Physics · Electric Current and Electromagnetism · Magnetic Effect of Electric Current and Measuring Instruments

# Magnetic Effect of Electric Current (continued)

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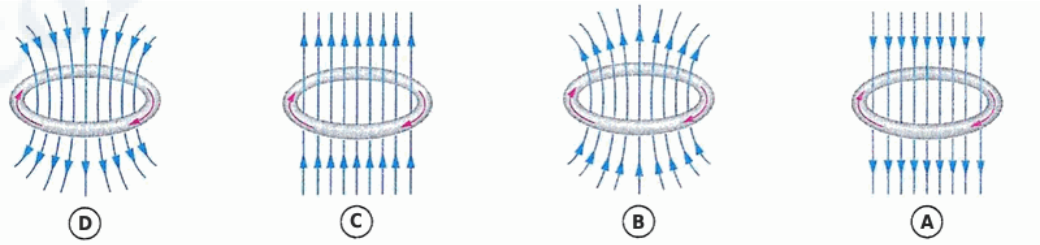
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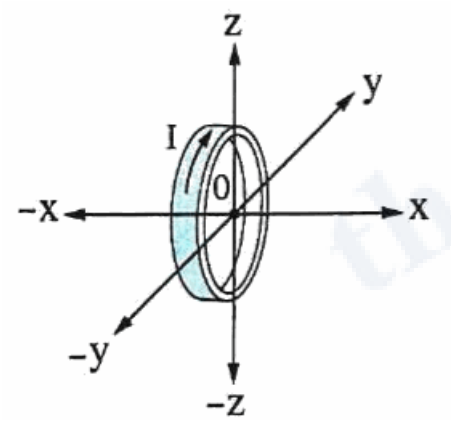

Click a question number to jump to its answer, and an answer number to go back to the question.

## Multiple choice questions — 108 questions

**1** Which of the following figures correctly shows the pattern of magnetic flux lines produced by a direct current flowing in a circular metal loop?

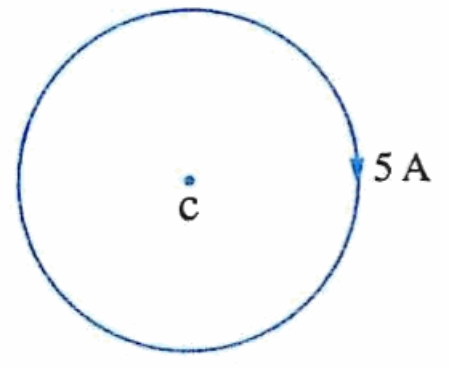



**2** A circular metal loop carries an electric current in the direction shown in the figure. Which of the following directions is the direction of the magnetic field at the centre of the loop due to the current?




(A) The positive x-axis
(B) The positive z-axis
(C) The negative x-axis
(D) The negative y-axis

**3** In the opposite figure, a circular loop of radius 10 cm carries a current of 5 A. The magnetic flux density at the centre of the loop (c) and its direction are ..... (given: $\pi = 3.14$)




(A) $2.6 \times 10^{-5}$ T, perpendicular to the page and outwards

(B) $3.14 \times 10^{-5}$ T, perpendicular to the page and outwards

(C) $3.14 \times 10^{-5}$ T, perpendicular to the page and inwards

(D) $2.6 \times 10^{-5}$ T, perpendicular to the page and inwards

---

**4** If the magnetic flux density at the centre of a circular loop of radius $4\pi$ cm is $5 \times 10^{-5}$ T and the magnetic permeability of air is $4\pi \times 10^{-7}$ Wb/A.m, the current in the loop is .....

(A) 7 A (B) 7.14 A (C) 10 A (D) 17 A

---

**5** An electric current flows in a circular coil and produces a magnetic field of flux density B at the centre of the coil. When the current is doubled and the diameter of the coil is doubled without changing the number of turns, the flux density at the centre of the coil equals .....

(A) B (B) 2 B (C) $B/2$ (D) $B/4$

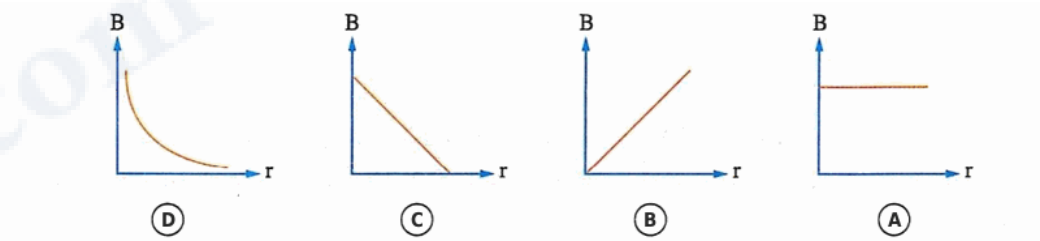
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**6** Two metal loops (x) and (y) carry currents I and 2I respectively, and the flux densities at their centres are equal. The ratio between the diameters of the two loops $(d_x/d_y)$ equals .....

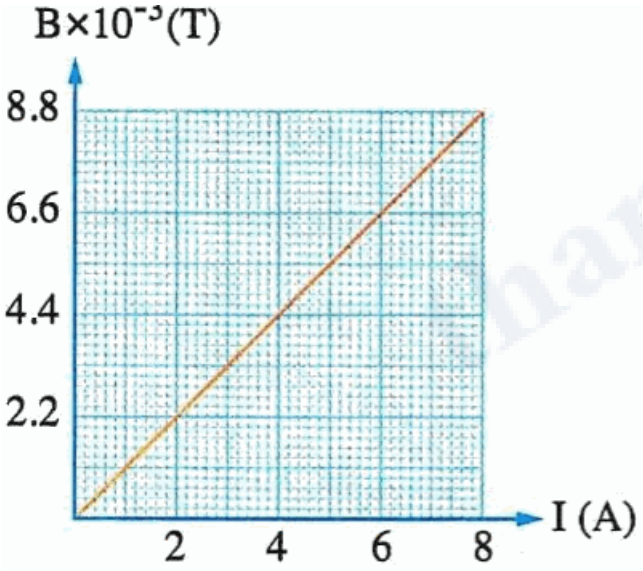
(A) $1/2$ (B) $2/1$ (C) $1/4$ (D) $4/1$

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7 Several circular coils have the same number of turns and carry the same current. Which of the following graphs shows the relation between the magnetic flux density (B) at the centre of each coil and the radius of the coil (r)?

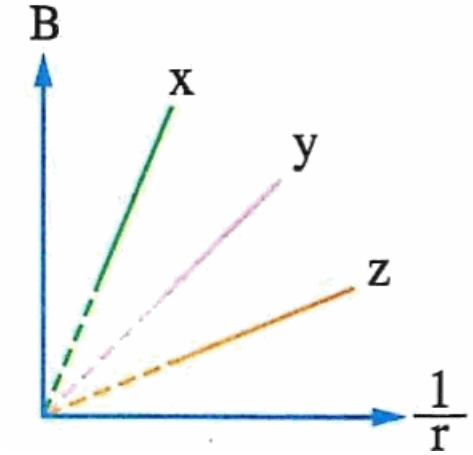



8 The opposite graph shows the relation between the magnetic flux density (B) at the centre of a circular coil of 350 turns and the current (I) in it. The diameter of this circular coil equals .....



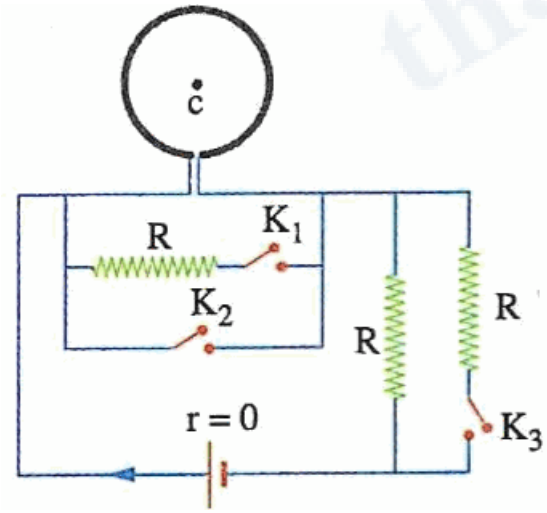

(A) 10 cm (B) 20 cm (C) 30 cm (D) 40 cm

**9** Three groups of metal loops x, y and z carry currents $I_x$, $I_y$ and $I_z$ respectively. The opposite graph shows the relation between the magnetic flux density (B) at the centre of each loop and the reciprocal of its radius $(1/r)$. The correct order of the currents is .....




(A) $I_x < I_y < I_z$ (B) $I_x > I_y > I_z$ (C) $I_x > I_z > I_y$ (D) $I_x = I_y = I_z$

**10** A wire of resistance (R) is shaped into a circular coil with centre (c), and the coil is connected in an electric circuit as in the opposite figure. Closing which of the switches in the circuit increases the magnetic flux density at the centre of the coil due to the current in it?




(A) Switch $(K_1)$ only (B) Switch $(K_2)$ only
(C) Switch $(K_3)$ only (D) All three switches

**11** A circular coil of radius 10 cm is made of a wire of cross-sectional area $0.4 \times 10^{-4}$ m² and resistivity $10^{-6}$ Ω.m. When the coil is connected to a source of emf $V_B$ and negligible internal resistance, the flux density at its centre is 0.01 T. The emf of the source equals .....

(A) 10 V (B) 15 V (C) 20 V (D) 25 V

**12** A potential difference (V) is applied across a circular coil of radius (r), and the magnetic flux density at its centre is (B). When half the turns of the coil are cut off and the ends of the rest of the coil are connected to the same potential difference (V), the magnetic flux density at the centre of the coil .....

(A) stays (B) (B) becomes (2 B) (C) becomes $(B/4)$ (D) becomes $(B/2)$

---

**13** A copper wire 50.24 m long with a cross-sectional area of $1.79 \times 10^{-7}$ m² is wound into a circular coil of radius 4 cm, and its ends are connected to a DC source of emf 12 V and internal resistance 1 Ω. If the resistivity of copper is $1.79 \times 10^{-8}$ Ω.m, the magnetic flux density at the centre of the coil equals ..... (given: π = 3.14)

(A) $3.125 \times 10^{-4}$ T (B) $5.93 \times 10^{-4}$ T (C) $6.25 \times 10^{-3}$ T (D) $8.12 \times 10^{-3}$ T

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**14** A wire of length $(\ell)$ is shaped into a circular coil of area (A). When a current (I) flows in the coil, the magnetic flux density (B) at the centre of the coil can be calculated from the relation .....

(A) $B = (\mu I \ell)/A$ (B) $B = 4 \times (\mu I \ell)/A$

(C) $B = 1/2 \times (\mu I \ell)/A$ (D) $B = 1/4 \times (\mu I \ell)/A$

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**15** A straight wire 31.4 m long is wound into a circular coil whose face area is 3.14 cm², and a current of 1 A flows in it. The magnetic flux density at the centre of the coil equals ..... (given: π = 3.14)

(A) $1.57 \times 10^{-2}$ T (B) $3.14 \times 10^{-2}$ T (C) $6.28 \times 10^{-2}$ T (D) $9.42 \times 10^{-2}$ T

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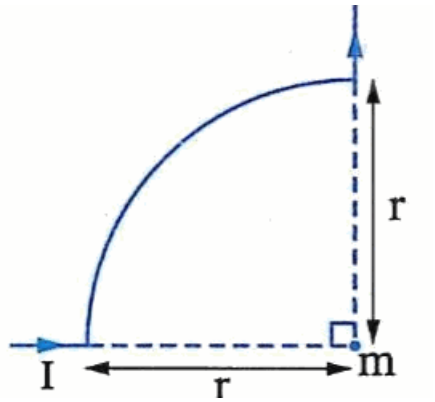
**16** A long straight wire carries a current of 5 A, and the magnetic flux density at a point 5 cm (perpendicular distance) from the axis of the wire is B. If a 120 cm piece is cut from this wire and wound into a circular coil of radius 9.55 cm carrying the same current, the magnetic flux density at the centre of the coil .....

(A) is greater than (B) by $8.6 \times 10^{-5}$ T (B) is greater than (B) by $4.6 \times 10^{-5}$ T

(C) is less than (B) by $8.6 \times 10^{-5}$ T (D) is less than (B) by $4.6 \times 10^{-5}$ T

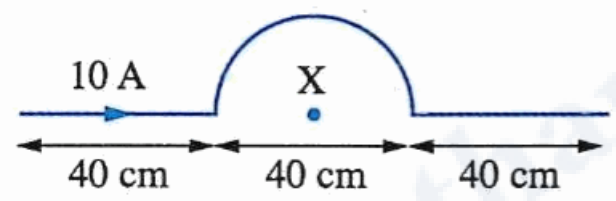
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**17** In the opposite figure, part of a long straight wire is bent into a quarter circle and a current I flows in it. The magnetic flux density at point m equals .....



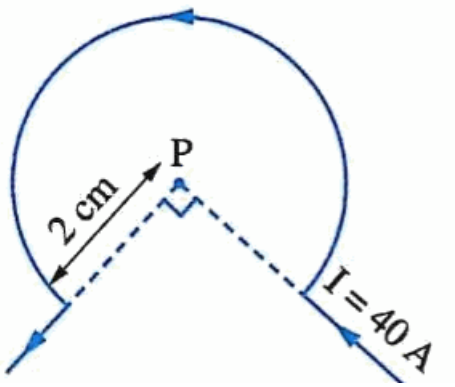

(A) $(\mu I)/2r$ (B) $(\mu I)/4r$ (C) $(\mu I)/6r$ (D) $(\mu I)/8r$

**18** In the opposite figure, part of a long wire is bent into a semicircle of diameter 40 cm, and a current of 10 A flows in the wire. The magnetic flux density at point X equals .....




(A) $3.14 \times 10^{-5}$ T (B) $6.28 \times 10^{-5}$ T (C) $1.57 \times 10^{-5}$ T (D) $2.826 \times 10^{-4}$ T

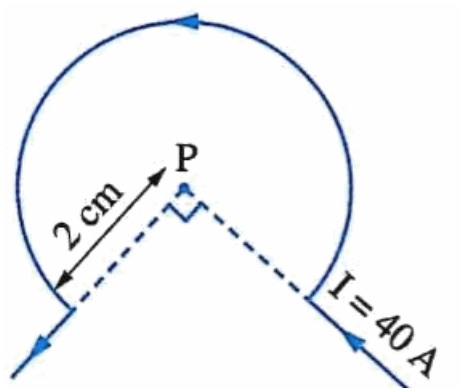
**19** From the opposite figure:
The magnetic flux density at point P equals .....




(A) $9.43 \times 10^{-5}$ T (B) $6.28 \times 10^{-5}$ T (C) $3.14 \times 10^{-5}$ T (D) $9.43 \times 10^{-4}$ T

**20** From the opposite figure:

The direction of the magnetic field at point P is .....




(A) perpendicular to the page and inwards

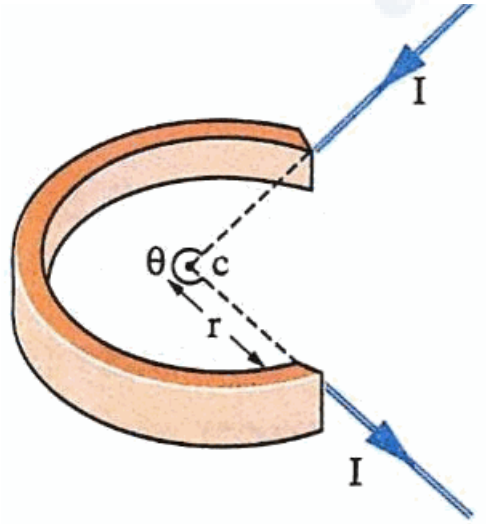
(B) perpendicular to the page and outwards

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

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

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**21** The opposite figure shows part of a circular metal loop of radius (r) placed on a horizontal surface and carrying a current I. If the angle θ is measured in degrees, the magnetic flux density at the centre (c) is calculated from the relation .....




(A) $B = (\mu I \theta)/r$

(B) $B = (\mu I \theta)/(360\, r)$

(C) $B = (\mu I \theta)/(2\pi r)$

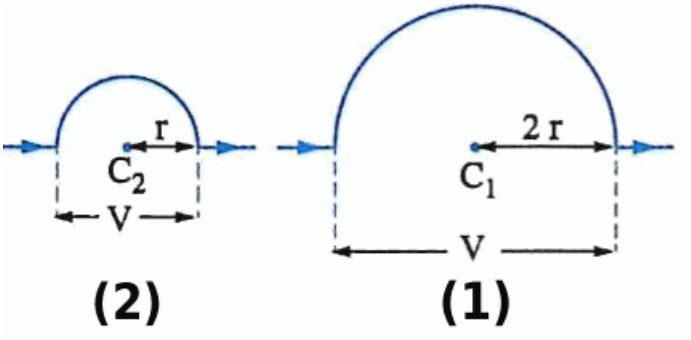
(D) $B = (\mu I \theta)/(720\, r)$

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**22** A current flows in a wire 26.4 cm long bent into an arc of a circle of radius 5.6 cm, and the magnetic flux density at the centre of this circle is $8.25 \times 10^{-6}$ T. The current equals .....

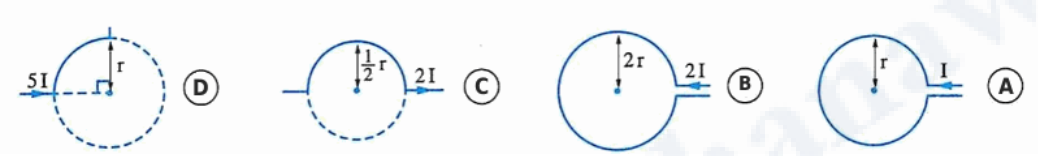
(A) 1.5 A (B) 0.98 A (C) 0.75 A (D) 0.49 A

**23** The two opposite figures show two half loops made of two wires of the same cross-sectional area, made of a material of high resistivity, with different radii. When the potential difference across each of them was the same, the magnetic flux density at $C_1$ was B. The magnetic flux density at $C_2$ equals .....

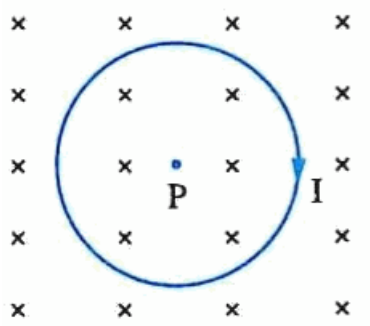



(A) $B/2$ (B) 2 B (C) 3 B (D) 4 B

**24** Which of the following coils has the greatest flux density at its centre?




**25** The opposite figure shows a circular coil of 14 turns and radius 8 cm in the plane of the page, carrying a current of 12 A. A uniform external magnetic field of flux density $10^{-5}$ T acts on it, perpendicular to the page and inwards. The magnitude and direction of the resultant flux density at the centre of the coil (P) are .....



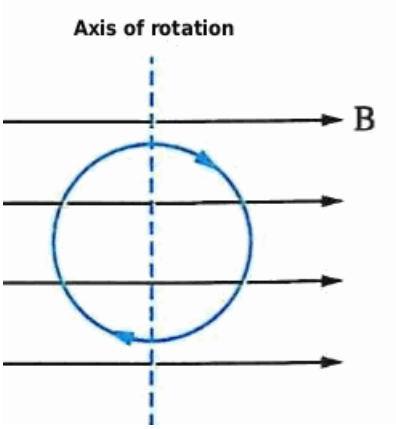

(A) magnitude $1.33 \times 10^{-3}$ T, perpendicular to the page and inwards

(B) magnitude $1.33 \times 10^{-3}$ T, perpendicular to the page and outwards

(C) magnitude $3.13 \times 10^{-3}$ T, perpendicular to the page and inwards

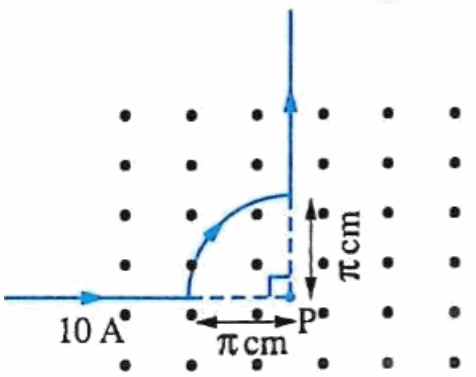
(D) magnitude $3.13 \times 10^{-3}$ T, perpendicular to the page and outwards

**26** In the opposite figure, a circular coil carrying a current is placed parallel to a uniform magnetic field of flux density B, and the resultant flux density at the centre of the coil is $\sqrt{(5)}$ B. When the coil is rotated through 90°, the resultant flux density at the centre of the coil can be .....




(A) B or 2 B (B) B or 5 B (C) B or 3 B (D) zero or B

**27** The opposite figure shows a straight wire, part of which is shaped into a quarter of a circular turn in the plane of the page. An external magnetic field of flux density $6 \times 10^{-6}$ T acts on it, perpendicular to the page and outwards. The resultant magnetic flux density at its centre P equals .....



