \Rightarrow N = 500$

50 **Answer (B)**

From the parallel position: $\Delta\varphi_1 = BA\sin 60^\circ$; from the perpendicular position: $\Delta\varphi_2 = BA(1-\cos 60^\circ)$

$I_1/I_2 = \text{fracsin}60^\circ 1-\cos 60^\circ = 0.866/0.5 = \sqrt{3}$

51 **Answer (A)**

$Q = (N\ \Delta\varphi_m)/R = NBA/R = (150 \times 8 \times 10^{-5} \times 0.045)/0.9 = 6 \times 10^{-4}$ C

52 **Answer (D)**

The induced emf depends only on the relative motion between the coil and the magnet, and the relative velocity is the same in both figures, so it gives the same deflection in the same direction.

53 **Answer (A)**

An anticlockwise induced current produces a field in the same direction as the original field of the coil. This happens when the flux decreases (Lenz's rule), so the current in the coil is decreased.

54 **Answer (C)**

$emf = BA/(\Delta t) = (0.4 \times 0.2^2)/0.08 = 0.2$ V

The flux into the page decreases, so a field into the page is induced, that is, a clockwise current (from A to B).

55 **Answer (D)**

Figure (A): the frame moves away from the wire, so the flux decreases (the field is into the page to the right of the wire), and the current is clockwise.

Figure (B): the motion is parallel to the wire, so the flux does not change and the current is zero.

56 **Answer (A)**

$emf = (\mu I v)/(2\pi) L(1/d-1/(d+L))$, which increases with the side length L, so frame (x), with side $2l$, has the greater emf.

57 **Answer (D)**

While entering: the inward flux increases, so the current is anticlockwise.

While leaving: the flux decreases, so the current is clockwise.

58 **Answer (D)**

59 **Answer (B)**

$emf = A(\Delta B)/(\Delta t) = 0.1^2 \times 150 = 1.5$ V

The inward field decreases, so a clockwise current is induced, while the battery drives the current anticlockwise, so they oppose each other.

$I = (5-1.5)/10 = 0.35$ A

60 **Answer (C)**

The total flux $= \varphi_x - \varphi_y$ (out of the page is positive), and it increases at a constant rate because φ_x increases and φ_y decreases.

So the current has a constant direction; the outward flux increases, so a field into the page is induced, that is, a clockwise current.

61 **Answer (A)**

The total flux $= \varphi_x - \varphi_y$, and when both fields increase at the same rate, $\Delta\varphi_m = 0$, so no current is induced.

62 **Answer (B)**

Frame (x) is symmetric about the wire, so the outward flux equals the inward flux and the total flux stays zero: no emf is induced.

Frame (y) is not symmetric about the wire, so the total flux changes as the current increases: an emf is induced.

63 **Answer (D)**

The two wires are at equal distances from the frame and their fields are opposite inside it. They increase at the same rate, so the total flux stays zero and no current is induced.

64 **Answer (A)**

The field of wire (x) at the frame is out of the page and that of (y) is into the page, so the total outward flux $=\varphi_x-\varphi_y$ increases.

A field into the page is induced, that is, a clockwise current.

65 **Answer (C)**

$emf = -(\Delta\varphi_m)/(\Delta t)$, that is, the negative of the slope of the curve.

While the flux increases the emf is negative, while it is constant the emf is zero, and while it decreases the emf is positive.

66 **Answer (D)**

$\varphi_m = BA\sin\omega t$, so $emf = -BA\omega\cos\omega t$

The emf starts negative, becomes zero at the peak of the flux, then becomes positive.

67 **Answer (D)**

The current reverses where the slope of the curve changes from positive to negative or the opposite, that is, at the peak B and the trough D.

68 **Answer (D)**

The emf is proportional to the slope of the curve, and in interval DE the slope increases (in magnitude), so the emf increases.

69 **Answer (C)**

$emf = -N(\Delta\varphi_m)/(\Delta t) = -200\times(6-0)/2 = -600$ V

70 **Answer (D)**

The flux is constant during this interval, so $\Delta\varphi_m = 0$ and $emf = 0$

71 **Answer (C)**

$emf = -N(\Delta\varphi_m)/(\Delta t) = -200\times(0-6)/3 = 400$ V

72 **Answer (A)**

$emf = NA(\Delta B)/(\Delta t)$, so it is proportional to the rate $(\Delta B)/(\Delta t)$

$ab: (9\times10^{-3})/0.06 = 0.15$, $cd: (15\times10^{-3})/0.04 = 0.375$

$(emf_{ab})/(emf_{cd}) = 0.15/0.375 = 2/5$

73 **Answer (A)**

The flux density is constant in stage bc, so the flux does not change and $emf = 0$

74 **Answer (C)**

ab: $emf = A\,(\Delta B)/(\Delta t) = 45\times10^{-4}\times0.08/0.1 = 3.6\times10^{-3}$ V

In cd the flux into the page decreases, so a field into the page is induced, that is, a clockwise current.