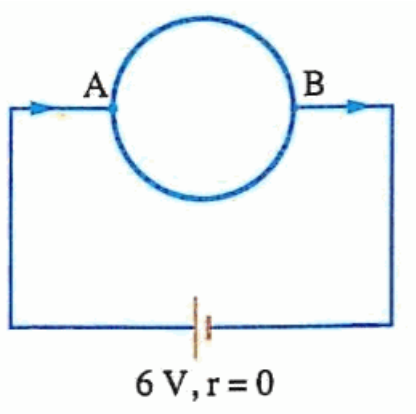

(A) $11 \times 10^{-5}$ T (B) $5.6 \times 10^{-5}$ T (C) $4.4 \times 10^{-5}$ T (D) 0

**28** A circular loop of radius 5 cm carries a current of 10 A. If the loop is bent at its middle so that each half is perpendicular to the other half, the resultant magnetic flux density at the centre equals .....

(A) $8.9 \times 10^{-5}$ T (B) $7.3 \times 10^{-5}$ T (C) $13.21 \times 10^{-6}$ T (D) $12.5 \times 10^{-6}$ T

**29** A straight wire of resistance 48 Ω is shaped into a closed loop of diameter 0.1 m, and a 6 V battery of negligible internal resistance is connected across the ends of its diameter as in the figure. Then:

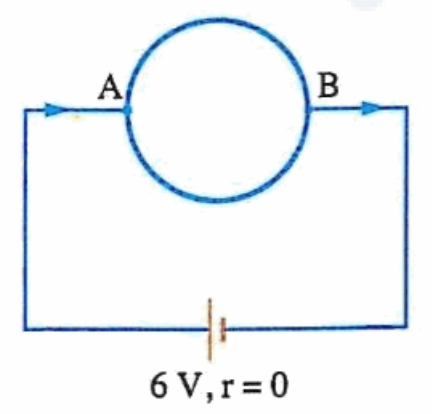
The current in either half of the loop equals .....




(A) 0.75 A (B) 0.25 A (C) 0.36 A (D) 0.41 A

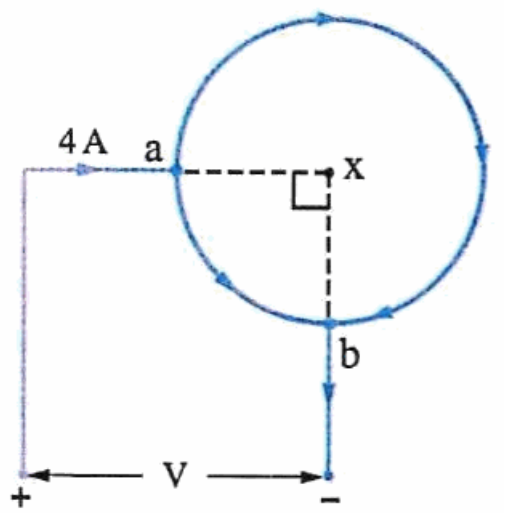
**30** A straight wire of resistance 48 Ω is shaped into a closed loop of diameter 0.1 m, and a 6 V battery of negligible internal resistance is connected across the ends of its diameter as in the figure. Then:

The magnetic flux density at the centre of the loop equals .....



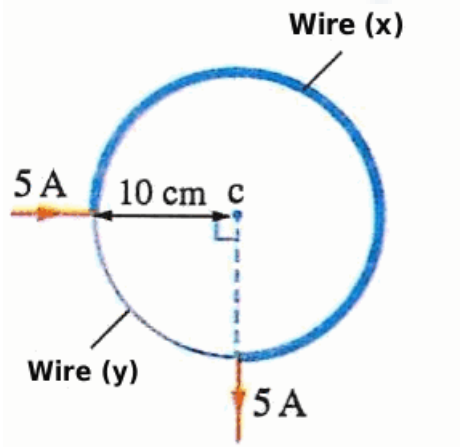

(A) 0 (B) π μT (C) 2π μT (D) 3π μT

**31** A metal loop with centre x is connected to a voltage source through two points (a, b) on the circumference of the loop as in the opposite figure, so a current flows through it. The resultant magnetic flux density at the centre of the loop equals .....



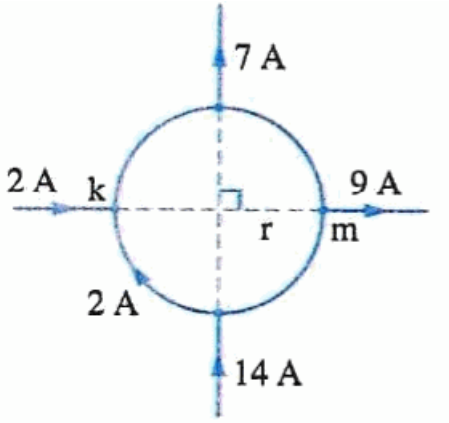

(A) $(3\mu)/8r$ (B) $(6\mu)/8r$ (C) $(4\mu)/8r$ (D) 0

**32** Two wires x and y are made of the same metal; the cross-sectional area of wire (x) is twice that of wire (y). They are joined together to form one circular loop, and a current flows in it as in the opposite figure. The magnetic flux density at the centre (c) equals .....




(A) $1.26 \times 10^{-5}$ T (B) $7.54 \times 10^{-6}$ T (C) $4.71 \times 10^{-6}$ T (D) $3.77 \times 10^{-6}$ T

**33** A metal loop carries an electric current through several paths as shown in the opposite figure. The direction of the magnetic flux density at the centre of the loop is .....




(A) inwards, perpendicular to the plane of the loop

(B) outwards, perpendicular to the plane of the loop

(C) to the right, towards point m

(D) to the left, towards point k

---

**34** A current I flows in a straight wire wound into a circle of one turn. Then the same wire is wound into a circular coil of four turns and a current $I/2$ flows in it. The ratio of the flux density at the centre of the coil in the first case to that in the second case equals .....

(A) $4/9$ (B) $9/4$ (C) $1/8$ (D) $8/1$

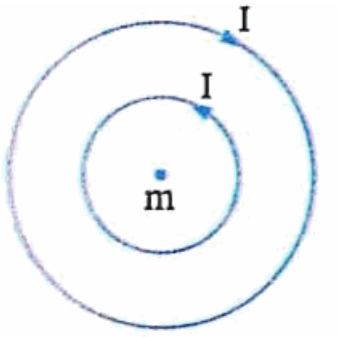
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**35** According to Bohr's model of the hydrogen atom, the electron revolves around the nucleus in a circular orbit of radius $5.3 \times 10^{-11}$ m with a frequency of $6.6 \times 10^{15}$ Hz. The magnetic flux density at the centre of the orbit due to the electron's motion equals .....

(A) 12.52 T (B) 8.48 T (C) 5.65 T (D) 4.24 T

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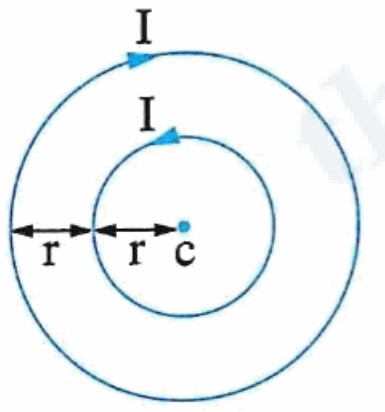
**36** Two concentric metal loops in the same plane each carry a current I as in the figure. The direction of the magnetic flux at the common centre m is towards .....




(A) the right of the page
(B) the left of the page
(C) into the page
(D) out of the page

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**37** Two concentric loops in the plane of the page carry equal currents (I) in opposite directions as in the opposite figure. Which of the following actions reverses the direction of the resultant magnetic flux density at the centre of the two loops (c)?




(A) Decreasing the current of the inner loop to *2/3* I
(B) Decreasing the current of the inner loop to *1/2* I
(C) Increasing the current of the outer loop to 2 I
(D) Increasing the current of the outer loop to 3 I

---

**38** Two concentric circular coils in the same plane have 400 turns and 500 turns and radii 20 cm and 10 cm respectively. They carry currents in the same direction of 7 A and 10 A respectively. Then:
The magnetic flux density at the common centre of the two coils equals .....

(A) $16.3 \times 10^{-3}$ T (B) $32.6 \times 10^{-3}$ T (C) $40.2 \times 10^{-3}$ T (D) $81.5 \times 10^{-3}$ T

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**39** Two concentric circular coils in the same plane have 400 turns and 500 turns and radii 20 cm and 10 cm respectively. They carry currents in the same direction of 7 A and 10 A respectively. Then:

The magnetic flux density at the common centre when one coil is rotated through 180° about the common centre, so that it is turned over, equals .....

(A) $22.6 \times 10^{-3}$ T (B) $45.3 \times 10^{-3}$ T (C) $67.8 \times 10^{-3}$ T (D) $90.4 \times 10^{-3}$ T

**40** Two concentric circular coils in the same plane have 400 turns and 500 turns and radii 20 cm and 10 cm respectively. They carry currents in the same direction of 7 A and 10 A respectively. Then:

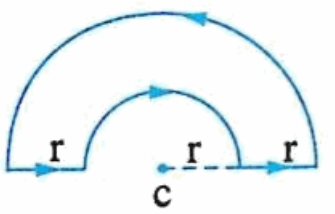
The magnetic flux density at the common centre when one coil is rotated through 90° about the common centre, so that the two coils become perpendicular, equals .....

(A) $18.5 \times 10^{-3}$ T (B) $32.6 \times 10^{-3}$ T (C) $65.2 \times 10^{-3}$ T (D) $97.8 \times 10^{-3}$ T

**41** Two concentric circular coils in the same plane carry equal currents in opposite directions. The first has a diameter of 10 cm and 100 turns, and the second has a diameter of 20 cm. The number of turns of the second coil that makes the flux density at their common centre zero equals .....

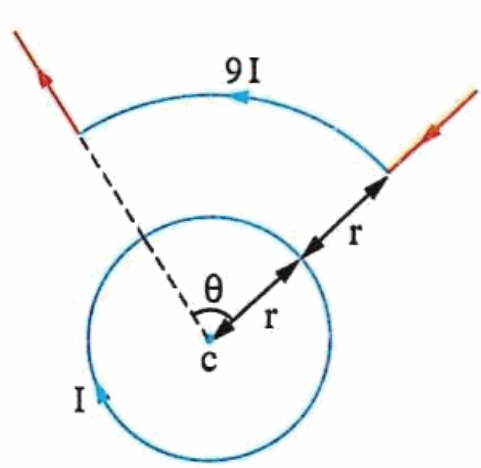
(A) 50 turns (B) 100 turns (C) 150 turns (D) 200 turns

**42** In the figure shown, if a current of 1 A flows in the wires, the resultant flux density at point c is .....




(A) $(\mu)/5r$ (B) $(\mu)/2r$ (C) $(\mu)/4r$ (D) $(\mu)/8r$

**43** A circular loop and part of another circular loop are concentric with radii r and 2r respectively and lie in the same plane. They carry currents I and 9I respectively as in the opposite figure, and the resultant magnetic flux density at the centre (c) is zero. The angle θ equals .....

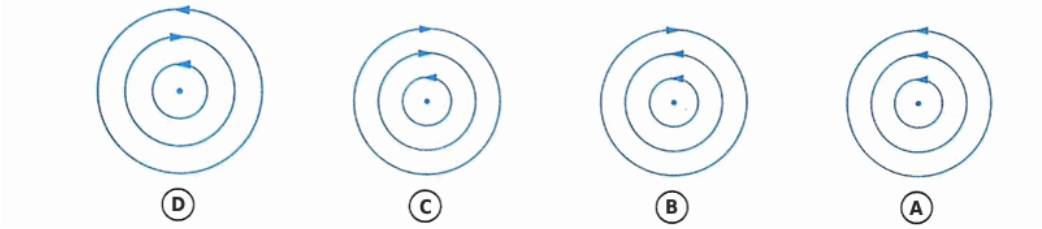



(A) 60° (B) 80° (C) 90° (D) 95°

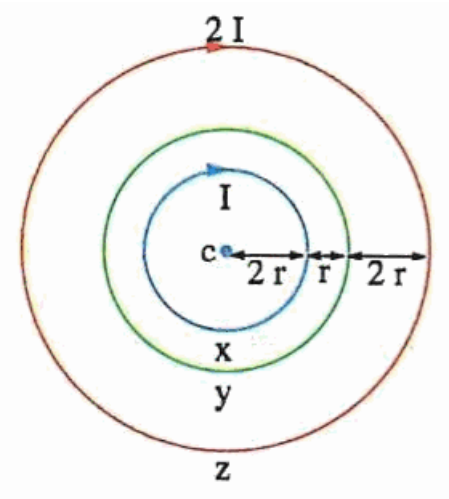
**44** Two concentric circular coils in the same plane: the diameter of the first is twice that of the second. They carry the same current in the same direction, and $B_1$ (outer coil) > $B_2$ (inner coil). When the current in the outer coil is reversed, the flux density due to both at the centre drops to half. The ratio of the numbers of turns of the two coils $N_1/N_2$ equals .....

(A) *4/5* (B) *6/11* (C) *2/3* (D) *9/8*

**45** In each of the following figures, three concentric metal loops in the same plane carry currents of the same magnitude. In which figure is the magnetic flux density at the centre the smallest?

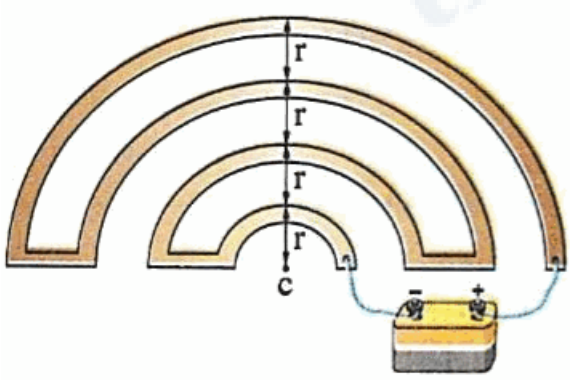


**46** Three concentric loops (x), (y) and (z) with centre (c) lie in the same plane, and each carries a current as shown in the opposite figure. If the resultant magnetic flux density at the centre (c) is zero, the magnitude and direction of the current in loop (y) are .....




(A) 1.5 I, clockwise
(B) 1.5 I, anticlockwise
(C) 2.7 I, clockwise
(D) 2.7 I, anticlockwise

**47** Four circular metal half loops are connected together and to a battery as in the opposite figure. The direction of the resultant magnetic flux density at the common centre (c) is .....

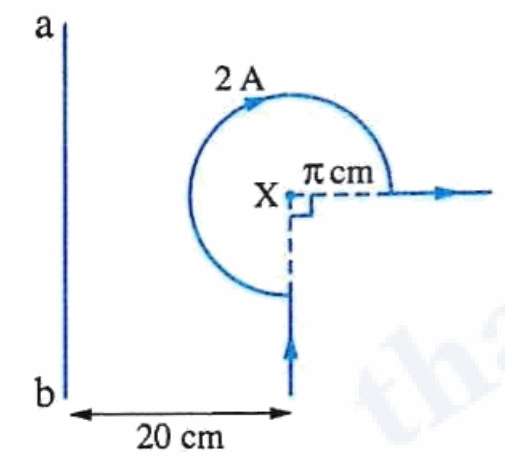



(A) perpendicular to the page and outwards
(B) perpendicular to the page and inwards
(C) in the plane of the page and to the right
(D) in the plane of the page and to the left

**48** A long straight wire carries a current (I), and the magnetic flux density at a point at a perpendicular distance (d) from it is (B). If a current of the same magnitude (I) flows in a circular loop and the flux density at its centre is also (B), the radius of the loop is .....

(A) greater than (d)
(B) less than (d)
(C) equal to (d)
(D) the answer cannot be determined

**49** The opposite figure shows part of a metal loop with centre X. A long straight wire in the same plane is 20 cm from the centre of the loop and carries a current I. The magnitude and direction of the current I needed to make the magnetic flux density at the centre of the loop zero are .....

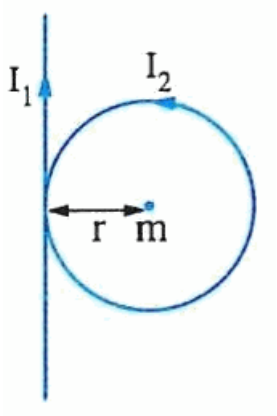



(A) 15 A, from a to b
(B) 30 A, from a to b
(C) 15 A, from b to a
(D) 30 A, from b to a

**50** A straight wire is placed vertically so that it touches a circular coil of one turn whose plane is in the plane of the magnetic meridian. A magnetic needle, free to move in a horizontal plane, is placed at the centre of the coil. The current in the wire that causes no deflection of the needle when the coil carries a current of 0.42 A equals .....

(A) 0.96 A
(B) 1.07 A
(C) 1.32 A
(D) 2.56 A

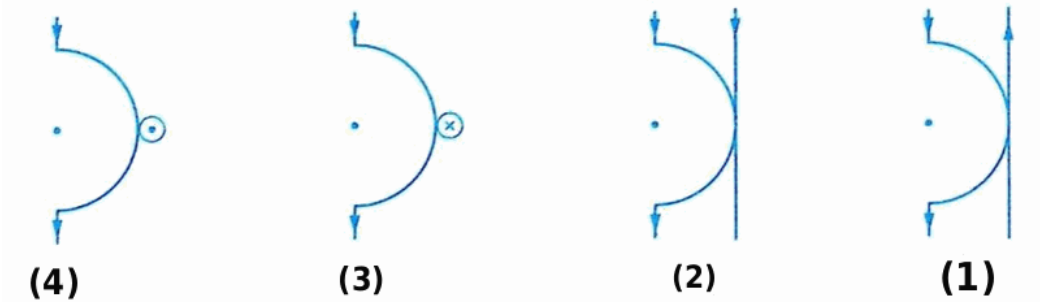
**51** In the opposite figure, a long straight wire touches a circular coil, lies in the same plane and is insulated from it, and each carries a current in the direction shown. If the resultant magnetic flux density at the centre of the coil is zero, and then the coil is turned over, the resultant magnetic flux density at the centre of the coil becomes .....




(A) half the flux density of the coil
(B) the flux density of the coil
(C) the flux density of the wire
(D) twice the flux density of the wire

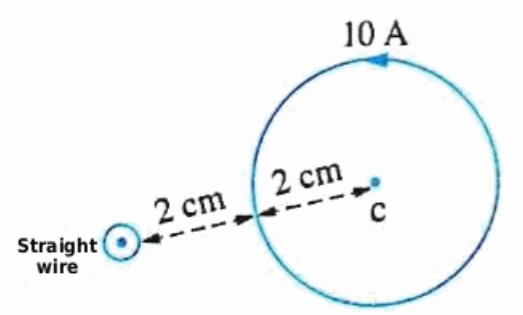
**52** An insulated straight wire carrying a current I is placed touching a semicircular loop, either in the same plane or perpendicular to it. The loop carries a current I in the direction shown in the following figures.

The correct order of the magnetic flux densities at the centre of the half loop in these cases is .....




(A) $B_4 > B_2 > B_3 > B_1$
(B) $B_1 > B_3 = B_4 > B_2$
(C) $B_2 > B_3 = B_4 > B_1$
(D) $B_3 = B_4 > B_2 > B_1$

**53** In the figure shown, a long straight wire is placed near a metal loop, perpendicular to its plane, and each carries a current of 10 A. The magnitude of the resultant magnetic flux density at the centre of the loop (c) is approximately .....




(A) $10^{-4}$ T (B) $2.6 \times 10^{-4}$ T (C) $3.2 \times 10^{-4}$ T (D) $3.6 \times 10^{-4}$ T

**54** An insulated long wire carrying a current I has a part wound into a circular loop of radius r in two ways, as in the following two figures.

The ratio between the resultant magnetic flux densities at the centre of the loop in the two figures $(B_1/B_2)$ is .....