75 **Answer (C)**

$emf = -(\Delta\varphi_m)/(\Delta t)$, that is, the negative of the slope of the flux curve.

The flux decreases with a large slope, then increases with a large slope, then decreases with a smaller slope, which is shown by figure (C).

76 **Answer (D)**

$emf = A\,(\Delta B)/(\Delta t)$ and the resistance $R \propto r$, so the current $I \propto r\,(\Delta B)/(\Delta t)$

Slope of (x) : slope of (y) $= \tan30^\circ : \tan60^\circ = 1:3$

$I_x/I_y = r_x/r_y\times1/3 = 2/3 \Rightarrow r_x/r_y = 2 \Rightarrow A_x/A_y = 4$

77 **Answer (B)**

The time of one complete revolution is 60 s, so $(\Delta A)/(\Delta t) = (11/14)/60$

$emf = B\,(\Delta A)/(\Delta t) \Rightarrow 5.5\times10^{-3} = B\times11/(14\times60) \Rightarrow B = 0.42$ T

78 **Answer (D)**

The electric current in the furnace coil produces a changing magnetic field, which induces electric eddy currents in the pot that heat it.

Electrical → magnetic → electrical → thermal

79 **Answer (D)**

K1 (alternating current): the changing flux induces eddy currents, so the rod heats up.

K2 (direct current): a constant field, so the rod is magnetized.

80 **Answer (C)**

Eddy currents are greater when the resistance is smaller, so the cylinder is thick (larger cross-section) and made of copper (smaller resistivity).

81 **Answer (A)**

Plate (y) has slots that reduce the eddy currents, while large eddy currents are induced in the solid plate (x) and oppose its motion, so (x) comes to rest first.

82 **Answer (C)**

$emf = BLv$, which does not depend on the resistance, so it is equal to emf.

83 **Answer (D)**

An induced current needs a change in flux: in (D) the area of the circuit inside the field changes, so the flux changes.

In (A), (B) and (C) the flux stays constant (motion parallel to the field lines, or a whole circuit inside a uniform field).

84 **Answer (C)**

$emf = (B\,L\,\Delta x)/(\Delta t)$ and the time is the same, so the greatest emf is in the longest wire with the largest displacement, which is figure (C).

85 **Answer (B)**

$emf = BLv$, so it is directly proportional to the length ℓ, and its graph is a straight line through the origin.

86 **Answer (B)**

$emf = BLv\sin\theta$, which is greatest when $\theta = 90^\circ$, that is, when the wire moves perpendicular to the field. The field is horizontal, so the direction is b.

87 **Answer (B)**

$emf = BLv \Rightarrow B = emf/Lv = 0.04/(0.2\times 1) = 0.2$ T

88 **Answer (B)**

$emf = BLv$ and $R_{\text{circuit}} \propto L$ because the rod has a uniform cross-section, so $I = BLv/R$ is constant.

89 **Answer (A)**

$emf = BLv$ increases because the length of the rod between the rails increases, and the resistance R is constant, so $I = emf/R$ increases.

90 **Answer (C)**

Figure (1): the length of the part inside the field is constant, so the emf is constant.

Figure (2): the length of the part inside the circular field changes, so the emf changes.

91 **Answer (A)**

The length of the part inside the field increases uniformly with time, so $emf = BLv$ increases linearly.

92 **Answer (C)**

$emf = Bv\sin\theta$, where θ is the angle between v and B, so it starts at a maximum at x, becomes zero at y, then reverses its sign, reaches a negative maximum at z and becomes zero at p.

93 **Answer (C)**

$emf = BLv \Rightarrow v = emf/BL = 0.3/(0.1 \times 3) = 1$ m/s

94 **Answer (A)**

The force on the positive charges $F = qvB$ pushes them towards A (right-hand rule), so the potential of A is greater than that of B.

95 **Answer (C)**

The current inside the rod flows from a to b, so b is the positive terminal: $V_b > V_a$

For the current to flow from a to b with the field into the page, the rod moves down the page.

96 **Answer (D)**

$emf = BLv \Rightarrow B = 0.4/(2 \times 5) = 0.04$ T

The positive charges move towards a, so $v \times B$ points towards a, which means the field is out of the page.

97 **Answer (B)**

$v = emf/BL = 0.03/(0.4 \times 0.15) = 0.5$ m/s

The current flows from A to B (downwards) and the field is into the page, so the motion is to the left of the page.

98 **Answer (C)**

Each part inside a field has the same $emf = B(\ell)/3v$, and the two fields are opposite, so they push the positive charges towards b in one part and towards a in the other.

So the potential of both ends rises above the middle of the rod by the same amount, that is, they have the same potential.

99 **Answer (B)**

Perpendicular to the field: $emf = BLv = 0.8 \times 0.3 \times 0.5 = 0.12$ V

Parallel to the field: the rod does not cut the flux lines, so $emf = 0$

100 **Answer (A)**

$emf = BLv = 0.5 \times 0.05 \times 0.02 = 5 \times 10^{-4}$ V

$I = emf/R = (5 \times 10^{-4})/1 = 0.5$ mA

101 **Answer (D)**

$v = 80/3.6 = 22.2$ m/s

$B = emf/Lv = (4\times10^{-4})/(1\times22.2) = 18\times10^{-6}$ T

102 **Answer (B)**

$emf = BLv\sin\theta \Rightarrow 0.336 = 0.4\times0.5\times2\times\sin\theta$

$\sin\theta = 0.84 \Rightarrow \theta = 57^\circ$

103 **Answer (B)**

The field below the wire is into the page, and moving the rod to the right pushes the positive charges upwards (towards a).

So $V_a > V_b$

104 **Answer (D)**

Each conductor: $emf = BLv = 0.4\times0.2\times5 = 0.4$ V

The two conductors move in opposite directions, so their emfs add up in the same direction around the circuit: $emf_{total} = 0.8$ V

$I = 0.8/2 = 0.4$ A

105 **Answer (C)**

$emf_{net} = IR = 2.5\times10^{-3}\times10 = 0.025$ V

$emf_{net} = Bv\,(L_x - L_y) \Rightarrow 0.025 = 0.2\times0.5\times\Delta L \Rightarrow \Delta L = 0.25$ m $= 25$ cm

106 **Answer (D)**

The induced emf in the rod drives the current from x to y, which is the same direction as the battery current, so the current increases and the lamp becomes brighter.

107 **Answer (C)**

The rod is the source of current for both lamps. As it moves to the left, the resistance of the left rail decreases, so the brightness of P_1 increases.

The resistance of the right rail increases, so the brightness of P_2 decreases.

108 **Answer (A)**

At constant velocity $F = F_{mag}$, so the mechanical power equals the consumed power: $F\,v_0 = (P_w)_0$

$F = ((P_w)_0)/v_0$

109 **Answer (A)**

$emf = BLv = 0.6 \times 0.15 \times 8 = 0.72$ V

110 **Answer (A)**

$I = emf/R = 0.72/25 = 0.0288$ A

111 **Answer (C)**

$F = BIL = 0.6 \times 0.0288 \times 0.15 = 2.59 \times 10^{-3}$ N

112 **Answer (D)**

$P = I^2R = (0.0288)^2 \times 25 = 20.7 \times 10^{-3}$ W

113 **Answer (C)**

$emf = BLv = 0.15 \times 0.5 \times 2 = 0.15$ V, $I = 0.15/3 = 0.05$ A

$F = BIL = 0.15 \times 0.05 \times 0.5 = 3.75 \times 10^{-3}$ N

114 **Answer (D)**

$F = BIL$ depends on the current, and the force is smaller than its greatest value but not zero when the circuit is closed through R and the rod.

So K1 is closed (R is in the circuit) and K2 is open (it does not short the resistance).

115 **Answer (A)**

The 6 and 3 resistances are in parallel: $R_{eq} = (6 \times 3)/9 = 2\ \Omega$, and the total is $2 + 2 = 4\ \Omega$

$emf = BLv = 2 \times 1 \times 2 = 4$ V , $I = 4/4 = 1$ A

$F = BIL = 2 \times 1 \times 1 = 2$ N

116 **Answer (A)**

In rod a: $v \times B$ gives a current down the page, so the current in rod b flows up the page.

The force $F = IL \times B$ on rod b is in the plane of the page and to the right.

117 **Answer (A)**

Side bc is parallel to the velocity, so no emf is induced in it, while ab and cd have the same emf (Blv) in opposite directions along the wire.

$V_b - V_a = Blv$, $V_c - V_d = Blv$ and $V_b = V_c$, so $V_a - V_d = 0$

118 **Answer (B)**

$emf = B\, v_{\perp}\, L_{\perp}$ for each side:

(1): $V_1 = B(2\ell)v = 2B\ell\, v$

(2): $V_2 = B\ell\, v$

(3): $V_3 = B(2\ell)\, v\cos 45^\circ + B\ell\, v\sin 45^\circ = 2.12\, B\ell\, v$

So $V_3 > V_1 > V_2$

Essay questions

1 **Model answer**

An induced current flows in the ring in figure (a) while the current in the wire increases, because the magnetic flux produced by the current in the wire and acting on the ring is perpendicular to its plane. So as the current in the wire increases, the flux through the ring increases and a current is induced in it.