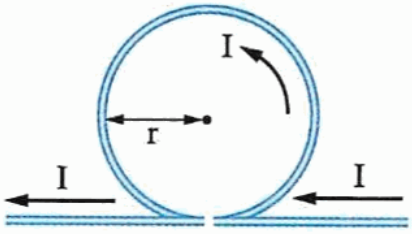



Figure (2)

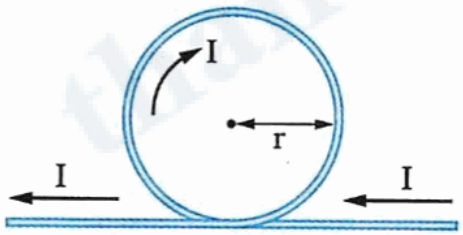
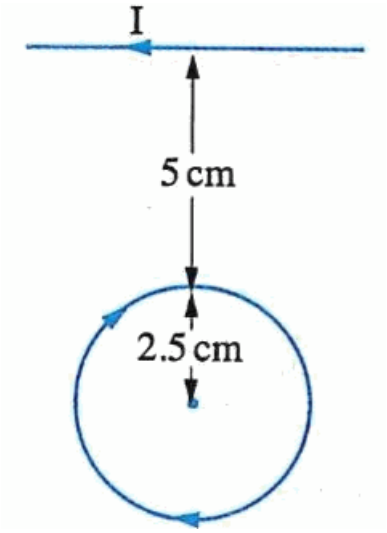



Figure (1)

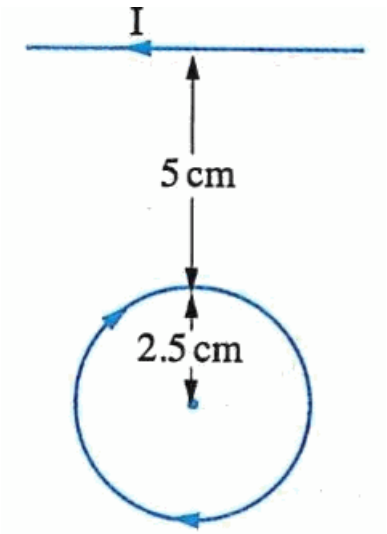
(A) $1/1$ (B) $(\pi + 1)/(\pi)$ (C) $1/(\pi - 1)$ (D) $(\pi + 1)/(\pi - 1)$

**55** A circular loop of radius 2.5 cm carries a current of 3 A. A long straight wire in the same plane, 5 cm from the loop, carries a current I as in the figure. Then:
The value of I that makes the flux density at the centre of the loop zero is .....



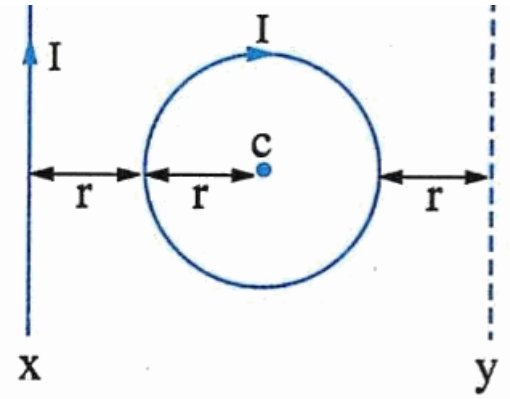

(A) 35.64 A (B) 28.29 A (C) 23.79 A (D) 20.81 A

**56** A circular loop of radius 2.5 cm carries a current of 3 A. A long straight wire in the same plane, 5 cm from the loop, carries a current I as in the figure. Then:
The flux density at the centre of the loop if the direction of the current I is reversed equals .....



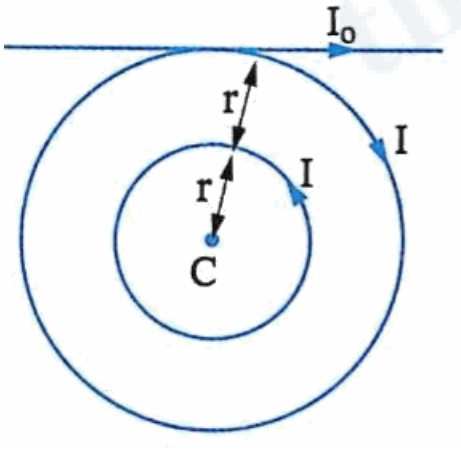

(A) $7.54 \times 10^{-3}$ T (B) $3.79 \times 10^{-3}$ T (C) $1.51 \times 10^{-4}$ T (D) $2.24 \times 10^{-4}$ T

**57** In the opposite figure, a circular loop and a straight wire placed at position x in the same plane as the loop each carry a current I, and the resultant flux density at the centre of the loop c is B. If the wire is moved to position y, the flux density at point c becomes .....



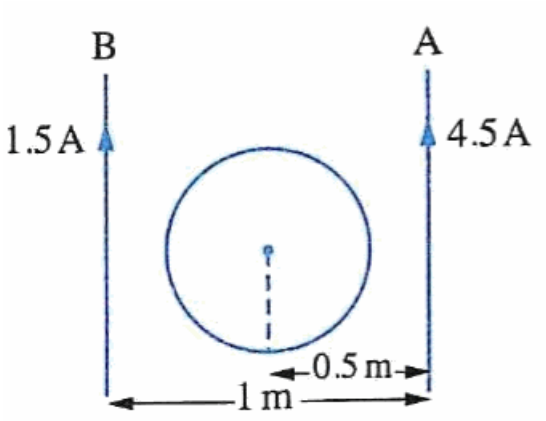

(A) 2 B (B) B (C) 0.73 B (D) 1.38 B

**58** Two concentric circular loops in the same plane have radii r and 2r, and each carries a current I in opposite directions. A long straight wire is placed touching the outer loop, in the same plane, and carries a current $I_o$ as in the opposite figure. If the resultant magnetic flux density at the centre of the two loops (C) is zero, the ratio of the two currents $(I_o/I)$ equals .....



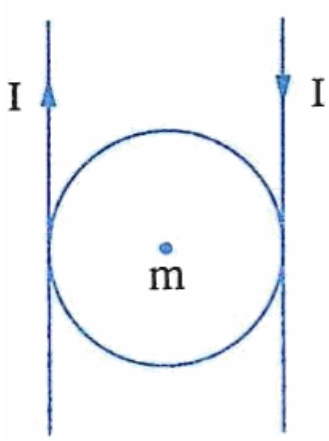

(A) π (B) $1/(\pi)$ (C) 2π (D) $1/(2\pi)$

**59** Two parallel straight wires A and B, 1 m apart, carry currents in the same direction of 4.5 A and 1.5 A respectively. A circular coil of one turn and radius 10π cm is placed in the same plane as the two wires, with its centre 0.5 m from wire A as shown in the figure. The magnitude and direction of the current in the circular coil that makes the magnetic flux density at its centre zero are .....



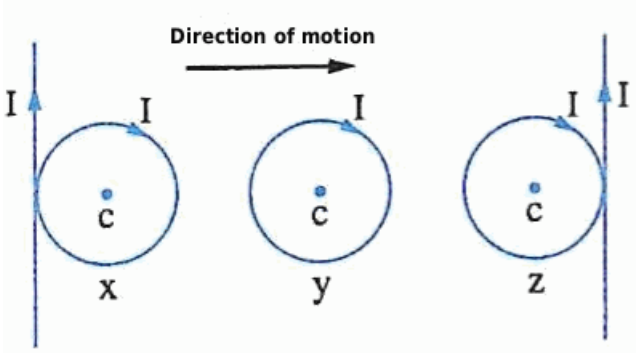

(A) 0.3 A, clockwise
(B) 0.6 A, clockwise
(C) 0.3 A, anticlockwise
(D) 0.6 A, anticlockwise

**60** Using the opposite figure, if the magnetic flux density due to the current in each of the two straight wires at the centre of the circular coil (m) is B, and the resultant magnetic flux density at the centre of the coil (m) is zero, then .....



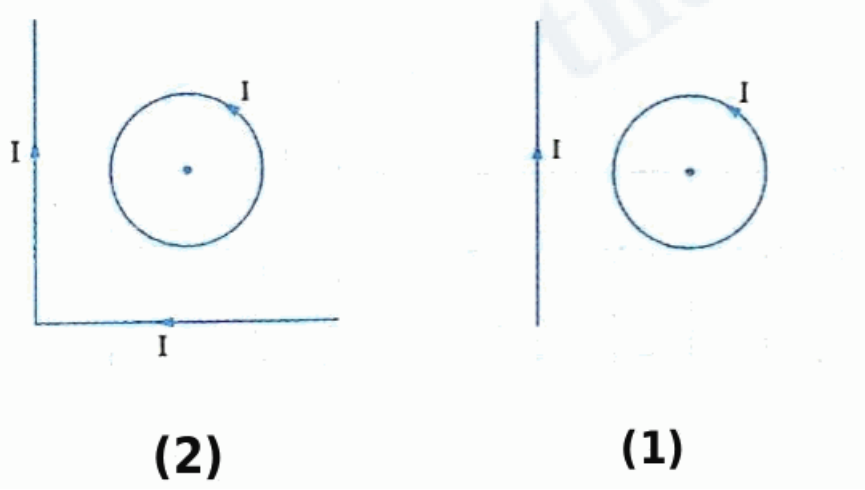

(A) current in the coil: clockwise, flux density of the coil: $B/2$
(B) current in the coil: anticlockwise, flux density of the coil: $B/2$
(C) current in the coil: clockwise, flux density of the coil: 2 B
(D) current in the coil: anticlockwise, flux density of the coil: 2 B

**61** A metal loop carrying a current I moves between two straight wires, each carrying a current I, placed in the same plane as the loop as in the opposite figure. What is the correct order of the resultant magnetic flux density at the centre of the loop (c) when it is fixed at each of the three positions shown in the figure?




(A) $B_z > B_y > B_x$ (B) $B_x > B_y > B_z$ (C) $B_x > B_z > B_y$ (D) $B_x = B_y = B_z$

**62** A metal loop of radius (r) carries a current (I), and a long straight wire in the same plane, at a distance 2r from its centre, carries a current (I) as in figure $(1)$. If the wire is bent and carries the same current as in figure $(2)$, what happens to the magnitude and direction of the resultant magnetic flux density at the centre of the loop?




(A) Its magnitude increases and its direction stays the same

(B) Its magnitude increases and its direction reverses

(C) Its magnitude decreases and its direction stays the same

(D) Its magnitude decreases and its direction reverses

**63** The magnetic field produced by a current in a solenoid has the advantage over the magnetic field of a bar magnet that we can control .....

(A) the magnetic polarity only

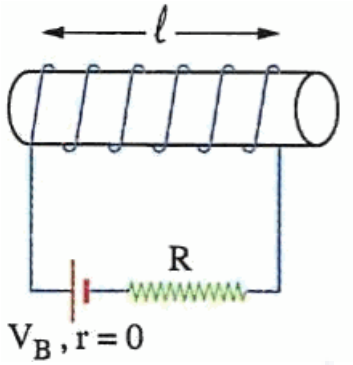
(B) the magnetic flux density only

(C) the direction of the magnetic field only

(D) the polarity, flux density and direction of the magnetic field

---

**64** From the opposite figure, which of the following doubles the magnetic flux density inside the solenoid, other factors being constant?




(A) Doubling the length of the coil $(\ell)$

(B) Doubling the emf $(V_B)$

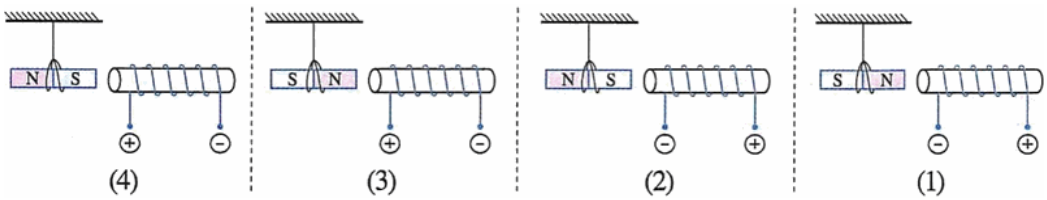
(C) Halving the number of turns of the coil (N)

(D) Doubling the electric resistance (R)

---

**65** The following figures show a permanent magnet hanging freely near a solenoid carrying an electric current.

In which two of these figures is the magnet attracted to the coil?

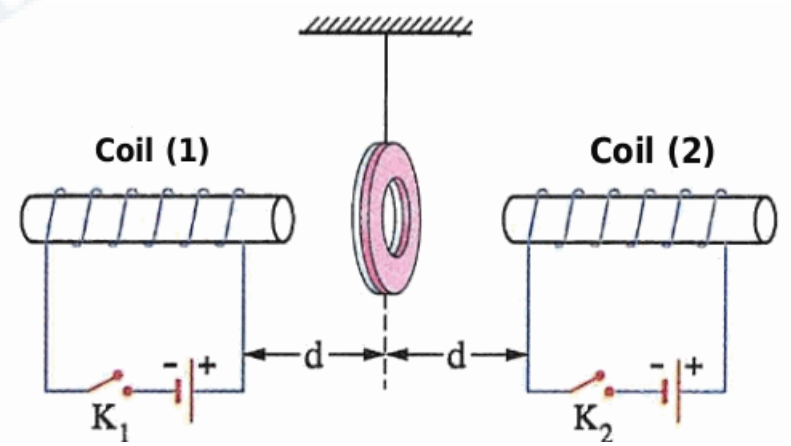



(A) (1), (2) (B) (3), (4) (C) (1), (3) (D) (2), (3)

---

**66** Two identical solenoids $(1)$ and $(2)$ are each connected to a battery of emf $(V_B)$ with negligible internal resistance and a switch. A ring magnet hangs between the two coils at equal distances from them, as in the following figure.

After closing the two switches $K_1$ and $K_2$ together, the magnet .....



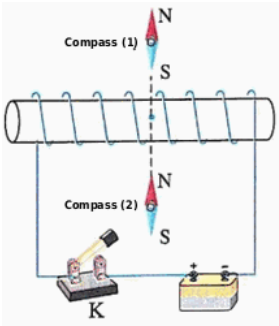

(A) is attracted to coil $(1)$

(B) is attracted to coil $(2)$

(C) rotates about its axis

(D) stays still

**67** Two compasses $(1)$ and $(2)$ are placed on either side of a solenoid connected to a battery and a switch (K), and the compass needles settle under the Earth's magnetic field as shown in the opposite figure. Which of the following figures shows the position in which the two needles settle when the switch K is closed?




| Compass (2) | Compass (1) | |
|---|---|---|
| S N | N S | (A) |
| N S | N S | (B) |
| N S | S N | (C) |
| S N | S N | (D) |

**68** A solenoid 20 cm long with 200 turns carries a current of 0.5 A. The flux density at the middle of its length on its axis (given: the magnetic permeability of iron = $2 \times 10^{-3}$ Wb/A.m, $\pi = 3.14$):
if the medium is air, equals .....
(A) $8.93 \times 10^{-5}$ T (B) $3.11 \times 10^{-4}$ T (C) $6.28 \times 10^{-4}$ T (D) $7.92 \times 10^{-5}$ T

**69** A solenoid 20 cm long with 200 turns carries a current of 0.5 A. The flux density at the middle of its length on its axis (given: the magnetic permeability of iron = $2 \times 10^{-3}$ Wb/A.m, $\pi = 3.14$):
if an iron core is placed inside the coil, equals .....
(A) 0.5 T (B) 0.25 T (C) 0.75 T (D) 1 T

**70** A solenoid 0.22 m long with a face area of $25 \times 10^{-4}$ m² has 300 turns and carries a current, and the flux density at a point at the middle of its length on its axis is $1.2 \times 10^{-3}$ Wb/m².
Then:
The current in the coil equals .....
(A) 0.3 A (B) 0.5 A (C) 0.7 A (D) 1.1 A

**71** A solenoid 0.22 m long with a face area of $25 \times 10^{-4}$ m² has 300 turns and carries a current, and the flux density at a point at the middle of its length on its axis is $1.2 \times 10^{-3}$ Wb/m².
Then:
The total flux passing through a cross-section at the middle of the coil equals .....
(A) $3 \times 10^{-6}$ Wb (B) $5 \times 10^{-6}$ Wb (C) $9 \times 10^{-6}$ Wb (D) $18 \times 10^{-6}$ Wb

**72** A solenoid 0.6 m long carries a current of 10 A, and the flux density at a point at the middle of its length on its axis is 0.05 T. Then:
The number of turns per unit length equals ..... turns/m.
(A) 2388.5 (B) 3679.4 (C) 3977.3 (D) 5123.5

**73** A solenoid 0.6 m long carries a current of 10 A, and the flux density at a point at the middle of its length on its axis is 0.05 T. Then:
Its number of turns equals ..... turns.
(A) 1194.5 (B) 2386.4 (C) 3582.7 (D) 8359.3

**74** A solenoid of N turns and length 50 cm, with a resistance of 0.01 Ω per turn, is connected to a 2 V source of negligible internal resistance. Then:

The magnetic flux density at a point at the middle of its length on its axis equals .....

(A) $2.15 \times 10^{-3}$ T (B) $4.11 \times 10^{-3}$ T (C) $3.17 \times 10^{-4}$ T (D) $5.03 \times 10^{-4}$ T

---

**75** A solenoid of N turns and length 50 cm, with a resistance of 0.01 Ω per turn, is connected to a 2 V source of negligible internal resistance. Then:

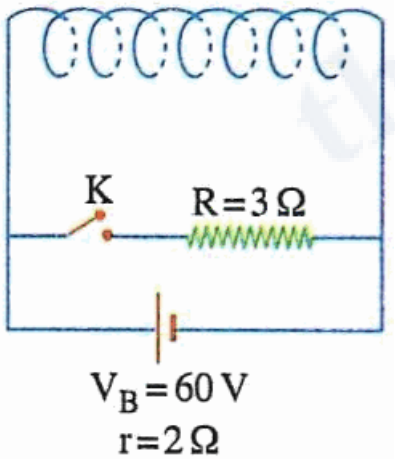
The value the magnetic flux density will have if half of its turns are cut off and the other half is connected to the same source is .....

(A) $1.01 \times 10^{-3}$ T (B) $3.09 \times 10^{-3}$ T (C) $2.17 \times 10^{-4}$ T (D) $7.18 \times 10^{-4}$ T

---

**76** A solenoid 20 cm long with 100 turns and a resistance of 6 Ω is part of the electric circuit shown. The magnetic flux density at a point at the middle of its length on its axis, due to the current in it, when:

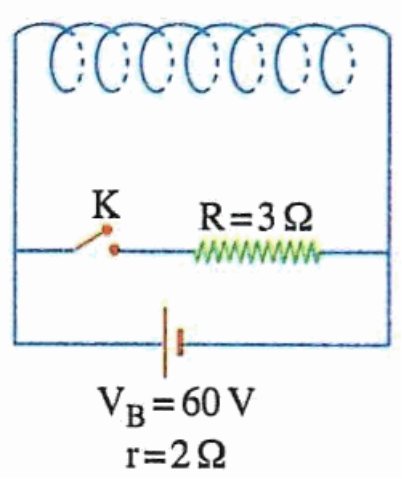
switch K is open, equals .....




(A) $3.14 \times 10^{-3}$ T (B) $4.71 \times 10^{-3}$ T (C) $6.22 \times 10^{-3}$ T (D) $9.78 \times 10^{-3}$ T

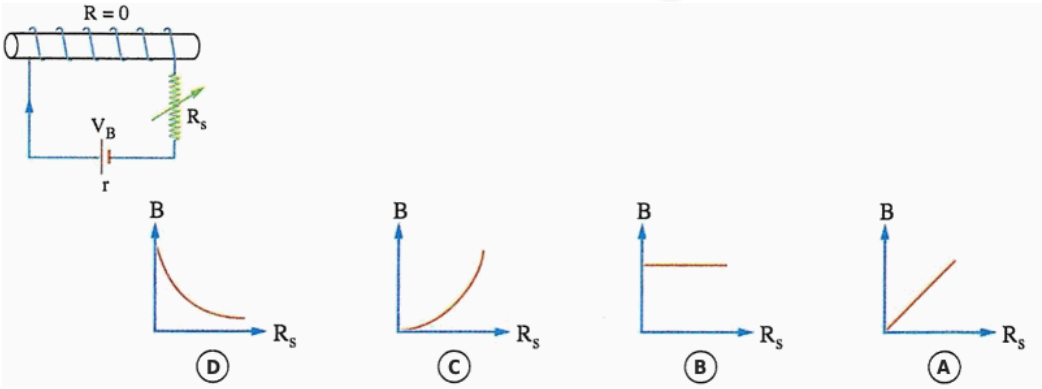
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**77** A solenoid 20 cm long with 100 turns and a resistance of 6 Ω is part of the electric circuit shown. The magnetic flux density at a point at the middle of its length on its axis, due to the current in it, when:
switch K is closed, equals .....

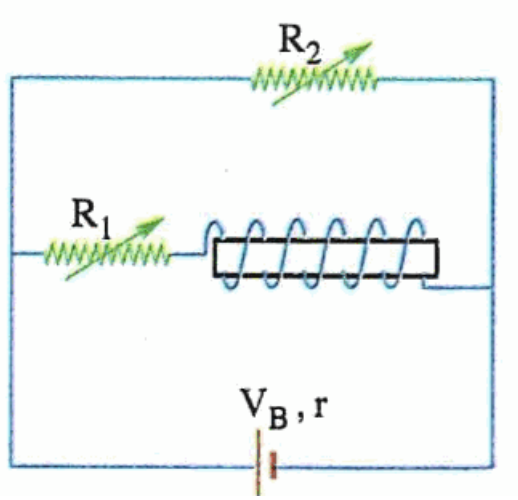



(A) $3.14 \times 10^{-3}$ T (B) $5.19 \times 10^{-3}$ T (C) $6.03 \times 10^{-3}$ T (D) $7.16 \times 10^{-3}$ T

**78** The opposite figure shows a solenoid of negligible resistance in an electric circuit. Which of the following graphs shows the relation between the magnetic flux density (B) at a point at the middle of the coil on its axis and the resistance taken from the rheostat ($R_s$)?