In figure (b), the plane of the ring is parallel to the field produced by the current in the wire, so the ring does not cut the flux and no current is induced in it.

2 **Model answer**

When the frame is moved in direction (1), no current is induced in it, because the magnetic flux through the frame does not change.

When the frame is moved in direction (2), a clockwise current is induced, because the magnetic flux through the frame decreases, so a current is induced in the direction that opposes the decrease in flux, that is, it produces a magnetic flux in the same direction as the external flux (perpendicular to the page and inwards).

3 **Model answer**

(1) The induced current in the ring is anticlockwise, because when the ring is moved out of the magnetic field the flux through it decreases, and according to Lenz's rule a current is induced in the ring that produces a field in the same direction as the acting (original) field.

(2) No current is induced in the ring, because the magnetic flux lines do not pass through the ring.

(3) The induced current in the ring, as seen by the observer, is anticlockwise, because when the ring rotates a quarter of a revolution the flux through it increases, so a current is induced in the ring that produces a field opposite to the external field.

4 **Model answer**

(1) A south pole (S) forms at the upper end of the coil near the magnet, because the approaching pole is the S pole, and the direction of the induced current is such that it opposes the approach. The rule used: Lenz's rule.

(2) The momentary deflection of the galvanometer pointer increases, because the iron cylinder concentrates the magnetic flux lines through the coil, so the induced emf and the induced current increase.

5 **Model answer**

The speed of the magnet in case (1) is less than in case (2), because the deflection of the galvanometer pointer is smaller in case (1).

The direction of motion of the magnet in case (1) is opposite to its direction in case (2), because the pointer deflected to the other side of the zero, which shows that the direction of the current through it reversed.

6 **Model answer**

(1) The lamp becomes brighter while the magnet approaches.

(2) The brightness of the lamp stays constant.

(3) The lamp becomes dimmer while the magnet moves away.

7 **Model answer**

The induced current is clockwise, because increasing the resistance taken from the rheostat decreases the current in the circuit, so the flux through coil abcd decreases and a current is induced in the coil that produces a magnetic flux in the same direction as the flux produced by the current in the wire (perpendicular to the page and inwards).

8 **Model answer**

When the circuit of the coil is closed, the current in it grows, and so does the flux density it produces through the ring, which induces a current in the ring. According to Lenz's rule the facing poles are alike, so a repulsive force is produced between the ring and the coil, which makes the ring jump upwards.

9 **Model answer**

Magnet A reaches the ground first, because magnet B falls towards a closed ring, so an induced current flows in it that forms a like (north) pole on the face of the ring facing the magnet while it approaches. A north pole also forms on the lower face of the ring while the magnet moves away from it, so the ring attracts the magnet. This slows down the motion of magnet B.

This does not happen to magnet A, because its ring is open, so no current is induced in it.

10 **Model answer**

$emf = -N(\Delta \varphi_m)/(\Delta t) = -N((\Delta B)\, \pi\, r^2)/(\Delta t)$

$= -N \times ((0-0.1) \times 22/7 \times (10 \times 10^{-2})^2)/0.01 = 0.31N\ V$

$I = emf/(N R_1) = 0.31N/(N \times 1) = 0.31\ A$

11 **Model answer**

$\Delta \varphi_m = BA\cos\theta - BA = BA(\cos\theta - 1)$

$emf = -N(BA(\cos 80^\circ - 1))/(\Delta t)$

$= -(1 \times 0.05 \times 22/7 \times (22 \times 10^{-2})^2 \times (\cos 80^\circ - 1))/0.25 = 0.025\ V$

12 **Model answer**

$emf = -N(\Delta \varphi_m)/(\Delta t) = -1 \times (0-\varphi_m)/t = (\varphi_m)/t$

$I = emf/R = (\varphi_m)/Rt\ ,\ I = Q/t$

$Q = (\varphi_m)/R$

13 **Model answer**

Because while the copper plate oscillates between the poles of the magnet, it cuts the magnetic flux lines between the poles, so an induced (eddy) current is produced in the plate. This current produces a magnetic field that opposes the motion, which gradually decreases the amplitude of the oscillation, that is, the oscillation is damped (dies out).

14 **Model answer**

(1) The pointer of the sensitive galvanometer deflects.

(2) It deflects in the opposite direction.

(3) Wire AB moves between the poles in a direction parallel to the magnetic flux lines.

15 **Model answer**

$emf = B\ell v = 1 \times 10 \times 10^{-2} \times 4 = 0.4\ V$

The p.d. is divided between the resistances connected in series in the ratio of their resistances.

$V_{xy} = V \times (R_{xy})/R = 0.4 \times 2/8 = 0.1\ V$

16 **Model answer**

The galvanometer reading decreases, because when rod a moves at a uniform velocity a constant emf is induced in it, but the lengths of the parts of rods b and c that carry the current increase, so the total resistance of the circuit increases, and according to $I = emf/R_t = (B\ell v)/R_t$ the induced current in the circuit decreases.

17 **Model answer**

$F = BI\ell$, $I = emf/R$, $emf = B\ell v$

$I = (B\ell v)/R$

$F = B((B\ell v)/R)\ell = (B^2\ell^2 v)/R$

18 **Model answer**

Because while the rod slides its velocity changes, so the induced emf in it changes, and the induced current changes.

19 **Model answer**

The two rods move in opposite directions, away from each other, because as the magnetic field decreases gradually a current is induced in the circuit. According to Lenz's rule the induced current is clockwise, so currents in opposite directions flow in the two facing parallel rods, and by applying Fleming's left-hand rule the two rods move away from each other.

Past exam questions

1 B	2 D	3 A	4 B	5 A	6 D	7 A	8 C	9 B	10 A
11 C	12 A	13 C	14 C	15 D	16 D	17 A	18 D	19 A	20 D
21 A	22 A	23 B	24 B	25 D	26 C	27 B	28 B	29 A	30 A
31 D	32 A	33 A	34 A	35 C	36 C	37 C	38 C	39 A	40 C
41 C	42 B	43 C	44 A	45 B	46 B	47 A	48 A	49 C	50 D
51 D	52 B	53 A	54 C	55 B	56 C	57 B	58 B	59 D	60 B
61 C	62 B	63 A	64 C	65 C	66 B	67 B	68 C	69 D	70 A
71 D	72 A	73 D	74 B	75 A	76 B	77 A	78 A	79 D	80 B
81 D	82 B	83 —							

1 **Answer (B)**

The magnet moves away from end x, so a north pole forms there to attract the receding south pole (Lenz's rule).

The induced current makes point (b) have a positive potential.

2 **Answer (D)**

The field produced by the wire below it is perpendicular to the page and inwards.

An anticlockwise induced current produces an outward field, that is, it opposes an increase of the inward flux.

So the ring approaches the wire, in direction D.

3 **Answer (A)**

$emf = -NA(\Delta B)/(\Delta t)$

$emf_2/emf_1 = (2N \times A/2)/NA = 1$

It stays E.

4 **Answer (B)**

In step (II) there is no relative motion between the magnet and the coil, so the flux through the coil does not change.

5 **Answer (A)**

Reversing the pole reverses the direction of the deflection.

Doubling the speed doubles the rate of change of flux, so the deflection doubles: 4 divisions to the left.

6 **Answer (D)**

There is no relative motion between the magnet and the coil, so no current is induced.

The potential of point a equals the potential of point b.

7 **Answer (A)**

$emf = -NA(\Delta B)/(\Delta t)$, with the same N and the same rate of change of B

$emf \propto A$, $A_1 = 2A_2$

8 **Answer (C)**

$emf = -N(\Delta (BA))/(\Delta t)$, with the same change in B and the same time

$emf_x/emf_y = (N_x A_x)/(N_y A_y) = (N_x \times 2)/N_y = 3$

$N_x/N_y = 3/2$

9 **Answer (B)**

$emf = -NA(\Delta B)/(\Delta t)$

Increasing the area and the number of turns increases the emf, while increasing the time decreases it.

10 **Answer (A)**

$emf = -N(\Delta \varphi_m)/(\Delta t)$

$emf' = 4N \times 1/2(\Delta \varphi_m)/(\Delta t) = 2E$

11 **Answer (C)**

$emf_x/emf_y = (N_x A_x)/(N_y A_y) = 1/3 \times 1/2 = 1/6$

12 **Answer (A)**

Eddy currents are greater in a solid cylinder (not divided into laminations) of smaller resistivity.

The solid cylinder of metal B: circuit (3).

13 **Answer (C)**

The field between the two wires is greatest at the midpoint between them.

At 1 and 2 the ring approaches the midpoint, so the flux increases and an induced field opposite to the original field is produced.

14 **Answer (C)**

Same area and same rate: $emf \propto N$

$emf_2 = 1/4emf_1$, $N_1 = 4N_2$

15 **Answer (D)**

The smallest electrical conductivity means the greatest resistance, so the eddy currents and the heat produced are smallest.