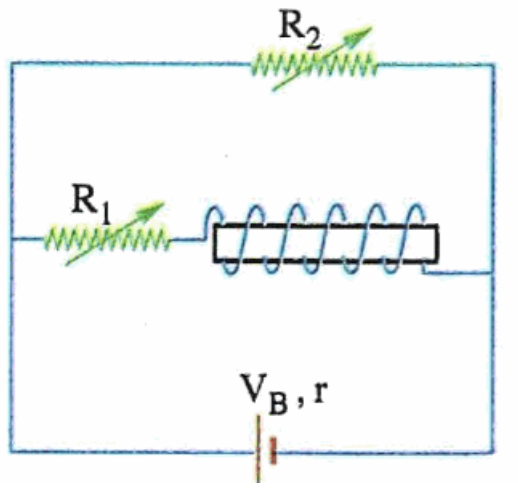


**79** In the opposite electric circuit, what happens to the magnetic flux density inside the solenoid, due to the current in the coil, when the value of:
resistance $R_1$ is increased?



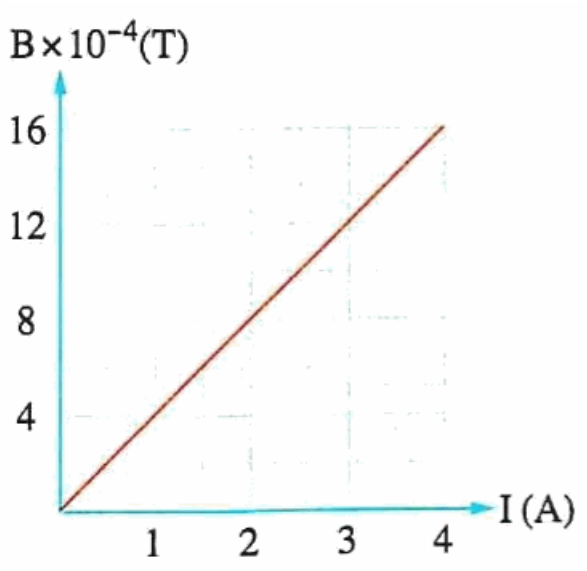

(A) It increases
(B) It decreases
(C) It does not change
(D) The answer cannot be determined

**80** In the opposite electric circuit, what happens to the magnetic flux density inside the solenoid, due to the current in the coil, when the value of:
resistance $R_2$ is increased?



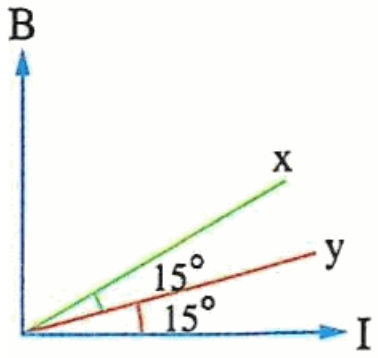

(A) It increases
(B) It decreases
(C) It does not change
(D) The answer cannot be determined

**81** The opposite graph shows the relation between the magnetic flux density (B) at a point at the middle of a solenoid on its axis and the current (I) in it. The number of turns per metre of the coil equals .....




(A) 215.2 turns/m (B) 250.5 turns/m (C) 318.18 turns/m (D) 341.4 turns/m

**82** Two solenoids (x) and (y) have the same number of turns and cores of two different materials; the length of coil (y) is four times the length of coil (x), and each carries a current. The opposite graph shows the relation between the magnetic flux density (B) at the middle of each coil on its axis and the current (I) in each. Which core is made of the material with the greater magnetic permeability?



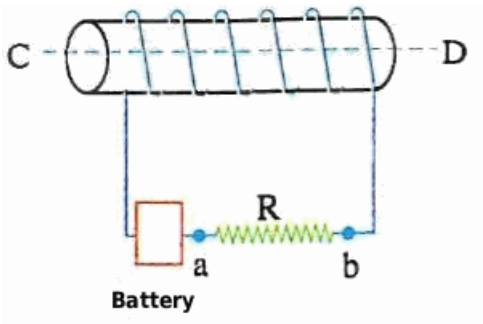

(A) The core of coil (x)

(B) The core of coil (y)

(C) The permeabilities of the two core materials are equal

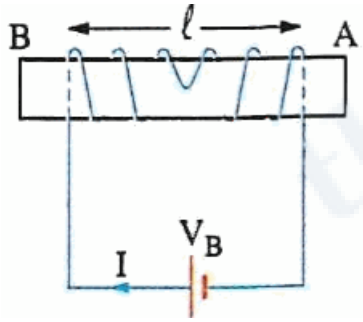
(D) The answer cannot be determined

**83** In the opposite figure, a solenoid $10\pi$ cm long with 500 turns is connected in series with a battery and a resistor R. If the magnetic flux density at a point at the middle of the coil on its axis is $2.4 \times 10^{-2}$ T and its end D is a south pole, the magnitude and direction of the current in resistor R are .....



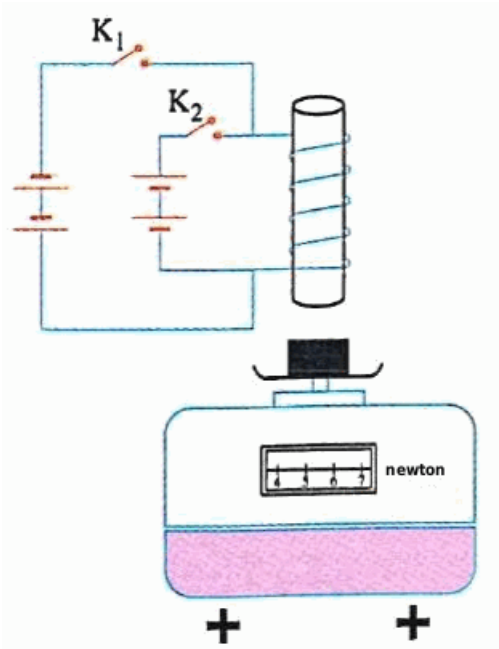

(A) 12 A, from a to b (B) 12 A, from b to a (C) 24 A, from a to b (D) 24 A, from b to a

**84** In the opposite figure, a wire is wound as a long solenoid and connected to a battery. The magnetic poles formed at the ends A and B respectively are .....




(A) north, north (B) north, south (C) south, north (D) south, south

**85** In the opposite figure, a coil is fixed above a piece of soft iron placed on the pan of a balance that reads w. What happens to the balance reading when one of the switches $K_1$ or $K_2$ is closed while the other is kept open?



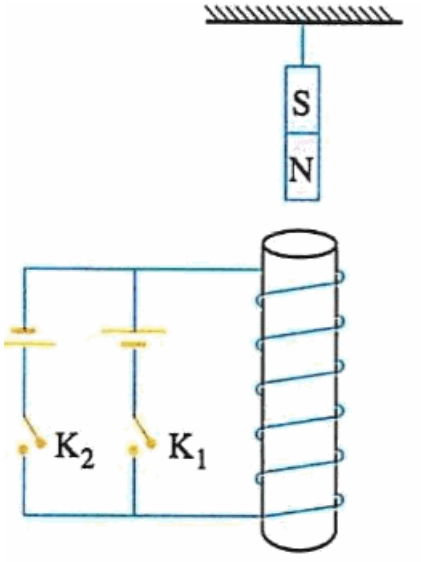

(A) It increases above w in both cases

(B) It decreases below w in both cases

(C) It increases above w in one case and decreases below w in the other

(D) It stays w in both cases

**86** In the opposite figure, a solenoid of resistance (R) is connected to two identical batteries through two switches $K_1$ and $K_2$, and a magnet hangs freely from a thread above the coil. Which of the following decreases the tension in the thread?




(A) Closing switch $(K_1)$ only

(B) Closing switch $(K_2)$ only

(C) Closing switches $(K_1)$ and $(K_2)$ together

(D) The answer cannot be determined

---

**87** An insulated wire of diameter 0.2 cm is wound around an iron rod of magnetic permeability $2 \times 10^{-3}$ Wb/A.m so that the turns touch each other along the rod. If a current of 1 A flows in it, the magnetic flux density at a point at the middle of its length on its axis equals .....

(A) 0.5 T (B) 1 T (C) 1.2 T (D) 1.5 T

---

**88** A uniformly wound solenoid has length $\ell$ and N turns. If the coil is cut into two parts x and y of lengths $\ell_1$ and $3\ell_1$ respectively, and each is connected to the same potential difference, the ratio of the magnetic flux densities $(B_x/B_y)$ at the middle of each part on its axis equals .....

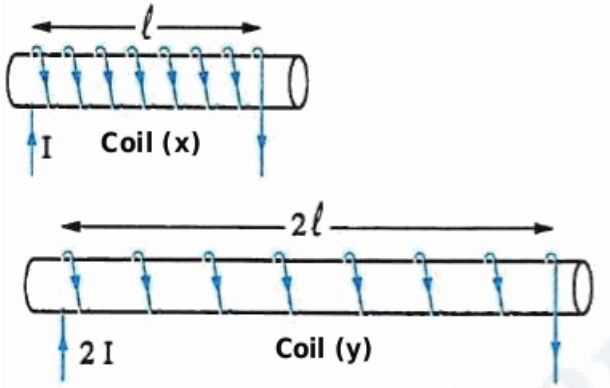
(A) *1/1* (B) *1/3* (C) *1/4* (D) *3/1*

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**89** Two identical solenoids, the first of copper and the second of aluminium, are each connected separately to the same battery, and the magnetic flux densities at the middle of their axes due to the current in them are $B_1$ and $B_2$ respectively. Then ..... (given: the resistivity of copper is less than that of aluminium)

(A) $B_1 > B_2$ (B) $B_1 < B_2$ (C) $B_1 = B_2 = 0$ (D) $B_1 = B_2 \neq 0$

**90** The opposite figure shows two solenoids x and y with the same number of turns wound around an iron cylinder, each carrying a direct current. The ratio of the magnetic flux densities at the middle of each coil on its axis $(B_x/B_y)$ equals .....




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

**91** Two solenoids X and Y have the same number of turns per unit length and are made of two copper wires of the same length but different cross-sectional areas, connected to two sources of the same voltage. If the ratio of the magnetic flux densities at the middle of each coil on its axis is $B_X/B_Y = 9/1$, which of the following is correct?

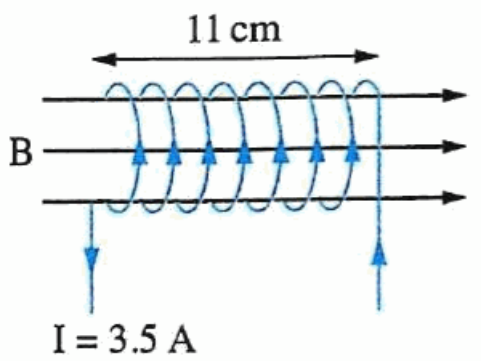
(A) The cross-sectional area of the wire of coil X is three times that of coil Y

(B) The cross-sectional area of the wire of coil X is nine times that of coil Y

(C) The resistance of coil X is three times that of coil Y

(D) The resistance of coil X is twice that of coil Y

**92** The opposite figure shows a solenoid of 60 turns carrying a current. If the whole coil is placed in an external magnetic field of flux density $5.2 \times 10^{-3}$ T, parallel to the axis of the coil and to the right of the page, then at the middle of the solenoid on its axis the resultant magnetic flux density and its direction are .....




(A) $2.8 \times 10^{-3}$ T, in the direction of the external field

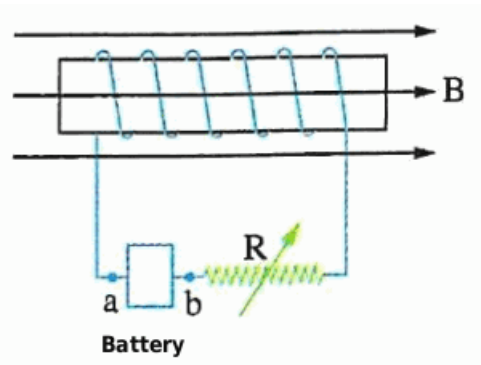
(B) $2.8 \times 10^{-3}$ T, opposite to the external field

(C) $7.6 \times 10^{-3}$ T, opposite to the external field

(D) $7.6 \times 10^{-3}$ T, in the direction of the external field

---

**93** In the opposite electric circuit, the solenoid has 210 turns and a length of 1.1 m and is placed in an external magnetic field parallel to the axis of the coil with a flux density of $1.2 \times 10^{-3}$ T. The current that must flow in the circuit to make the resultant magnetic flux density at the middle of the solenoid on its axis zero, and the type of the battery terminals, are .....




(A) current 8 A, battery terminals: a positive, b negative

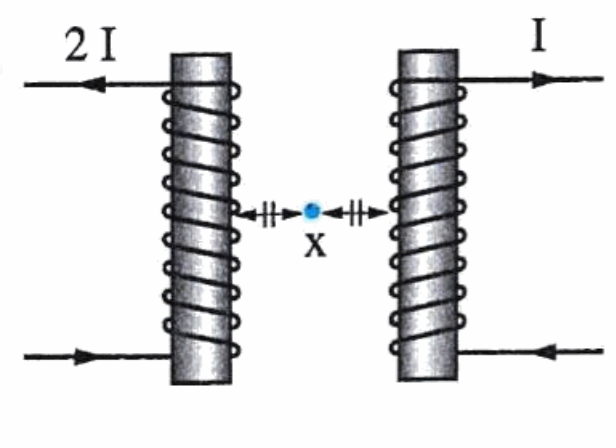
(B) current 8 A, battery terminals: a negative, b positive

(C) current 5 A, battery terminals: a positive, b negative

(D) current 5 A, battery terminals: a negative, b positive

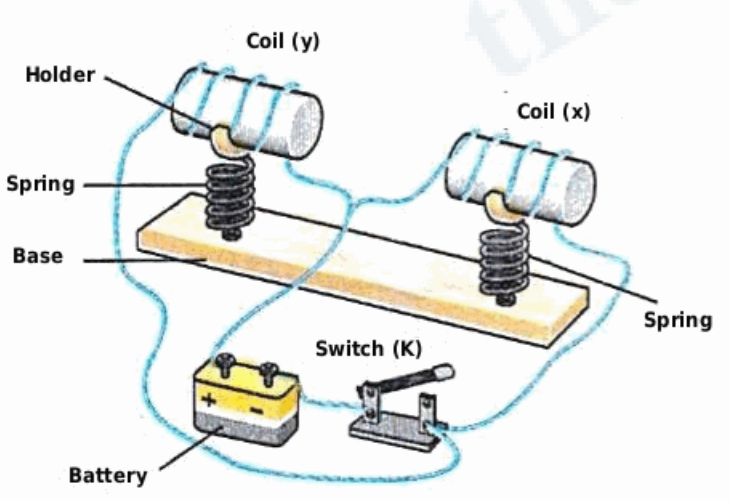
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**94** In the figure shown, two identical solenoids with parallel axes each carry a current. The direction of their total magnetic field at point x is .....




(A) into the page
(B) out of the page
(C) towards the top of the page
(D) towards the bottom of the page

**95** A student designed an apparatus to study the magnetic field produced by a current in two identical solenoids x and y, as in the opposite figure. What do you expect to happen when switch (K) is closed?




(A) The two coils repel
(B) The two coils attract
(C) No magnetic force is produced between the two coils
(D) The two coils vibrate vertically

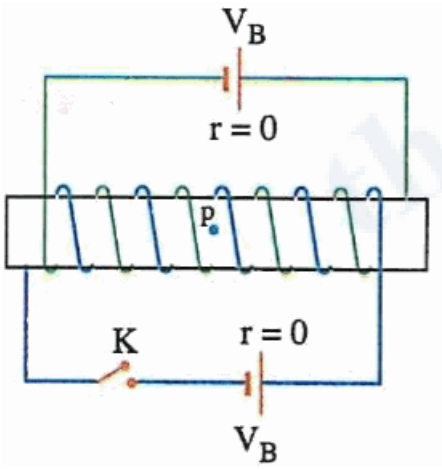
**96** Two solenoids, one inside the other, have a common axis. Each unit length of the first coil has 10 turns and of the second 20 turns. If the current in the first coil is 2 A and in the second 4 A, the magnetic flux density at the middle of their lengths on the axis:
when the two currents are in the same direction, equals .....

(A) $125.71 \times 10^{-6}$ T (B) $432.7 \times 10^{-5}$ T (C) $79.7 \times 10^{-4}$ T (D) $45.31 \times 10^{-3}$ T

**97** Two solenoids, one inside the other, have a common axis. Each unit length of the first coil has 10 turns and of the second 20 turns. If the current in the first coil is 2 A and in the second 4 A, the magnetic flux density at the middle of their lengths on the axis:
when the two currents are in opposite directions, equals .....

(A) $96.41 \times 10^{-6}$ T (B) $85.7 \times 10^{-6}$ T (C) $75.43 \times 10^{-6}$ T (D) $41.8 \times 10^{-6}$ T

**98** In the figure shown, there are two identical solenoids. The resultant magnetic flux density at the middle of the two coils on their common axis (point p) after closing switch K .....




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

**99** A circular coil of N turns and radius r carries a current I, and the flux density at its centre is B. If its turns are spread out uniformly to form a solenoid of length 20r carrying the same current, the flux density at a point at the middle of its length on its axis is .....

(A) $B/20$ (B) $B/10$ (C) $B/40$ (D) B

**100** A circular coil of radius 2.2 cm carries a current and produces a magnetic field of flux density B. If its turns are spread apart uniformly until its length becomes 110 cm, the flux density at a point at the middle of its length on its axis equals .....

(A) B (B) 2 B (C) 0.5 B (D) 0.04 B

**101** A solenoid of diameter 10 cm and length 200 cm carries a current that produces a magnetic flux density of $4 \times 10^{-6}$ T at the middle of its length on its axis. If its turns are pressed together uniformly until it becomes a circular coil, the flux density at the centre of the coil in this case equals .....

(A) $2.75 \times 10^{-3}$ T (B) $4.5 \times 10^{-3}$ T (C) $8 \times 10^{-5}$ T (D) $13 \times 10^{-3}$ T

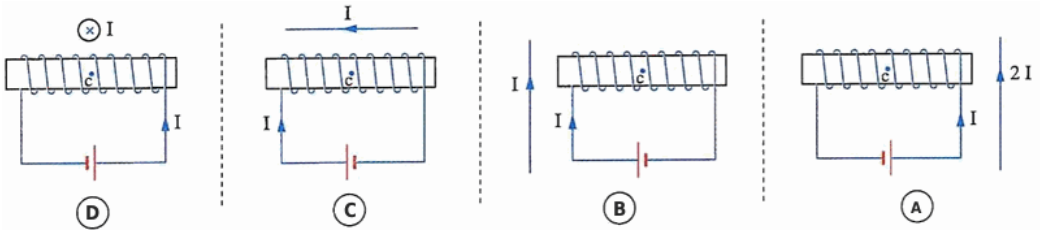
**102** A solenoid 50 cm long with 100 turns carries a current of 2 A. A circular coil is placed exactly at its middle so that the centre of the circular coil is on the axis of the solenoid and its plane is perpendicular to that axis. If the circular coil has 20 turns, carries a current of 1 A and has a radius of 15 cm, the flux density at the centre of the circular coil if the two currents are:
in the same direction, equals .....

(A) $3.32 \times 10^{-4}$ T (B) $4.19 \times 10^{-4}$ T (C) $5.87 \times 10^{-4}$ T (D) $6.93 \times 10^{-4}$ T

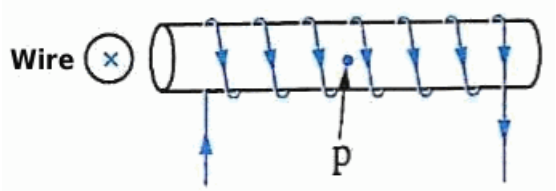
**103** A solenoid 50 cm long with 100 turns carries a current of 2 A. A circular coil is placed exactly at its middle so that the centre of the circular coil is on the axis of the solenoid and its plane is perpendicular to that axis. If the circular coil has 20 turns, carries a current of 1 A and has a radius of 15 cm, the flux density at the centre of the circular coil if the two currents are:
in opposite directions, equals .....

(A) $4.19 \times 10^{-4}$ T (B) $9.73 \times 10^{-3}$ T (C) $8.62 \times 10^{-4}$ T (D) $12.5 \times 10^{-4}$ T

**104** In which of the following figures is the resultant magnetic flux density at the middle of the solenoid (point c) in the plane of the page and to the left?

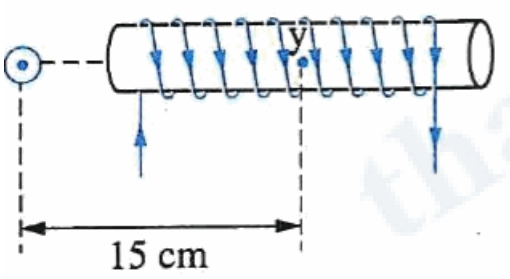


**105** In the figure shown, a solenoid carries a current that produces a flux density B at a point at the middle of its length on its axis (point p). Next to it, a straight wire perpendicular to the plane of the page carries a current that produces a flux density B at point p. The total flux density at point p is .....