Smallest conductivity: metal Z.

16 **Answer (D)**

The deflection increases as the relative velocity between the magnet and the coil increases.

In (D) they move in opposite directions: the relative velocity is 3v, which is the greatest.

17 **Answer (A)**

$emf = -(\Delta B)/(\Delta t)\pi r^2$, $R \propto 2\pi r$

$I = emf/R \propto r$, so it is the largest ring, D.

18 **Answer (D)**

$emf = N(\Delta B)/(\Delta t)A$, slope $= N(\Delta B)/(\Delta t) = \tan 30^\circ = 0.577$

$(\Delta B)/(\Delta t) = 0.577/100 = 5.77 \times 10^{-3}\ T/s$

19 **Answer (A)**

Eddy currents increase as the frequency of the current increases, so the heat produced increases.

$T_1 > T_2 > T_3$

20 **Answer (D)**

When moved in direction (1), the induced emf is in the same direction as the resultant emf of the two batteries, so the brightness increases.

In direction (2) it is opposite, so the brightness decreases but does not become zero, because the induced emf is less than V_B

21 **Answer (A)**

No current is induced when there is no relative motion, so the coil moves at the same speed and in the same direction as the magnet: (v) to the left.

22 **Answer (A)**

Poles A and D are the ones facing the coil.

Since they are alike (north and north), the two fluxes entering the coil are opposite, so each cancels the effect of the other.

23 **Answer (B)**

(2) At rest: no emf.

(3) The coil approaches one pole and moves away from an unlike pole, so the two changes cancel: emf = 0

(1) and (4): the two changes are in the same direction, so they add up, and with the same relative speed the emfs are equal.

24 **Answer (B)**

Bringing a south pole nearer gives the same current direction as moving a north pole away: possibilities 1 and 4.

25 **Answer (D)**

The frame enters the field in 20 ms: $v = (\ell)/0.02$

$emf = B\ell v = (B\ell^2)/0.02$

$A = \ell^2 = (2.5 \times 0.02)/0.2 = 0.25\ m^2$

26 **Answer (C)**

$\Delta \varphi_m = 2BA = 2 \times 10^{-6} \times 36 \times 10^{-4} = 7.2 \times 10^{-9}$ *Wb*

$emf = N(\Delta \varphi_m)/(\Delta t) = (60 \times 7.2 \times 10^{-9})/0.4 = 1.08 \times 10^{-6}$ *V*

27 **Answer (B)**

$emf = -(\Delta \varphi_m)/(\Delta t)$ (the slope of the curve with a negative sign)

From 0 to 2 s: $-10/2 = -5$ *V*, and from 2 to 4 s: zero

From 4 to 6 s: $-40/2 = -20$ *V*, and from 6 to 8 s: $+50/2 = 25$ *V*

28 **Answer (B)**

The relative velocity with coil (1): $2v - v = v$ (approaching).

The relative velocity with coil (2): $2v + 3v = 5v$ (moving away), so $G_2 > G_1$

Approaching one and moving away from the other makes the two currents flow in opposite directions.

29 **Answer (A)**

$emf = N(\Delta \varphi_m)/(\Delta t) = (10 \times 0.3 \times 10^{-3})/0.02 = 0.15$ *V*

30 **Answer (A)**

$\Delta \varphi_m = (emf \times \Delta t)/N = (0.3 \times 10^{-3} \times 0.4)/200 = 6 \times 10^{-7}$ *Wb*

$BA = 6 \times 10^{-4} \times 5 \times 10^{-4} = 3 \times 10^{-7}$ *Wb*

$\Delta \varphi_m = 2BA$: half a revolution from the perpendicular position.

31 **Answer (D)**

$emf_1/emf_2 = (N_1 A_1)/(N_2 A_2) = 2 \times 2 = 4/1$

32 **Answer (A)**

While the magnet approaches, an induced emf is produced that adds to the emf of the battery, so the brightness increases.

33 **Answer (A)**

During interval (bc), B stays constant, so the flux does not change: emf = 0

34 **Answer (A)**

When the south pole is moved away, the flux inside the coil decreases, so a field is induced in the same direction (from b to a).

By applying the right-hand rule, the current in R flows from c to d.

35 **Answer (C)**

$emf = -N(\Delta \varphi_m)/(\Delta t)$ is maximum when the rate of change of flux (the slope) is greatest.
This is at points B and D.

36 **Answer (C)**

For a coil at rest in a uniform field, the flux through it does not change, so no emf is produced.

37 **Answer (C)**

The current is proportional to the rate of change of flux (the slope).
In interval C the slope gradually decreases, so the current gradually decreases.