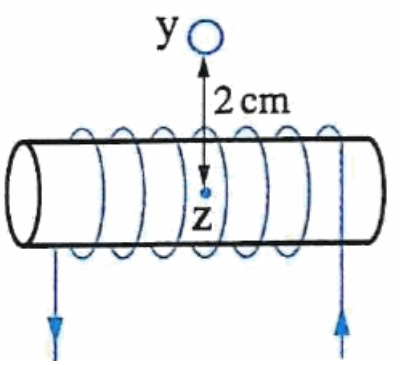

(A) zero (B) B (C) $\sqrt{(2)}$ B (D) 2 B

**106** A straight wire carrying a current of 15 A is placed perpendicular to the axis of a solenoid of 10 turns and length 15 cm that carries a current of $7/22$ A, as in the figure. The magnetic flux density at point y, at the middle of the coil on its axis and 15 cm from the wire, equals .....




(A) $11.5 \times 10^{-3}$ T (B) $3.34 \times 10^{-5}$ T (C) $5.67 \times 10^{-4}$ T (D) $9.7 \times 10^{-6}$ T

**107** A straight wire (y), perpendicular to the plane of the page, is 2 cm from the axis of a solenoid of 50 turns/m carrying a current of 1.4 A, as in the figure. For the resultant magnetic flux density at a point at the middle of the solenoid on its axis (point z) to be zero, the magnitude and direction of the current in the wire are .....




(A) 2.2 A, perpendicular to the page and inwards

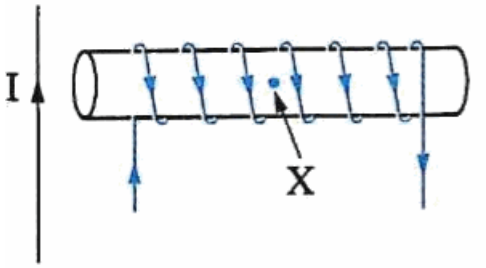
(B) 6.6 A, perpendicular to the page and inwards

(C) 8.8 A, perpendicular to the page and outwards

(D) 4.4 A, perpendicular to the page and outwards

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**108** In the figure shown, a solenoid carries a current that produces a flux density of $3 \times 10^{-6}$ T at the middle of the coil on its axis (point X). A straight wire in the plane of the page next to it carries a current that produces a flux density of $4 \times 10^{-6}$ T at point X. The total flux density at point X equals .....

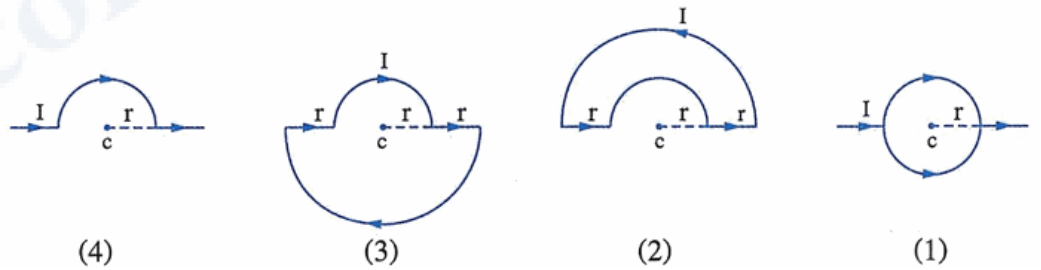



(A) $10^{-6}$ T (B) $5 \times 10^{-6}$ T (C) $7 \times 10^{-6}$ T (D) $12 \times 10^{-6}$ T

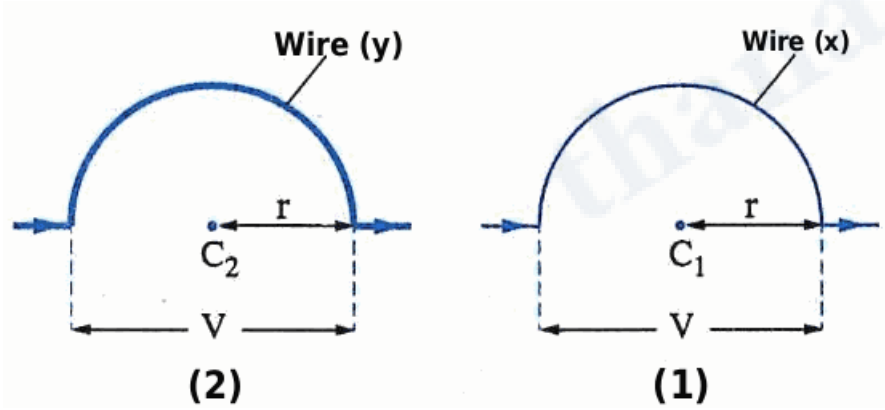
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## Essay questions — 20 questions

**1** Several wires are shaped as in the following figures and each carries an electric current. Arrange in ascending order the magnetic flux density B at the centre (c) in each figure.



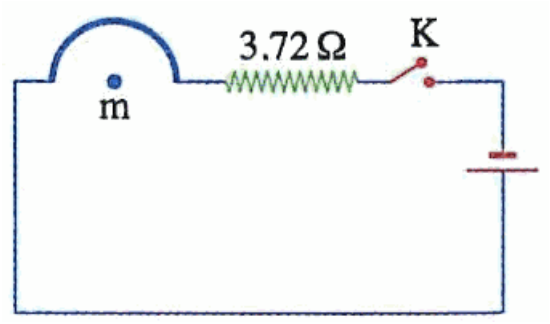

**2** Two straight wires x and y are made of the same material and have equal lengths; the cross-sectional area of wire x is half that of wire y. The two wires are shaped into half loops $(1)$ and $(2)$ respectively, and the potential difference across each is V as in the opposite figure. Calculate the ratio of the magnetic flux densities $B_x/B_y$ at the centres $C_1$ and $C_2$.



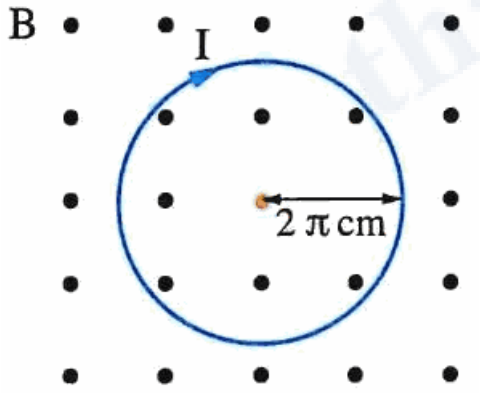

**3** An electric current flows in a circular coil of $N_1$ turns and produces a magnetic flux of density $B_1$ at its centre. If the coil is rewound into a circular coil of $N_2$ turns carrying the same current, the magnetic flux density at its centre becomes $B_2$. Prove that: $B_1/B_2 = (N_1/N_2)^2$

**4** A circular coil of radius $3.14\ cm$, with a resistance of $2\ \Omega$ per turn, has its ends connected to a DC source with a potential difference of $4\ V$ between its terminals. Calculate the magnetic flux density at the centre of the coil.

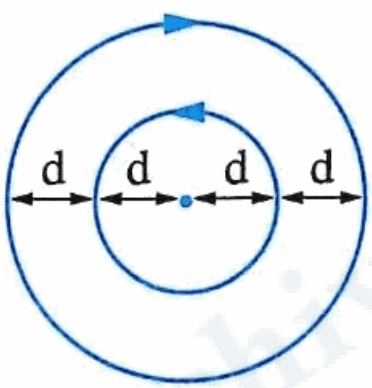
**5** In the opposite circuit, a wire of resistance R is shaped into a circular half loop of radius $3.14\ cm$, connected in series with a resistance of $3.72\ \Omega$, connecting wires of negligible resistance and a source of emf $24\ V$ and internal resistance $2\ \Omega$. After closing switch K, the magnetic flux density at the centre of the half loop m due to the current in it is $2.4\times10^{-5}\ T$. Calculate the resistance of the wire (R). (given: $\pi=3.14$)



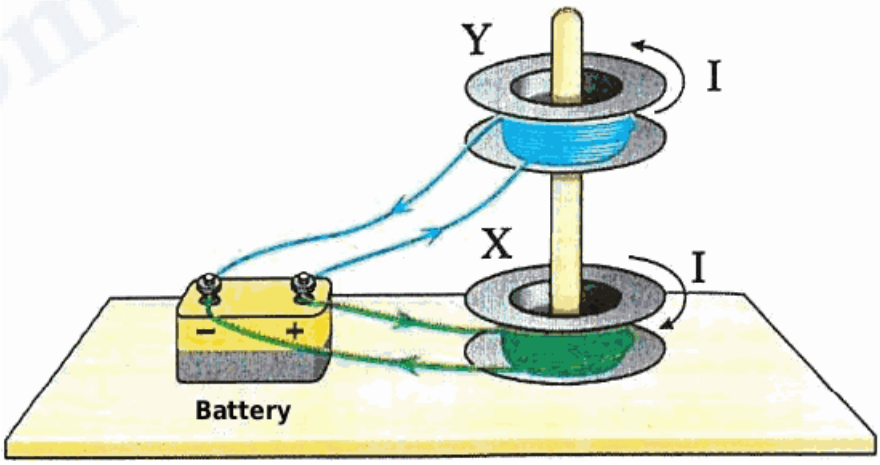

**6** An external magnetic field (B) of flux density $6\times10^{-5}\ T$ acts perpendicular to the plane of a metal loop of radius $2\pi\ cm$ carrying a current I in the direction shown in the opposite figure. If the resultant magnetic flux density at the centre of the loop is $4\times10^{-5}\ T$ in the direction of the external magnetic field B, calculate the current I.




**7** Two concentric circular copper loops in the same plane each carry a current (I) as in the figure. What change must be made to the current in the inner loop to make the common centre of the two loops a neutral point? Explain your answer.



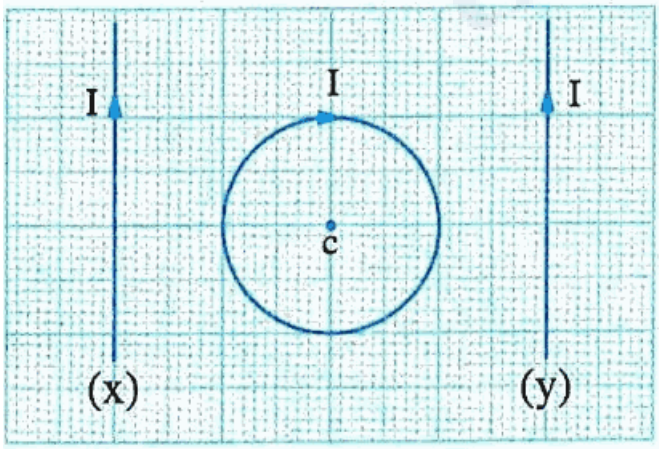
**8** Two identical circular coils X and Y: coil Y is placed freely above coil X, and each coil carries a current I whose direction in the upper face of the two coils is as shown in the figure. Explain why coil Y did not fall and stayed suspended.




**9** A metal loop carrying a current I has two straight wires in its plane, each carrying a current I, as in the opposite figure. Explain what happens to the magnitude of the resultant magnetic flux density at the centre of the loop (c) if the current is doubled in:

(1) wire x only.

(2) wire y only.

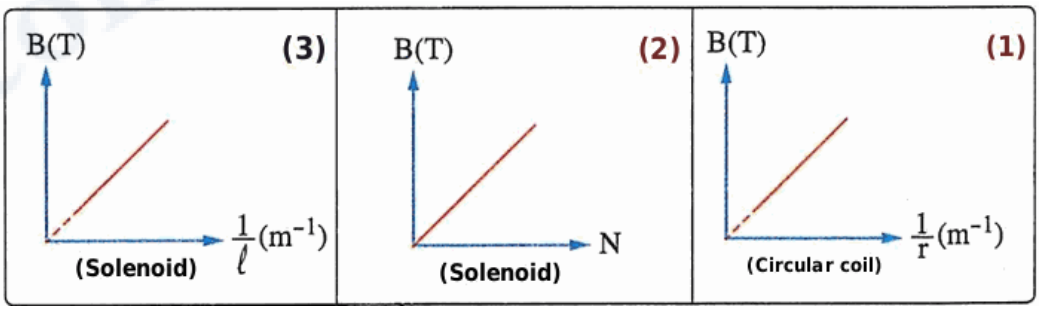



**10** A solenoid with a resistance R per turn and length $\ell$ has its ends connected to a DC source with a potential difference V between its terminals. Prove that the magnetic flux density at the middle of the coil on its axis is given by: $B = (\mu\ V)/(\ell\ R)$

**11** An air-core solenoid carries a direct current. State four suggestions, each of which alone increases the magnetic flux density at the middle of the coil on its axis.

**12** Write the mathematical relation shown by each graph and what the slope of the straight line equals in each of the following:

(where: (B) is the magnetic flux density, (r) the radius of the coil, (N) the number of turns of the coil, $(\ell)$ the length of the solenoid)




**13** A solenoid of resistance R with touching turns has its ends connected to a battery of negligible internal resistance. How is the magnetic flux density at a point at the middle of the coil on its axis affected by the following changes:

(1) spreading the turns of the coil apart uniformly?

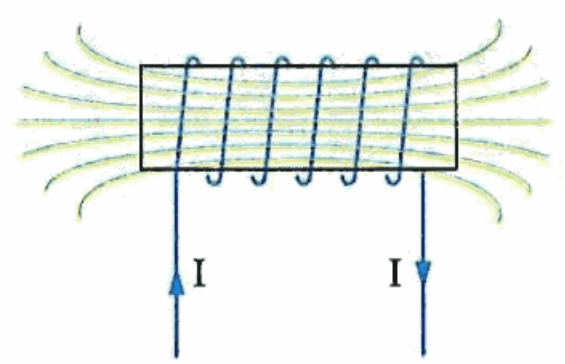
(2) reshaping the turns of the coil by doubling their diameter while keeping them touching?

(3) connecting an identical coil in series along the axis of the first coil so that they become one coil, keeping all the turns touching, and connecting the two free ends to the same battery?

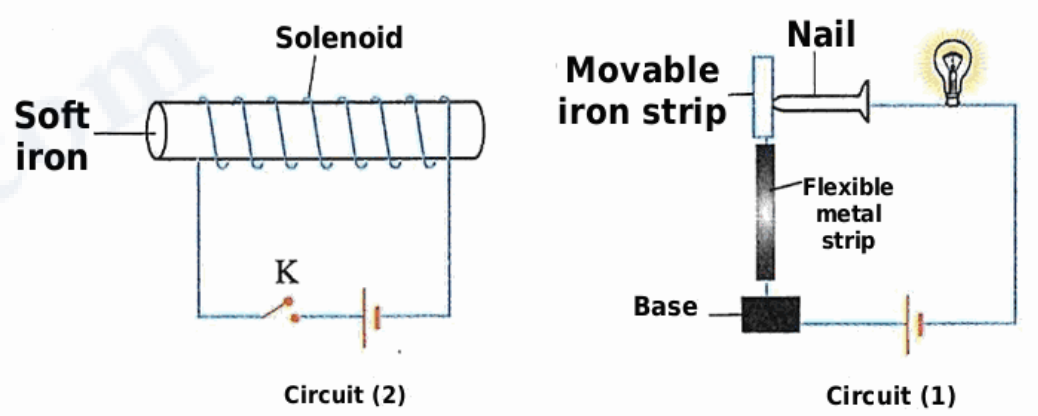
**14** The opposite figure shows the magnetic field produced by a current in a solenoid:

(1) Show with arrows on the figure the direction of the magnetic flux lines.

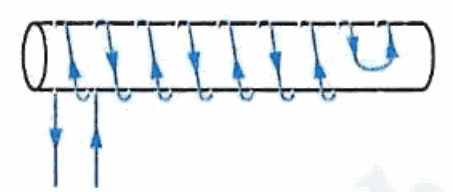
(2) Why is the magnetic flux density outside the ends of the coil less than the magnetic flux density at a point at the middle of the coil on its axis?



**15** In the opposite figure, explain why the lamp in circuit (1) goes out when switch K in circuit (2) is closed.




**16** In the opposite figure, a solenoid carrying a current is wound around an iron rod. Explain why the iron rod is not magnetised.

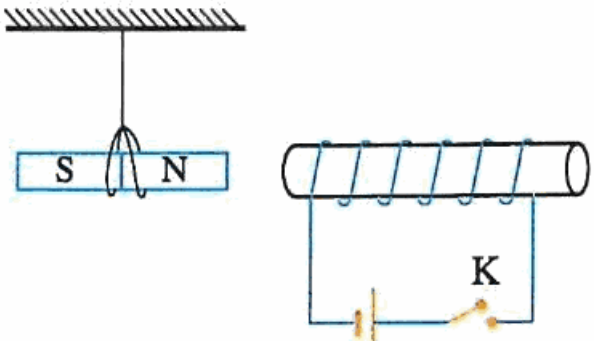


**17** In the opposite figure, a solenoid wound around a plastic cylinder is connected to an electric source and placed near a freely hanging magnet:

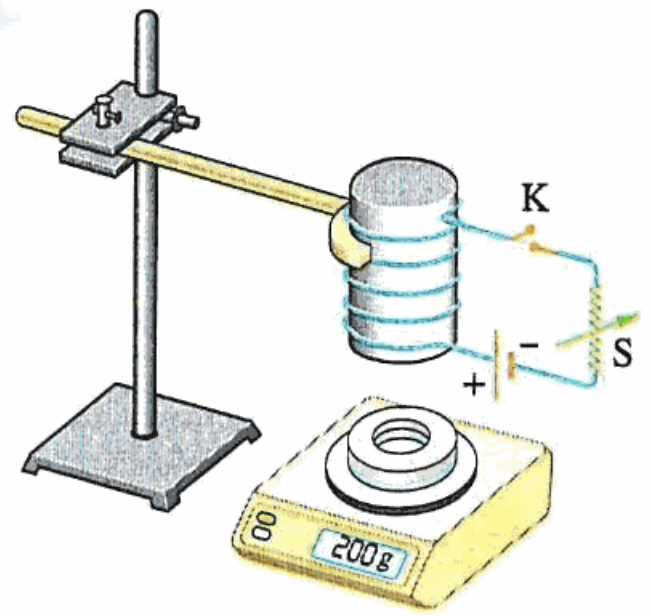
(1) What type of magnetic force acts on the N pole of the magnet when switch K is closed?

(2) What happens to the magnitude of the magnetic force when the plastic cylinder is replaced by one of soft iron and then the switch is closed?

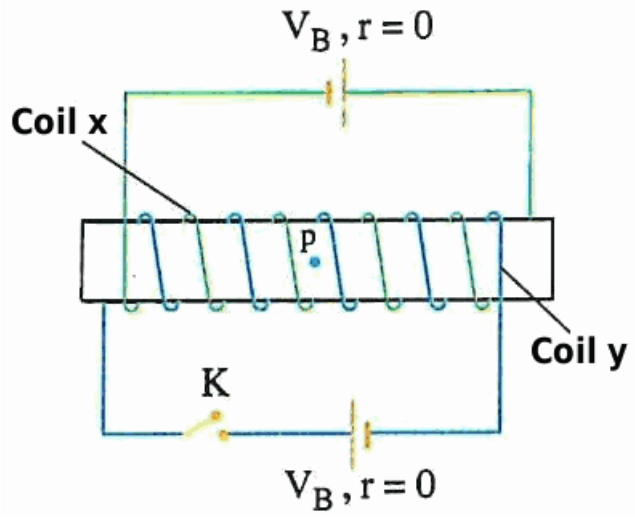
(3) What happens to the type of magnetic force between the coil and the magnet when the terminals of the source are reversed and then the switch is closed?



**18** In the opposite figure, a solenoid is connected to a switch (K), a rheostat (S) and a cell. The coil is fixed above the pan of a balance on which a short magnet is placed with its upper face a north pole. Explain, with reasons, what happens to the balance reading after closing switch (K).



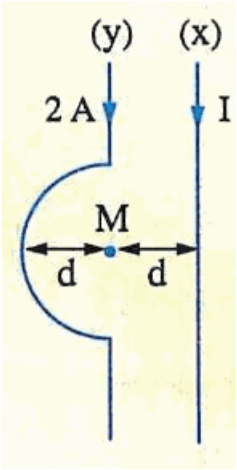

**19** In the opposite circuit, the two solenoids x and y are identical except that coil x is made of aluminium and coil y of copper. Given that the resistivity of aluminium is greater than that of copper, what happens, when switch K connected to coil y is closed, to the direction of the resultant magnetic flux density at a point at the middle of the two coils on their axis (point p)?




**20** A circular coil of diameter $12\ cm$ carries a current that produces a magnetic field at its centre. Its turns are spread apart uniformly along its axis to form a solenoid carrying the same current, and the magnetic flux density at a point inside it at the middle of its length on its axis becomes $1/4$ of the magnetic flux density at the centre of the circular coil. Calculate the length of the solenoid.

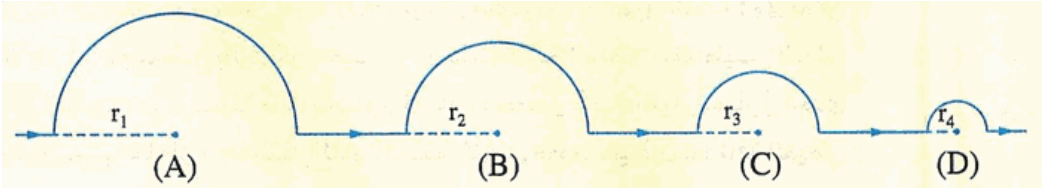
## Past exam questions — 43 questions

**1** The opposite figure shows two conductors (x) and (y). Conductor (x) carries a current I and conductor (y) carries a current of *2 A*. The current (I) that makes the magnetic flux density at point M zero is ..... (Trial exam / May 2021)




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

**2** The following figure shows a wire shaped into circular half loops joined together, with its ends connected to a cell. At the centre of which loop is the magnetic flux density the smallest? (Trial exam / May, June 2021)



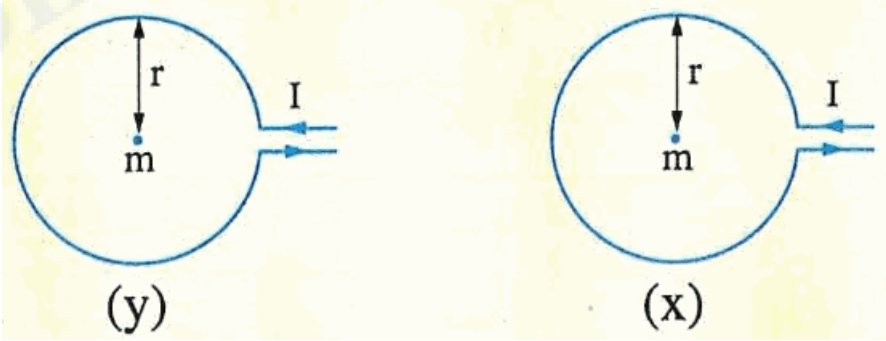

**3** A straight wire is shaped into a circular coil of N turns carrying a current I. If it is reshaped so that its number of turns becomes *N/4* with the same current, the magnetic flux density at the centre of the circular coil becomes ..... its original value. (Trial exam / June 2021)

(A) *1/16* (B) 16 times (C) 4 times (D) *1/4*

**4** A straight wire is made into a circular coil of (N) turns carrying a current (I), producing a magnetic flux of density (B) at the centre of the coil. If the same wire is reshaped into another circular coil of *2N/3* turns with the same current, the magnetic flux density at the centre of the coil becomes ..... (1st session 2021)

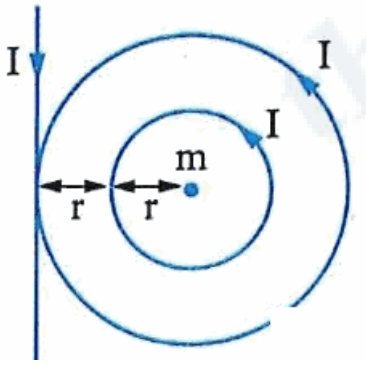
(A) *2/3B* (B) *2/9B* (C) *1/9B* (D) *4/9B*

**5** In the following figure, two circular coils (y) and (x) have the same diameter and each carries the same current (I). If coil (x) has twice as many turns as coil (y), which of the following relations correctly expresses the magnetic flux density (B) at the centre of each coil? (1st session 2021)




(A) $B_x = 2B_y$ (B) $B_x = B_y$ (C) $B_x = 1/2B_y$ (D) $B_x = 4B_y$

**6** Two circular loops with the same centre (m) and a straight wire all lie in the same plane, and each carries a current (I) as shown in the figure. The total magnetic flux density at the centre (m) due to the three currents equals ..... (1st session 2021)

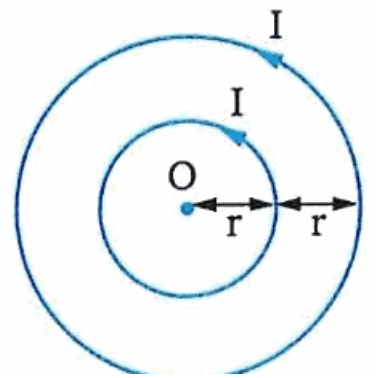



(A) $(0.83\mu\ I)/r$ (B) $(0.67\mu\ I)/r$ (C) $(0.54\mu\ I)/r$ (D) $(0.42\mu\ I)/r$

**7** A circular coil of N turns and radius r carries a current I, producing a magnetic flux of density $B_1$ at the centre. The coil is connected to another source, so a current three times the first flows and produces a magnetic flux of density $B_2$ at the centre. Then ..... (2nd session 2021)

(A) $B_2 = 3B_1$ (B) $B_2 = B_1$ (C) $B_2 = 1/3B_1$ (D) $B_2 = 3/2B_1$

**8** Two circular loops with the same centre (O) each carry a current I in the same direction as shown in the figure, so that the magnetic flux density due to the two currents at point (O) is B. If the current in one loop is reversed while the current in the other stays the same, the magnetic flux density at point (O) becomes ..... (2nd session 2021)

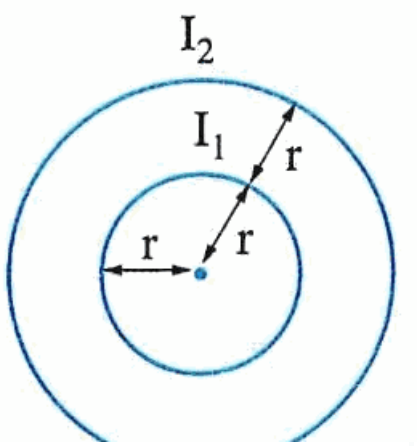



(A) $B/2$ (B) $B/4$ (C) $B/3$ (D) $B/5$

**9** A circular coil of N turns and radius r carries a current I, producing a magnetic flux of density B at the centre. A quarter of its turns are cut off and the same current flows in the coil, so the magnetic flux density at the centre of the coil in the second case equals ..... (1st session 2022)

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

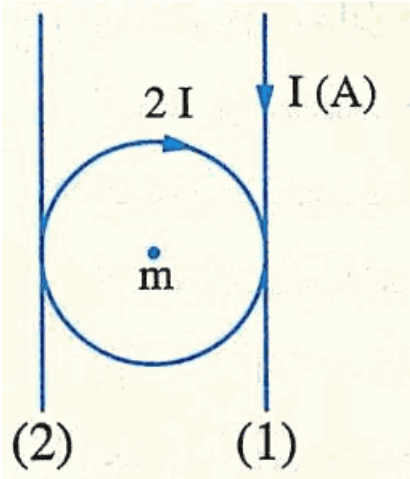
**10** Two circular coils with the same centre and the same number of turns but different radii carry currents $I_1$ and $I_2$ as shown in the figure. If the magnetic flux density due to the current of each coil at the common centre is (B), which of the following correctly expresses the relation between the values and directions of $I_1$ and $I_2$, and the resultant magnetic flux density due to them at the common centre $(B_t)$? (2nd session 2022)




(A) $I_1 = I_2$ in the same direction, $B_t = 2B$ (B) $I_2 = 2I_1$ in opposite directions, $B_t = 0$

(C) $I_2 = I_1$ in opposite directions, $B_t = 0$ (D) $I_2 = 1/2I_1$ in the same direction, $B_t = 2B$

**11** A metal loop carrying a current 2I produces a magnetic flux of density (B) at the centre of the loop (m). Then two straight wires (1) and (2) are placed touching the loop and in its plane as in the figure, and each carries a current. For the resultant magnetic flux density at point (m) to remain (B), the current in wire (2) must have a magnitude of ..... and a direction ..... (2nd session 2022)




(A) I, towards the top of the page
(B) I, towards the bottom of the page
(C) 2I, towards the bottom of the page
(D) 2I, towards the top of the page

**12** Using the data shown in figures (1) and (2), which of the following correctly expresses the relation between the resultant magnetic flux densities at points $C_1$ and $C_2$? (1st session 2023)

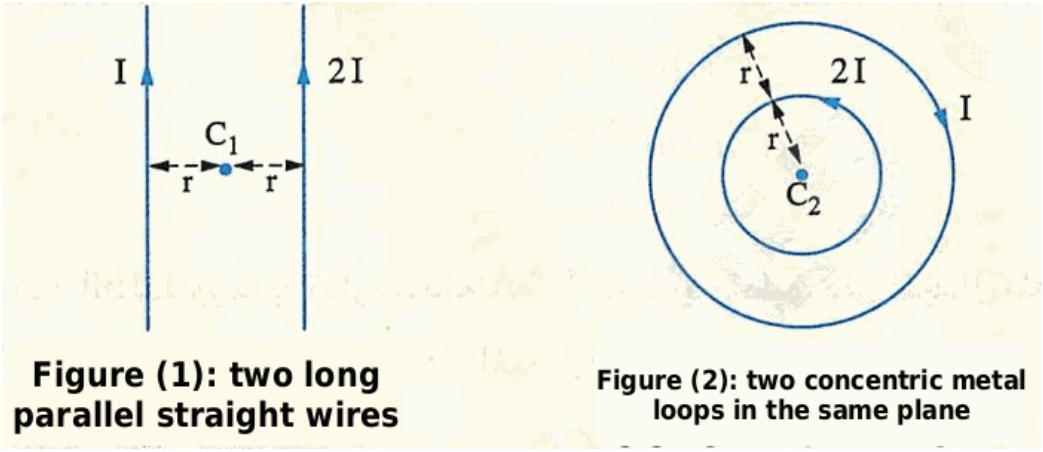
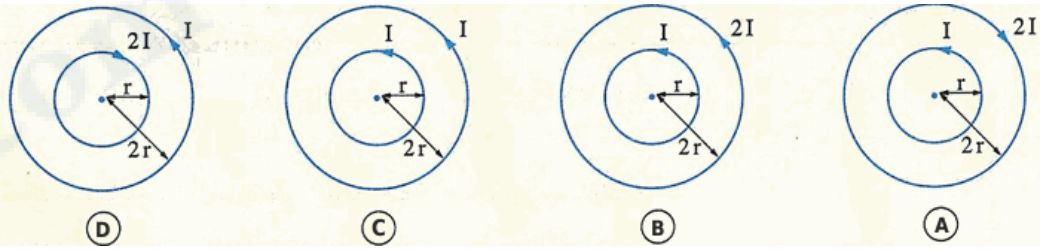



**Figure (1): two long parallel straight wires**

**Figure (2): two concentric metal loops in the same plane**

(A) $B_{C_1} = B_{C_2} = 0$
(B) $B_{C_1} > B_{C_2}$
(C) $B_{C_1} = B_{C_2} \neq 0$
(D) $B_{C_1} < B_{C_2}$

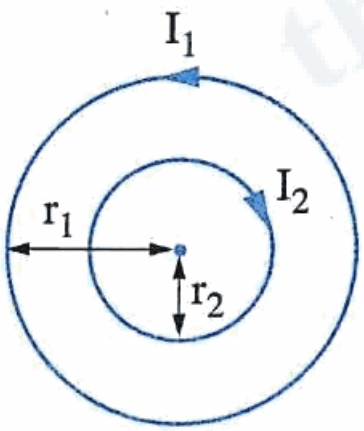
**13** Each of the following figures shows two concentric metal loops in the same plane carrying two currents. In which figure is the resultant magnetic flux density at the centre of the two loops the greatest? (2nd session 2023)




**14** A circular coil of 100 turns carries a current of $5\ A$. If the radius of the coil is $2\pi\ cm$, the magnetic flux density at the centre of the coil = ..... (2nd session 2024)

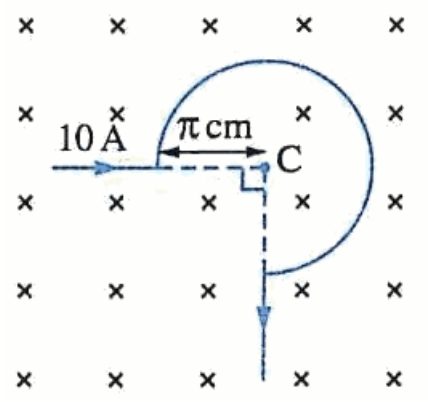
(A) $2\times10^{-3}\ T$ (B) $2\ T$ (C) $5\ T$ (D) $5\times10^{-3}\ T$

**15** In the opposite figure, two concentric circular coils lie in the plane of the page. The outer coil has a radius of $20\ cm$, 100 turns and carries a current of $4\ A$, and the inner coil has a radius of $10\ cm$, 50 turns and carries a current of $2\ A$. The resultant magnetic flux density at their common centre equals ..... (Sample exam 2025)




(A) $6.28\times10^{-4}\ T$ (B) $8.42\times10^{-4}\ T$ (C) $7.36\times10^{-5}\ T$ (D) $9.63\times10^{-5}\ T$

**16** A straight wire is shaped as in the opposite figure. The radius of the circular part is $\pi$ *cm* and a current of *10 A* flows in the wire. If the wire is placed in an external magnetic field perpendicular to its plane with a flux density of $1.5\times10^{-4}$ *T*, the resultant magnetic flux density at the centre (C) equals ..... (Sample exam 2025)

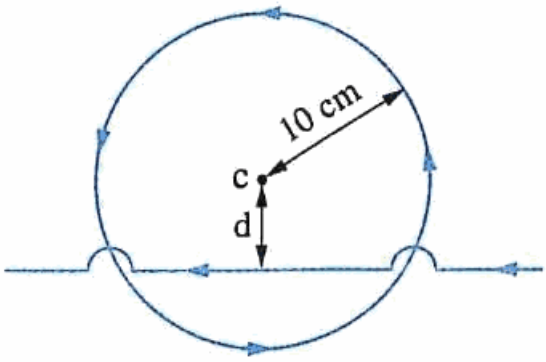



(A) 0 (B) $3\times10^{-4}$ *T* (C) $3.5\times10^{-4}$ *T* (D) $4.5\times10^{-4}$ *T*

**17** A circular coil of 50 turns carrying a current of *1.4 A* has its axis along the Earth's magnetic field, whose flux density is $5\times10^{-5}$ *T*. If the coil is turned over, the total magnetic flux density at the centre of the circular coil becomes twice what it was at first. The radius of the coil equals ..... (Sample exam 2025)
(given: the magnetic field due to the current in the circular coil is greater than the Earth's magnetic field, and the magnetic permeability $=12.56\times10^{-7}$ *Wb/A.m*)

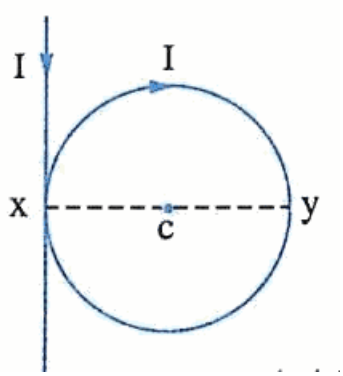
(A) *2.93 m* (B) *8.8 m* (C) *0.88 m* (D) *0.293 m*

**18** In the opposite figure, an insulated circular loop carries a current (I) and an insulated long straight wire carries a current (I), both in the same plane. If the resultant magnetic flux density at the centre of the loop (c) is zero, the distance (d) equals ..... (Sample exam 2025)




(A) *3.14 cm* (B) *6.28 cm* (C) *3.18 cm* (D) *5 cm*

**19** An insulated straight wire is placed touching a metal loop and in its plane. If the wire and the loop each carry a current (I) in the directions shown in the figure, the direction of the resultant magnetic flux density at the centre of the loop (c) is ..... (1st session 2025)




(A) perpendicular to the diameter (xy), in the plane of the loop

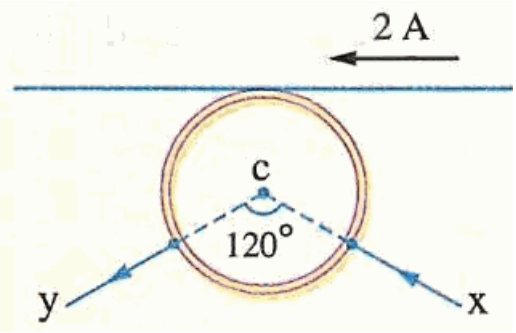
(B) perpendicular to the plane of the loop, into it

(C) along the diameter (xy)

(D) perpendicular to the plane of the loop, out of it

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**20** A metal loop of mean diameter $10\ cm$ and resistance (R) receives a current of $6\ A$ through two terminals (x) and (y). An insulated straight wire touches the loop, lies in its plane and carries a current of $2\ A$ as shown in the figure. What is the resultant magnetic flux density at the centre of the loop (c)? (1st session 2025)




(A) $4\times10^{-6}\ T$ (B) $8\times10^{-6}\ T$ (C) $1.6\times10^{-5}\ T$ (D) $3.2\times10^{-5}\ T$

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**21** A circular coil of insulated wire wound around a soft iron core carries an electric current. The magnetic flux density at the centre of the coil doubles when ..... (2nd session 2025)

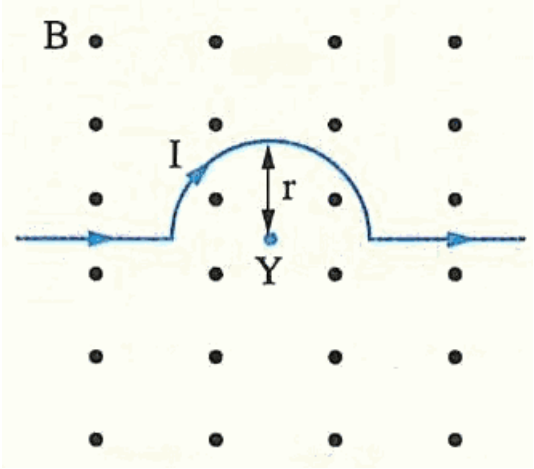
(A) the number of turns of the coil is halved

(B) the radius of the coil is doubled

(C) the current in the coil is doubled

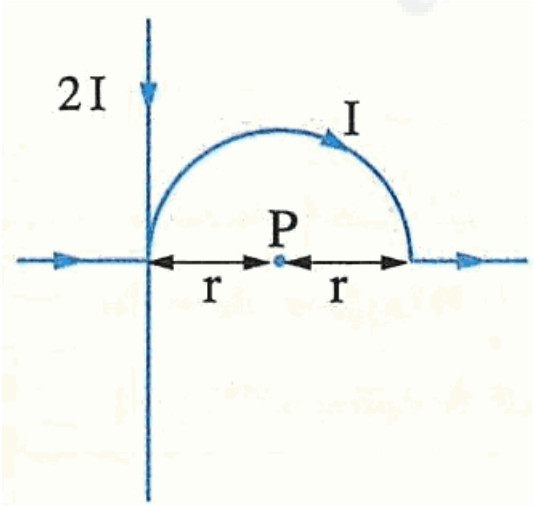
(D) the iron core is removed from the coil

**22** In the figure shown, a half loop carries a current (I) and is placed in a uniform external magnetic field of flux density (B) directed perpendicular to the page and outwards. If the resultant magnetic flux density at point (Y) is perpendicular to the page and outwards, which of the following relations is correct? (Sample exam 2026)



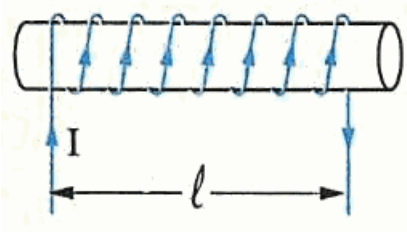

(A) $B < (\mu I)/8r$ (B) $B = (\mu I)/8r$ (C) $B < (\mu I)/4r$ (D) $B > (\mu I)/4r$

**23** The figure shows an insulated long straight wire placed touching a metal half loop, and each carries a direct current. The direction of the resultant magnetic field due to the two currents at point (P) is ..... (Sample exam 2026)




(A) perpendicular to the page, inwards
(B) perpendicular to the page, outwards
(C) parallel to the page, to the right
(D) parallel to the page, to the left

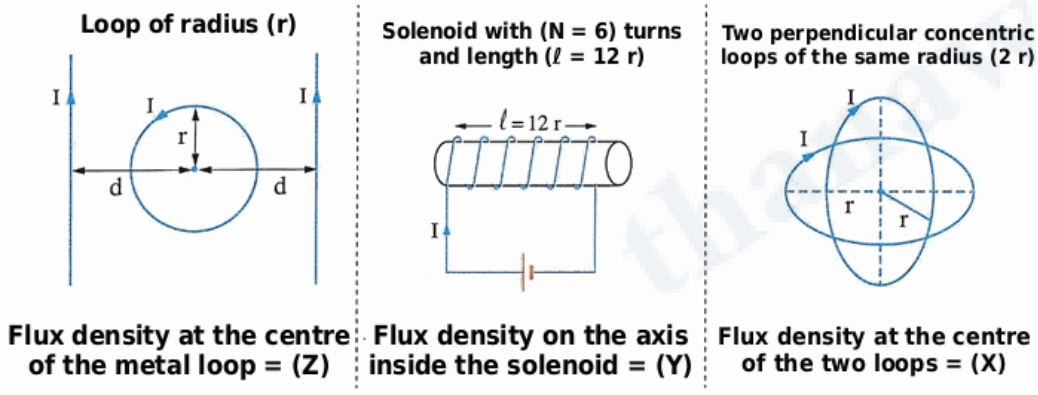
**24** The figure shows a solenoid carrying a current I, of length $\ell$, turn area A and N turns. If its turns are spread apart until its length becomes $3\ell$, the magnetic flux density at any point inside it on its axis ..... (Trial exam / May 2021)