38 **Answer (C)**

When B decreases, B_{ind} is in the same direction as B, and when B increases, it is opposite to it.
In (C), B is decreasing and B_{ind} is opposite to it, so it does not obey Lenz's rule.

39 **Answer (A)**

The greatest emf is produced when the greatest change in the area of the frame inside the field happens in the same time.
When moved a distance ℓ in direction (1), the whole frame leaves the field: the greatest change in flux.

40 **Answer (C)**

At c the flux into the page decreases and the flux out of the page increases.
So an induced field into the page is produced, that is, a clockwise current.

41 **Answer (C)**

Inside the frame, the field of wire x is into the page and the field of wire y (the greater one) is out of the page.
When the current of x vanishes: the resultant outward flux increases, so an inward field is induced: clockwise.
When the current of y vanishes: the outward flux decreases, so an outward field is induced: anticlockwise.

42 **Answer (B)**

In figure (2), bringing a south pole near one end and moving a south pole away from the other end change the flux in the same direction.
So the rate of change of flux doubles: a deflection of 2θ in the same direction.

43 **Answer (C)**

$emf = -N(\Delta \varphi_m)/(\Delta t)$ does not depend on the material of the coil.

Same N, area and speed: the same emf.

44 **Answer (A)**

Dividing tube (2) into insulated strips reduces the eddy currents in it: $I_2 < I_1$

So the opposition to the motion of magnet Q is smaller, and it leaves first.

45 **Answer (B)**

Increasing the electrical conductivity of the core decreases its resistance, so the eddy currents increase.

46 **Answer (B)**

The emf is proportional to the relative velocity between the magnet and the coil.

In (B) they move towards each other: the relative velocity is 2v, which is the greatest.

47 **Answer (A)**

$\varepsilon = -NA(\Delta B)/(\Delta t)$

From 0 to 2 s: $-100 \times 0.75 \times 0.8/2 = -30\ V$, and from 2 to 3 s: zero

From 3 to 4 s: $-100 \times 0.75 \times (-0.8)/1 = 60\ V$

48 **Answer (A)**

Increasing the frequency increases the rate of change of flux, so the eddy currents increase.

49 **Answer (C)**

The south pole approaching (1) and moving away (2) produce opposite currents.

So the potential of m is negative in direction (1) and positive in direction (2).

50 **Answer (D)**

A steady direct current does not change the flux, so no eddy currents are induced.

51 **Answer (D)**

No induced current flows in the open frame (X), so no force acts on it and its speed stays constant.

An induced current flows in the closed frame (Y) that opposes its motion (Lenz's rule), so its speed decreases.

52 **Answer (B)**

The motion of the rod produces an induced emf in the same direction as the emf of the battery, so the current increases and the brightness increases.

53 **Answer (A)**

$emf = B\ell v$

$v = emf/(B\ell) = 0.2/(0.4 \times 1) = 0.5\ m/s$

54 **Answer (C)**

By applying Fleming's right-hand rule (thumb for the motion, forefinger for the field, middle finger for the current).

In (C) the field is into the page and the motion is upwards, so the current is to the left as in the figure.

55 **Answer (B)**

By applying Fleming's right-hand rule, the positive charges move towards (a) when the wire is moved upwards with the field out of the page.

So the potential of (a) becomes greater than that of (b).

56 **Answer (C)**

$emf = B\ell v = 0.2 \times 0.1 \times 2 = 0.04\ V$

$I = emf/R = 0.04/5 = 8 \times 10^{-3}\ A$

57 **Answer (B)**

By applying Fleming's right-hand rule, with the field into the page and the current from z to y (upwards): the motion is towards (2).

58 **Answer (B)**

$emf = B\ell v \sin\theta$

$\sin\theta = (20 \times 10^{-3})/(0.4 \times 0.2 \times 0.5) = 0.5\ ,\ \theta = 30^\circ$

59 **Answer (D)**

$I_{ind} = (B\ell v)/R$, and B is directly proportional to the current in wire (1).

To reduce the induced current to half, the current in wire (1) is reduced to half.

60 **Answer (B)**

$emf = IR = 0.2 \times 0.1 = 0.02\ V$

$\ell = emf/Bv = 0.02/(2 \times 0.5) = 0.02\ m$

61 **Answer (C)**

By Fleming's right-hand rule the induced current in the wire flows from z to y, so the potential of y is greater (the wire is a source).

The induced emf is opposite to the emf of the battery, so the lamp becomes dimmer.

62 **Answer (B)**

By applying Fleming's right-hand rule: upward motion and a current from X to Y need a field perpendicular to the page and outwards.