(A) drops to $1/3$ of its original value
(B) drops to $1/6$ of its original value
(C) drops to $1/9$ of its original value
(D) drops to $1/12$ of its original value

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**25** You have several conductors, each carrying a current (I), as in the following figures. Which of the following relations is correct? (1st session 2022)




(A) $Z > Y$
(B) $X = Z$
(C) $Y < X$
(D) $X = Y$

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**26** A solenoid $20\ cm$ long has 100 turns, each of radius $0.1\ m$, and carries a current of $4.9\ A$; the permeability of the medium inside it is $88/7 \times 10^{-7}\ Wb/A.m$. The magnetic flux through a cross-section of the coil at its middle is ..... (given: $\pi = 22/7$) (Trial exam 2023)

(A) $6.166 \times 10^{-6}\ Wb$
(B) $30.8 \times 10^{-4}\ Wb$
(C) $6.166 \times 10^{-3}\ Wb$
(D) $9.68 \times 10^{-5}\ Wb$

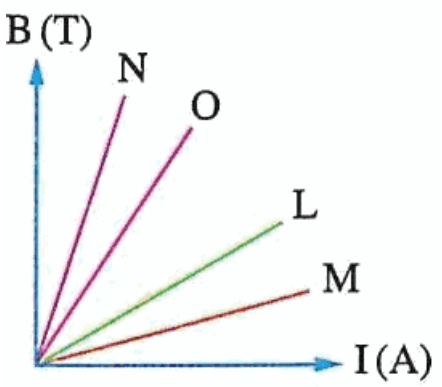
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**27** A solenoid of insulated copper wire carries a current (I), and the magnetic flux density at the middle of its length on its axis is (B). When its turns are spread apart uniformly, the magnetic flux density at the middle of its length on its axis becomes $(1/4B)$. If the flux density is brought back to its first value (B) by increasing the current in the coil by $3\ A$, the current (I) equals ..... (Trial exam 2023)

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

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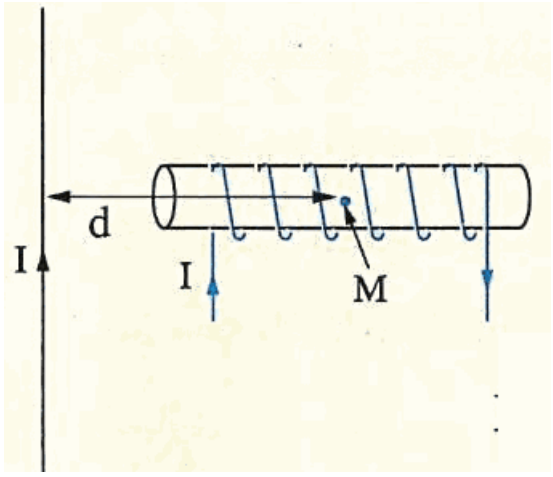
**28** The graph shows the relation between the magnetic flux density (B) at the middle of the axis of each of several solenoids (L, M, N, O) and the current (I) in each. If the coils have the same number of turns and the same permeability of the medium, the shortest coil is coil ..... (1st session 2023)




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

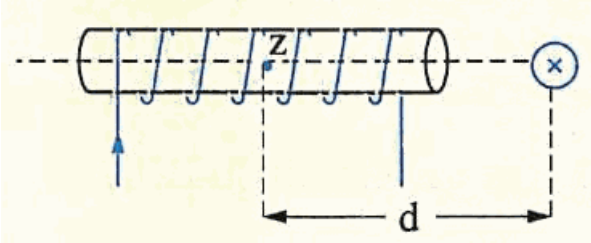
**29** In the opposite figure, a solenoid of length $\ell$ and N turns carries a current I. In front of it, a long straight wire carrying a current I is placed perpendicular to the axis of the solenoid. The resultant magnetic flux density due to the two currents at point (M) is ..... (1st session 2024)

(where $B_s$ is for the solenoid and $B_w$ for the wire)



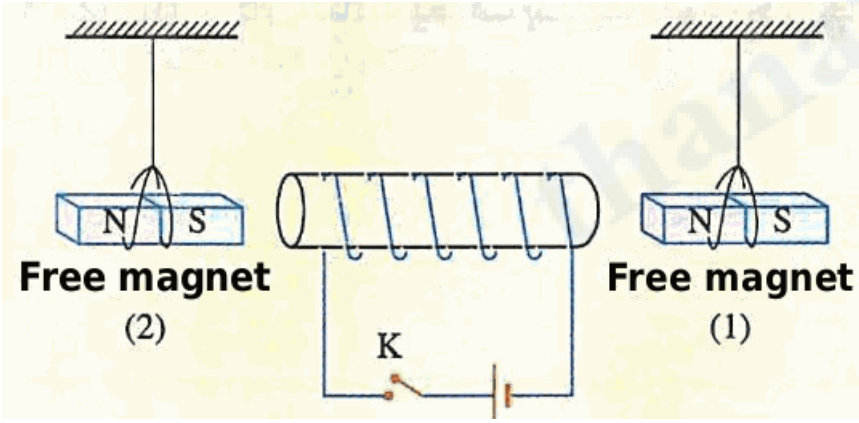

(A) $\sqrt{(B_s^2 - B_w^2)}$ (B) $B_s^2 - B_w^2$ (C) $\sqrt{(B_w^2 + B_s^2)}$ (D) $B_w^2 + B_s^2$

**30** The opposite figure shows a solenoid and a straight wire, each carrying a current; the wire is at a distance d from point z at the middle of the coil. The magnetic flux densities due to the coil's current alone and the wire's current alone at point z are B and $4/3B$ respectively, and the resultant magnetic flux density at point z due to both is $B_1$. If the distance between the wire and point z is increased to 2d, the resultant magnetic flux density at point z becomes $B_2$. Then ..... (1st session 2024)




(A) $B_2 = 1.4B_1$ (B) $B_2 = 0.72B_1$ (C) $B_2 = 1.6B_1$ (D) $B_2 = 0.5B_1$

**31** What happens when switch K in the figure shown is closed? (1st session 2024)




(A) Magnet (2) moves towards the coil while magnet (1) moves away from the coil

(B) Both magnets (1) and (2) move towards the coil

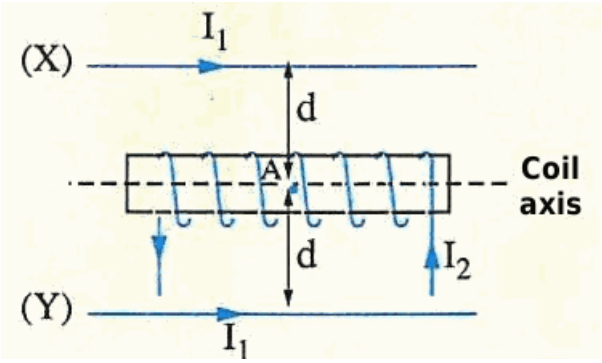
(C) Magnet (1) moves towards the coil while magnet (2) moves away from the coil

(D) Both magnets (1) and (2) move away from the coil

**32** A solenoid of 14 turns and length $22\ cm$ carries a current of $2\ A$. The magnetic flux density at a point on its axis at the middle of the coil = ..... $(\mu = 88/7 \times 10^{-7}\ T.m/A)$ (2nd session 2024)

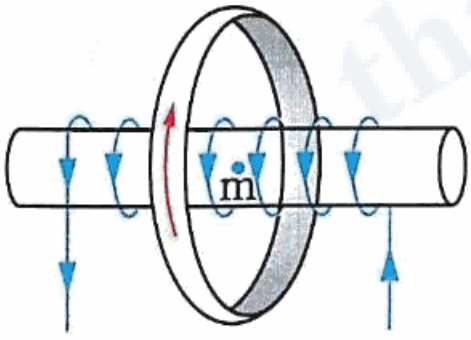
(A) $16 \times 10^{-7}\ T$ (B) $1.6 \times 10^{-4}\ T$ (C) $8 \times 10^{-4}\ T$ (D) $8 \times 10^{-7}\ T$

**33** In the opposite figure, if the magnetic flux density due to each of wire (X), wire (Y) and the solenoid alone at point (A) is (B), which of the following is the resultant magnetic flux density at the same point when the current in one of the wires is reversed? (2nd session 2024)



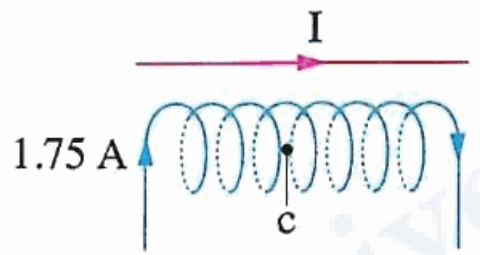

(A) $\sqrt{(3)}B$ (B) 5B (C) $\sqrt{(5)}B$ (D) 3B

**34** In the opposite figure, a long solenoid with 5 turns/cm of its length has a circular coil of radius $(\pi)/5\ cm$ and 10 turns wound around its middle so that the axes of the two coils coincide. If a current of $4\ A$ flows in each coil, the resultant magnetic flux density at the common centre of the two coils (m) equals ..... (Sample exam 2025)



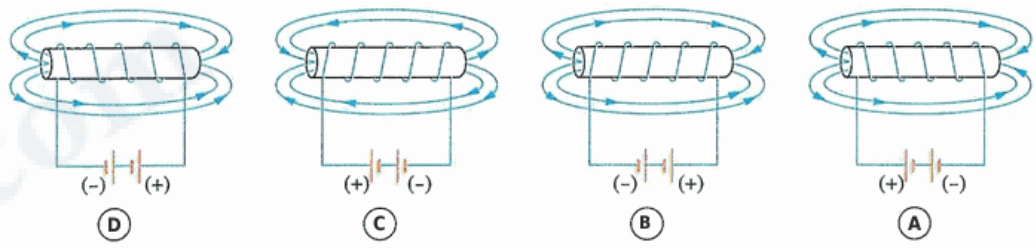

(A) $4\times10^{-3}\ T$ (B) $2.5\times10^{-3}\ T$ (C) $1.5\times10^{-3}\ T$ (D) $6.5\times10^{-3}\ T$

**35** In the opposite figure, a solenoid with 300 turns/m carries a current of $1.75\ A$, and a straight wire parallel to the axis of the solenoid is placed next to it. If the magnetic flux density due to the current in the straight wire at point (c), at the middle of the solenoid, is $2.33\times10^{-4}\ T$, the resultant magnetic flux density at point (c) is approximately ..... (Sample exam 2025)

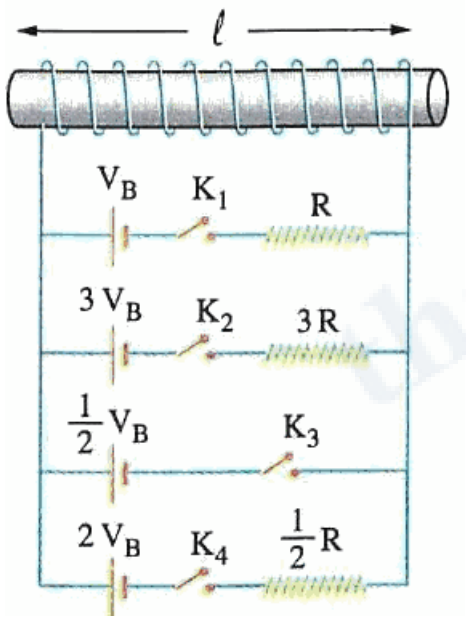



(A) $4.27\times10^{-4}\ T$ (B) $6.44\times10^{-4}\ T$ (C) $7\times10^{-4}\ T$ (D) $8.93\times10^{-4}\ T$

**36** Which of the following figures correctly describes the direction of the magnetic field produced by a current in a solenoid? (Sample exam 2025)

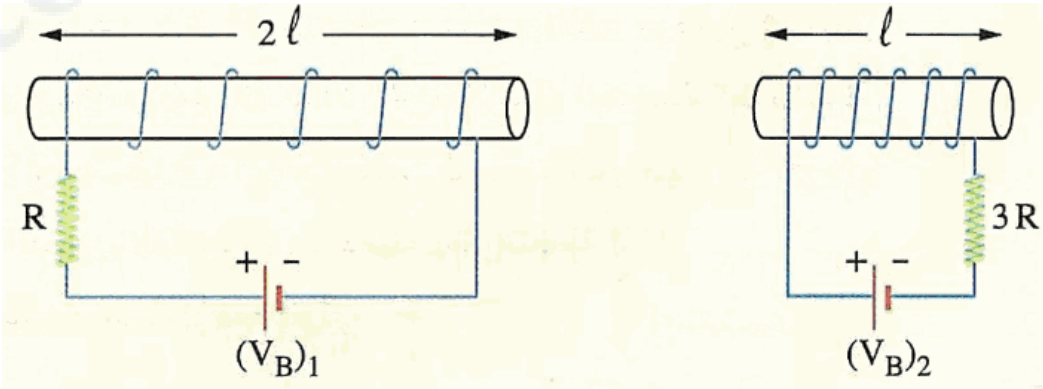



**37** A solenoid of resistance $0.5R$ is part of an electric circuit as shown in the opposite figure. The magnetic flux density at the middle of the coil on its axis is greatest after closing switch ..... only. (Sample exam 2025)




(A) $K_1$ (B) $K_2$ (C) $K_3$ (D) $K_4$

**38** The figure shows two insulated solenoids of negligible resistance with the same number of turns, each wound around a metal core of the same type and connected to a source of negligible internal resistance and a resistor. If the magnetic flux densities at the middle of each coil on its axis are equal, and the length of each coil is very large compared with its diameter, the ratio of the emfs of the two sources $((V_B)_1)/((V_B)_2)$ = ..... (Sample exam 2025)




(A) 2/3 (B) 1/12 (C) 1/4 (D) 1/2

**39** You have a solenoid of length $(\ell)$ with its turns uniformly distributed along its length, and its ends connected to the terminals of a battery $(V_B)$ of negligible internal resistance. When half of the coil is cut off and the rest is connected to the same battery, which of the following physical quantities is halved? (1st session 2025)

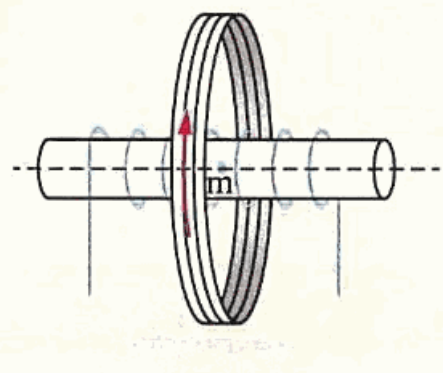
(A) The number of turns per unit length of the coil

(B) The ohmic resistance of the coil

(C) The current in the coil

(D) The magnetic flux density at the middle of the coil

**40** A circular coil of radius *10 cm* and 14 turns is wound around the middle of an insulated solenoid of 28 turns uniformly distributed over *10 cm*. The axis of the solenoid is perpendicular to the plane of the circular coil and passes through its centre. The circular coil carries a current of *2 A* in the direction shown in the figure. What are the magnitude and direction of the current in the solenoid that make the magnetic flux density at the centre of the circular coil zero? (2nd session 2025)




(A) *2 A*, opposite to the current in the circular coil

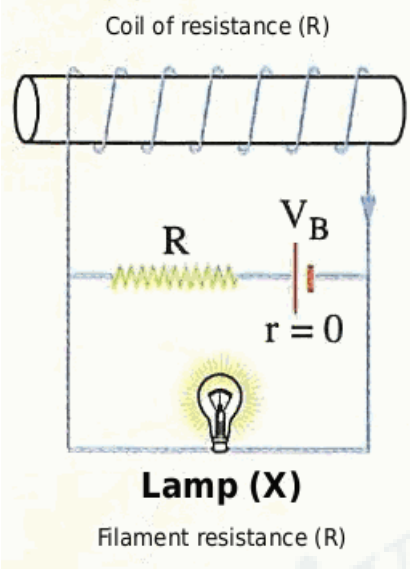
(B) *0.5 A*, in the same direction as the current in the circular coil

(C) *2 A*, in the same direction as the current in the circular coil

(D) *0.5 A*, opposite to the current in the circular coil

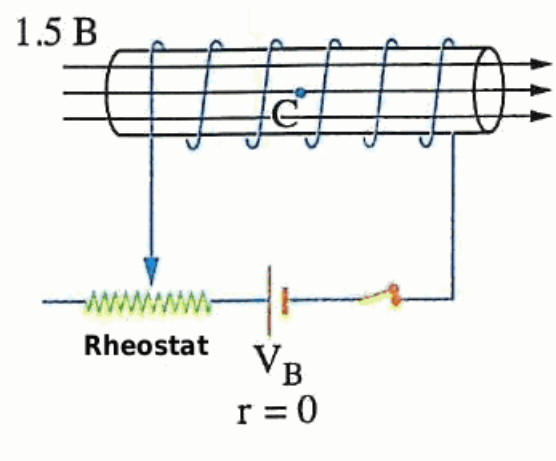
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**41** The figure shows a battery of negligible internal resistance connected to a resistor (R), a solenoid of ohmic resistance (R) and a lamp (X) whose filament has a resistance (R). If the filament of lamp (X) burns out, the magnetic flux density at the middle of the solenoid ..... (Sample exam 2026)



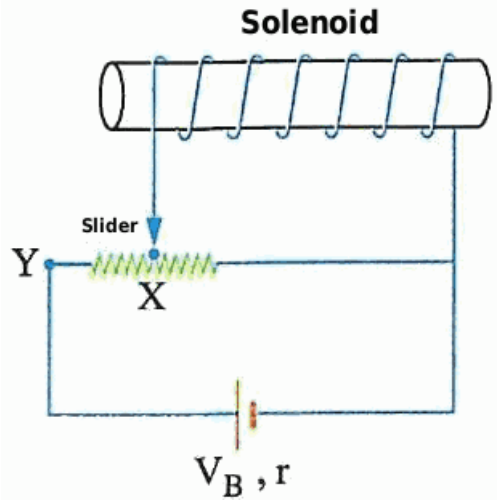

(A) decreases (B) increases (C) becomes zero (D) does not change

**42** A solenoid connected to a battery of emf $(V_B)$ with negligible internal resistance and a rheostat carries a current that produces a magnetic field of flux density (B) at the middle of the coil on its axis. The coil is placed in an external magnetic field of flux density (1.5B) directed to the right of the page as in the opposite figure. When the resistance taken from the rheostat is increased by one third of its first value, the resultant magnetic flux density at point (C) ..... (neglecting the resistance of the solenoid wire) (Sample exam 2026)




(A) increases (B) decreases (C) stays the same (D) becomes zero

**43** A solenoid is connected to a battery of emf $(V_B)$ and internal resistance (r) and a rheostat as in the opposite figure. When the slider is moved from position (X) to position (Y), the magnetic flux density at a point at the middle of the solenoid ..... (Sample exam 2026)




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

# Answer key and solutions

## Multiple choice questions

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

**1** **Answer (D)**

We find the field direction with the right-hand rule for a coil: fingers with the current, thumb with the field.

In figure (D) the current is clockwise as seen from above, so the field inside the loop points down.

The lines leave one face of the loop and enter the other as closed curves, not straight uniform lines as in (A) and (C).

Figure (B) has the same current direction but its lines point up, so it is wrong.

**2** **Answer (C)**

The current goes up on the $-y$ side, then towards $+y$ at the top.

Seen from the $+x$ side it is clockwise, so the field points away from the viewer.

That is the negative $x$ direction.

**3** **Answer (C)**

$B = (\mu_0 I)/2r = (4\pi \times 10^{-7} \times 5)/(2 \times 0.1) = \pi \times 10^{-5} = 3.14 \times 10^{-5}\ T$

The current is clockwise, so the field is perpendicular to the page and inwards.

**4** **Answer (C)**

$I = 2rB/(\mu_0) = (2 \times 4\pi \times 10^{-2} \times 5 \times 10^{-5})/(4\pi \times 10^{-7}) = 10\ A$

**5** **Answer (A)**

$B = (\mu_0 N I)/2r$, so the field is directly proportional to $I$ and inversely proportional to $r$.

Doubling the current doubles the field and doubling the diameter halves it, so the field stays $B$.

**6** **Answer (A)**

$B_x = B_y \Rightarrow I/d_x = 2I/d_y$

$d_x/d_y = 1/2$

**7** **Answer (D)**

$B \propto 1/r$ when $N$ and $I$ are constant, so the graph is a curve where $B$ decreases as $r$ increases.