63 **Answer (A)**

$B = emf/(\ell\, v) = 0.02/(0.2 \times 2) = 0.05\ T$

For the positive charges to gather at x with the motion to the right, the field is perpendicular to the page and inwards (Fleming's right-hand rule).

64 **Answer (C)**

$emf = B\ell\, v \sin\theta = 0.4 \times 0.2 \times 2 \times \sin 30^\circ = 0.08\ V$

65 **Answer (C)**

By applying Fleming's right-hand rule, the positive charges gather at the end the induced current points to.

In (C) the field is into the page and the motion is upwards, so the positive charges gather at B.

66 **Answer (B)**

$emf = B\ell\, v$, so $emf' = 2B \times \ell \times 2v = 4\ emf$

So the pointer deflects through 4θ.

67 **Answer (B)**

By applying Fleming's right-hand rule: the field is out of the page and the current is from Q to P, so the motion is in direction (3).

68 **Answer (C)**

69 **Answer (D)**

$emf = B\ell\, v \sin 30^\circ = 1/2B\ell\, v$

When the wire moves perpendicular to the field: $emf' = B\ell\, v = 2\ emf$

70 **Answer (A)**

When moving towards A, the induced current in the wire flows upwards (Fleming's right-hand rule), so its upper end is positive.

So the current in the resistance flows from C to D, and the potential of C is greater than that of D.

71 **Answer (D)**

By applying Fleming's right-hand rule: the motion is upwards and the field is inwards, so the positive charges gather at the left end and the negative charges at the right end.

72 **Answer (A)**

$emf = B\ell\, v = 0.5 \times 0.2 \times 3 = 0.3\ V$

The two resistances are in parallel: $R' = (3 \times 6)/(3 + 6) = 2\ \Omega$

$I = emf/(R' + r) = 0.3/(2 + 1) = 0.1\ A$, $V = IR' = 0.1 \times 2 = 0.2\ V$

73 **Answer (D)**

The motion is to the right and the field is inwards: the current in the conductor flows from A to B, so B is the positive terminal.

So the current in the external circuit flows from B to C then to D, and the potential of C is greater than that of D.

74 **Answer (B)**

For the current to flow in the galvanometer from 1 to 2, it flows in the wire from z to y (downwards).

By applying Fleming's right-hand rule: the motion is to the right and the field is perpendicular to the page and outwards.

75 **Answer (A)**

For the potential of a to be greater, the positive charges gather at a, so the current inside the wire flows from b to a.

By applying Fleming's right-hand rule with the field inwards, the motion is to the left of the page.

76 **Answer (B)**

$emf = B\ell\, v$

$emf_A = B(2\ell)(4v) = 8B\ell\, v$, $emf_B = 3B\ell\, v$, $emf_C = B\ell\, v$

77 **Answer (A)**

$emf = IR = 2 \times 0.2 = 0.4\ V$, $v = emf/(B\ell) = 0.4/(0.1 \times 0.8) = 5\ m/s$

An upward current in R means it flows in the conductor from x to y, and by applying Fleming's right-hand rule the motion is in direction (1).

78 **Answer (A)**

$emf_{KL} = B(2\ell)v$, $emf_{MN} = B\ell\ v$

The two conductors move in opposite directions, so their emfs add up in the circuit.

$I = (3B\ell\ v)/R$

79 **Answer (D)**

$V_R = IR = (B\ell\ v)/(R + r)R$, so it increases as the speed v increases.

80 **Answer (B)**

$v = emf/(B\ell) = 0.03/(0.4 \times 0.15) = 0.5\ m/s$

The current in the rod flows from B to A (upwards) and the field is inwards, so by Fleming's right-hand rule the motion is to the right.

81 **Answer (D)**

$I = F/(B\ell) = 0.16/(0.5 \times 0.8) = 0.4\ A$

$emf = I(R + r) = 0.4 \times (1.5 + 0.5) = 0.8\ V$

The motion is to the right and the field is inwards: the current in the conductor flows from N to M, that is, anticlockwise in the circuit.

82 **Answer (B)**

$P = I^2\ R$, $I = \sqrt{(1.92/3)} = 0.8\ A$

$I = (V_B + emf)/(R + r)$, $0.8 = (3 + emf)/4$, $emf = 0.2\ V$

$B = emf/(\ell\ v) = 0.2/(0.4 \times 2) = 0.25\ T$

83 **Model answer**

(1) Ring (Y), because it is nearer to the wire, so the flux density through it is greater.

(2) The downward current produces a field into the page at (Y) and out of the page at (Z). When the current increases, the flux increases, so an induced field opposite to it is produced (Lenz's rule):

(a) Ring (Y): an anticlockwise induced current.

(b) Ring (Z): a clockwise induced current.