**8** **Answer (D)**

From the graph: $B/I = (8.8 \times 10^{-3})/8 = 1.1 \times 10^{-3}$

$B/I = (\mu_0 N)/2r \Rightarrow r = (4\pi \times 10^{-7} \times 350)/(2 \times 1.1 \times 10^{-3}) = 0.2\ m$

Diameter $= 2r = 40\ cm$

**9** **Answer (B)**

$B = (\mu_0 N I)/2 \times 1/r$, so the slope of the straight line is proportional to the current.

Slopes: $x > y > z$, so $I_x > I_y > I_z$

**10** **Answer (C)**

The ends of the group ($R$ with $K_1$, and $K_2$) are joined to the ends of the coil, so it is in parallel with the coil.

Closing $K_2$ alone short-circuits the coil, so its current drops to zero.

Closing $K_1$ alone puts a resistance in parallel with the coil, so the coil current decreases: $V/3R$ instead of $V/2R$

Closing $K_3$ adds a branch in parallel with $R$, so the total resistance outside the coil decreases and the coil's voltage and current increase: $2V/3R$

**11** **Answer (D)**

$B = (\mu_0 N I)/2r$ , $I = V_B/R$ , $R = (\rho (2\pi r N))/A$

Substituting, $N$ cancels: $B = (\mu_0 V_B A)/(4\pi r^2 \rho)$

$V_B = (B\, 4\pi r^2 \rho)/(\mu_0 A) = (0.01 \times 4\pi \times 10^{-2} \times 10^{-6})/(4\pi \times 10^{-7} \times 0.4 \times 10^{-4}) = 25\ V$

**12** **Answer (A)**

Cutting off half the turns halves the resistance: $R' = R/2$, so the current becomes $I' = 2I$

$B' = (\mu_0 (N/2)(2I))/2r = B$, so the flux density stays the same.

**13** **Answer (C)**

$R = (\rho L)/A = (1.79 \times 10^{-8} \times 50.24)/(1.79 \times 10^{-7}) = 5.024\ \Omega$

$I = V/(R + r) = 12/(5.024 + 1) \approx 2\ A$

$N = L/(2\pi r) = 50.24/(2 \times 3.14 \times 0.04) = 200$

$B = (\mu_0 N I)/2r = (4\pi \times 10^{-7} \times 200 \times 2)/(2 \times 0.04) \approx 6.25 \times 10^{-3}\ T$

**14** **Answer (D)**

$N = (\ell)/(2\pi r)$ , $A = \pi r^2 \Rightarrow r = \sqrt{(A/(\pi))}$

$B = (\mu I N)/2r = (\mu I \ell)/(4\pi r^2) = 1/4(\mu I \ell)/A$

**15** **Answer (B)**

$A = \pi r^2 \Rightarrow r^2 = (3.14 \times 10^{-4})/3.14 = 10^{-4} \Rightarrow r = 0.01\ m$

$N = L/(2\pi r) = 31.4/(2 \times 3.14 \times 0.01) = 500$

$B = (\mu_0 N I)/2r = (4\pi \times 10^{-7} \times 500 \times 1)/(2 \times 0.01) = 3.14 \times 10^{-2}\ T$

**16** **Answer (B)**

Straight wire: $B = (\mu_0 I)/(2\pi d) = (2 \times 10^{-7} \times 5)/0.05 = 2 \times 10^{-5}\ T$

Number of turns of the coil: $N = 1.2/(2\pi \times 0.0955) = 2$

$B_{coil} = (\mu_0 N I)/2r = (4\pi \times 10^{-7} \times 2 \times 5)/(2 \times 0.0955) = 6.6 \times 10^{-5}\ T$

Greater than $B$ by $6.6 \times 10^{-5} - 2 \times 10^{-5} = 4.6 \times 10^{-5}\ T$

**17** **Answer (D)**

Point $m$ lies on the line of the straight parts, so they give no field there.

The quarter circle has its centre at $m$: $B = 1/4 \times (\mu I)/2r = (\mu I)/8r$

**18** **Answer (C)**

The two straight parts lie on the diameter of the semicircle through $X$, so they give no field.

$B = 1/2 \times (\mu_0 I)/2r = (4\pi \times 10^{-7} \times 10)/(4 \times 0.2) = 1.57 \times 10^{-5}\ T$

**19** **Answer (D)**

The two straight parts are in line with point $P$, so they have no effect, and the arc is $3/4$ of a circle.

$B = 3/4 \times (\mu_0 I)/2r = 3/4 \times (4\pi \times 10^{-7} \times 40)/(2 \times 0.02) \approx 9.43 \times 10^{-4}\ T$

**20** **Answer (B)**

The current goes round the arc from the right, up, then to the left, i.e. anticlockwise.

Right-hand rule: the field at the centre is perpendicular to the page and outwards.

**21** **Answer (D)**

The arc is the fraction $(\theta)/360$ of the circle.

$B = (\theta)/360 \times (\mu I)/2r = (\mu I\theta)/(720\ r)$

**22** **Answer (B)**

The arc is $L/(2\pi\ r)$ of the circle: $B = L/(2\pi\ r) \times (\mu_0 I)/2r = (\mu_0 I L)/(4\pi\ r^2)$

$I = (4\pi\ r^2 B)/(\mu_0 L) = (4\pi \times (0.056)^2 \times 8.25 \times 10^{-6})/(4\pi \times 10^{-7} \times 0.264) \approx 0.98\ A$

**23** **Answer (D)**

$I = V/R$ and $R = (\rho L)/A \propto r$ for constant $V$ and $A$, so $I \propto 1/r$

$B = (\mu I)/4r \propto I \times 1/r \propto 1/(r^2)$

The radius in $(2)$ is half the radius in $(1)$, so $B_2 = 4B$

**24** **Answer (C)**

(A) $B = (\mu I)/2r$ , (B) $B = (\mu (2I))/(2 (2r)) = (\mu I)/2r$

(C) semicircle: $B = 1/2 \times (\mu (2I))/(2 (r/2)) = (\mu I)/r$

(D) quarter circle: $B = 1/4 \times (\mu (5I))/2r = (5\mu I)/8r$

The greatest is (C): a large fraction of a circle with a larger current on a smaller radius.

**25** **Answer (A)**

Field of the coil: $B_c = (\mu_0 N I)/2r = (4\pi \times 10^{-7} \times 14 \times 12)/(2 \times 0.08) \approx 1.32 \times 10^{-3}\ T$

The current is clockwise, so the coil's field is inwards, in the same direction as the external field, so they add.

$B = 1.32 \times 10^{-3} + 10^{-5} \approx 1.33 \times 10^{-3}\ T$ perpendicular to the page and inwards

**26** **Answer (C)**

In the first position the coil's field is perpendicular to the external field: $\sqrt{(B^2 + B_c^2)} = \sqrt{(5)}B \Rightarrow B_c = 2B$

After rotating $90^\circ$ the coil's field becomes parallel to the external field, so the resultant is $B + 2B = 3B$ or $2B - B = B$ depending on the current direction.

**27** **Answer (C)**

The two straight parts are in line with point $P$, so they give no field.

Quarter circle: $B_1 = 1/4 \times (4\pi \times 10^{-7} \times 10)/(2 \times \pi \times 10^{-2}) = 5 \times 10^{-5}$ T inwards (clockwise)

The external field $6 \times 10^{-6}$ is outwards, so we subtract: $B = 5 \times 10^{-5} - 0.6 \times 10^{-5} = 4.4 \times 10^{-5}$ T

**28** **Answer (A)**

Each half loop gives at the centre: $B_1 = (\mu_0 I)/4r = (4\pi \times 10^{-7} \times 10)/(4 \times 0.05) = 6.28 \times 10^{-5}$ T

The two halves are perpendicular, so their fields are perpendicular: $B = \sqrt{(2)}\, B_1 \approx 8.9 \times 10^{-5}$ T

**29** **Answer (B)**

The two halves are equal: each has a resistance of $48/2 = 24\ \Omega$ and they are in parallel between $A$ and $B$, so each has $6$ V across it.

$I = V/R = 6/24 = 0.25$ A

**30** **Answer (A)**

The currents in the two halves are equal because their resistances are equal.

One current is clockwise and the other anticlockwise about the centre, so the two fields are equal and opposite; the connecting wires are in line with the centre, so they have no effect.

The resultant is zero.

**31** **Answer (D)**

Points $a$ and $b$ are a quarter circle apart, so the short arc has resistance $R/4$ and the long arc $3R/4$, so $I_1 = 3I/4$ and $I_2 = I/4$

$B_1 = 1/4 \times (\mu\ (3I/4))/2r$ and $B_2 = 3/4 \times (\mu\ (I/4))/2r$, which are equal.

The current flows in the two arcs in opposite directions about the centre, so the resultant is zero.

**32** **Answer (C)**

Length $L_y = 1/4L$ and length $L_x = 3/4L$, and the area of $x$ is twice that of $y$: $R = (\rho L)/A$

$R_x = (3/4)/2 = 3/8$ and $R_y = 1/4$ (in units of $(\rho L)/A_y$), so $R_x : R_y = 3 : 2$

The current divides inversely with resistance: $I_x = 2\ A$ and $I_y = 3\ A$

$B_x = 3/4 \times (\mu\ (2))/2r = 9.42 \times 10^{-6}$ and $B_y = 1/4 \times (\mu\ (3))/2r = 4.71 \times 10^{-6}$, in opposite directions

$B = 9.42 \times 10^{-6} - 4.71 \times 10^{-6} = 4.71 \times 10^{-6}\ T$

**33** **Answer (B)**

The wires going in and out lie along radii, so they give no field at the centre; what matters is the current in the four quarters.

At the lower junction $2\ A$ leaves through the lower left arc, and at $k$ the current becomes $2+2 = 4\ A$ in the upper left arc; the other arcs carry $12\ A$ and $3\ A$.

Clockwise: $2 + 4 = 6$, anticlockwise: $12 + 3 = 15$ (units proportional to the current, since the arcs are quarters)

The resultant is anticlockwise, so the field at the centre is outwards.

**34** **Answer (C)**

$r = L/(2\pi N)$, so winding the wire into 4 turns makes the radius $r_1/4$

$B_1 = (\mu I)/2r_1$

$B_2 = (\mu \times 4timesI/2)/(2timesr_1/4) = (4\mu I)/r_1$

$B_1/B_2 = 1/8$

**35** **Answer (A)**

The electron acts as a current: $I = ef = 1.6 \times 10^{-19} \times 6.6 \times 10^{15} = 1.056 \times 10^{-3}\ A$

$B = (\mu_0 I)/2r = (4\pi \times 10^{-7} \times 1.056 \times 10^{-3})/(2 \times 5.3 \times 10^{-11}) \approx 12.52\ T$

**36** **Answer (D)**

The outer loop is clockwise (its field is inwards) and the inner loop is anticlockwise (its field is outwards).

The currents are equal but the inner loop has a smaller radius, so its field is greater.

The resultant is in the direction of the inner loop's field: out of the page.

**37** **Answer (D)**

The directions are opposite and the inner loop is closer, so its field is greater: $(\mu I)/2r > (\mu I)/(2(2r))$

To reverse the direction, the outer loop's field must exceed the inner one's: $(\mu I')/(2(2r)) > (\mu I)/2r \Rightarrow I' > 2I$

So increasing the outer current to $3I$ works, while $2I$ only makes the resultant zero.

**38** **Answer (C)**

The currents are in the same direction, so the two fields add.

Coil $(400 \text{ turns}, r = 20\ cm, 7\ A)$: $B_1 = (4\pi \times 10^{-7} \times 400 \times 7)/(2 \times 0.2) = 8.8 \times 10^{-3}\ T$

Coil $(500 \text{ turns}, r = 10\ cm, 10\ A)$: $B_2 = (4\pi \times 10^{-7} \times 500 \times 10)/(2 \times 0.1) = 31.4 \times 10^{-3}\ T$

$B = 8.8 \times 10^{-3} + 31.4 \times 10^{-3} = 40.2 \times 10^{-3}\ T$

**39** **Answer (A)**

When one coil is turned over the two directions become opposite, so the fields are subtracted.

$B = 31.4 \times 10^{-3} - 8.8 \times 10^{-3} = 22.6 \times 10^{-3}\ T$

**40** **Answer (B)**

When the two planes are perpendicular, the two fields are perpendicular.

$B = \sqrt{(B_1^2 + B_2^2)} = \sqrt{((8.8 \times 10^{-3})^2 + (31.4 \times 10^{-3})^2)} = 32.6 \times 10^{-3}\ T$

**41** **Answer (D)**

The fields cancel $(B_1 = B_2)$ and the currents are equal: $N_1/r_1 = N_2/r_2$

$N_2 = N_1 times r_2/r_1 = 100 \times 20/10 = 200$ turns

**42** **Answer (D)**

The two straight parts are in line with $c$, so they give no field.

Outer arc (radius $2r$), anticlockwise: $B_{out} = 1/2 \times (\mu I)/(2\ (2r)) = (\mu I)/8r$ (out of the page)

Inner arc (radius $r$), clockwise: $B_{in} = 1/2 \times (\mu I)/2r = (\mu I)/4r$ (into the page)

$B = (\mu I)/4r - (\mu I)/8r = (\mu I)/8r$, and since $I = 1\ A$ the resultant is $(\mu)/8r$

**43** **Answer (B)**

The loop (radius $r$, current $I$ clockwise): $B_1 = (\mu I)/2r$ inwards

The arc (radius $2r$, current $9I$ anticlockwise): $B_2 = (\theta)/360 \times (\mu (9I))/(2\ (2r))$ outwards

Equal fields: $1/2 = (9\theta)/(4 \times 360) \Rightarrow \theta = 80^\circ$

**44** **Answer (C)**

$d_1 = 2d_2 \Rightarrow r_1 = 2r_2$, and each coil's field $B \propto N/r$: $(B_{out})/(B_{in}) = N_1/N_2 \times r_2/r_1 = N_1/2N_2$

In the first case the fields add, $B_{in} + B_{out}$, and after reversing the outer one they subtract, $B_{in} - B_{out}$ (so the inner field is the greater one).

$B_{in} - B_{out} = 1/2(B_{in} + B_{out}) \Rightarrow B_{in} = 3B_{out}$

$N_1/2N_2 = 1/3 \Rightarrow N_1/N_2 = 2/3$

**45** **Answer (C)**

For the three loops with the same current: $B \propto \pm 1/r$, the sign depending on the direction of circulation.

In (C) the two outer loops are in one direction and the inner loop in the opposite direction: $-1/1 + 1/2 + 1/3 = -0.17$ (in units of $(\mu I)/2r$)

The other figures are larger: (A) $1.83$ , (B) $1.17$ , (D) $0.83$, so the smallest value is in (C).

**46** **Answer (D)**

The currents in loops $x$ and $z$ are clockwise (their fields are inwards).

$B_x = (\mu I)/(2(2r)) = 0.25(\mu I)/r$ and $B_z = (\mu (2I))/(2(5r)) = 0.2(\mu I)/r$

$B_y = (\mu I_y)/(2(3r))$, and it must equal $B_x + B_z$ in magnitude and be opposite in direction.

$I_y/6 = 0.25 + 0.2 = 0.45 \Rightarrow I_y = 2.7I$ anticlockwise

**47** **Answer (B)**

The halves are connected in series, so the current flows through each of them, and its direction of circulation reverses in successive halves.

The outer one (radius $4r$) anticlockwise, then $3r$ clockwise, then $2r$ anticlockwise, then $r$ clockwise

$B \propto 1/4 - 1/3 + 1/2 - 1 < 0$, so the resultant is in the direction of the innermost one: perpendicular to the page and inwards.

**48** **Answer (A)**

$(\mu I)/(2\pi d) = (\mu I)/2r \Rightarrow r = \pi d$

That is $r = 3.14\, d$, which is greater than $d$.

**49** **Answer (B)**

The two straight parts are in line with $X$, so they give no field, and the arc is $3/4$ of a circle, clockwise.

$B_{arc} = 3/4 \times (\mu_0 I)/2r = 3/4 \times (4\pi \times 10^{-7} \times 2)/(2 \times \pi \times 10^{-2}) = 3 \times 10^{-5}$ $T$ inwards

We need a field from the wire outwards of the same value: $(\mu_0 I)/(2\pi d) = 3 \times 10^{-5} \Rightarrow I = (3 \times 10^{-5} \times 2\pi \times 0.2)/(4\pi \times 10^{-7}) = 30$ $A$

By the right-hand rule, the field to the right of the wire is outwards if the current is from $a$ to $b$ (downwards).

**50** **Answer (C)**

The plane of the coil is the plane of the magnetic meridian, so the fields of the coil and the wire at the centre are both perpendicular to this plane (east-west).

The needle is not deflected if the two fields are equal (and opposite): $(\mu_0 I)/(2\pi r) = (\mu_0 I_c)/2r$

$I = \pi I_c = 3.14 \times 0.42 \approx 1.32$ $A$

**51** **Answer (D)**

The wire gives an inward field at the centre and the coil an outward field, so a zero resultant means $B_{wire} = B_{coil}$

Turning the coil over makes its field inwards too, so they add: $B = B_{wire} + B_{coil} = 2B_{wire}$

**52** **Answer (C)**

In each case we combine the field of the arc $(\mu I)/4r$ (inwards) with the field of the wire $(\mu I)/(2\pi r)$.

(1) The wire gives a field opposite to the arc's, so they subtract: $0.25 - 0.16 = 0.09$ (in units of $(\mu I)/r$)

(2) Both in the same direction, so they add: $0.25 + 0.16 = 0.41$

(3) and (4) The wire is perpendicular to the plane, so its field is perpendicular to the arc's: $\sqrt{(0.25^2 + 0.16^2)} = 0.30$ in both cases (the direction of its current does not change the magnitude)

Order: $B_2 > B_3 = B_4 > B_1$

**53** **Answer (C)**

The loop: $B_1 = (\mu_0 I)/2r = (4\pi \times 10^{-7} \times 10)/(2 \times 0.02) = 3.14 \times 10^{-4}$ $T$ perpendicular to the plane

The perpendicular wire is $4$ $cm$ from the centre: $B_2 = (\mu_0 I)/(2\pi d) = (2 \times 10^{-7} \times 10)/0.04 = 5 \times 10^{-5}$ $T$, in the plane of the loop

The two fields are perpendicular: $B = \sqrt{(B_1^2 + B_2^2)} \approx 3.2 \times 10^{-4}$ $T$

**54** **Answer (D)**

In figure $(1)$ the straight wire continues below the loop and its field at the centre is in the same direction as the loop's field: $B_1 = (\mu I)/2r + (\mu I)/(2\pi r)$

In figure $(2)$ the two straight halves together give $2\times(\mu I)/(4\pi r) = (\mu I)/(2\pi r)$, but the current in the loop is reversed, so we subtract: $B_2 = (\mu I)/2r - (\mu I)/(2\pi r)$

$B_1/B_2 = (1 + 1/(\pi))/(1 - 1/(\pi)) = (\pi + 1)/(\pi - 1)$

**55** **Answer (B)**

Distance of the wire from the centre of the loop: $d = 5 + 2.5 = 7.5\ cm$

For a zero field: $(\mu_0 I)/(2\pi d) = (\mu_0 I_c)/2r \Rightarrow I = (\pi d I_c)/r = (\pi\times 0.075\times 3)/0.025 \approx 28.3\ A$

**56** **Answer (C)**

Field of the loop at the centre: $B_c = (\mu_0 I_c)/2r = (4\pi\times 10^{-7}\times 3)/(2\times 0.025) = 7.54\times 10^{-5}\ T$

At $I = 28.3\ A$ the wire's field was equal and opposite to the loop's field, so when $I$ is reversed they are in the same direction.

$B = 2B_c = 1.51\times 10^{-4}\ T$

**57** **Answer (C)**

The loop: the current is clockwise, so its field is inwards, $B_c = (\mu I)/2r$

The wire at $x$ is $2r$ from the centre and its current is upwards, so its field is also inwards: $B = B_c + (\mu I)/(2\pi(2r)) = B_c(1 + 1/(2\pi)) = 1.16B_c$

After moving it to $y$ its field reverses and becomes outwards: $B' = B_c(1 - 1/(2\pi)) = 0.84B_c$

$(B')/B = 0.84/1.16 = 0.73$

**58** **Answer (A)**

The outer loop (radius $2r$) is clockwise: $(\mu I)/4r$ inwards, and the inner loop is anticlockwise: $(\mu I)/2r$ outwards, so their resultant is $(\mu I)/4r$ outwards.

The wire touching the outer loop is $2r$ from the centre and its field is inwards: $(\mu I_0)/(2\pi(2r))$

For a zero resultant: $(\mu I_0)/(4\pi r) = (\mu I)/4r \Rightarrow I_0/I = \pi$

**59** **Answer (B)**

The centre of the coil is midway between the two wires, so it is $0.5\ m$ from each.

Wire $A$: $B_A = (2\times 10^{-7}\times 4.5)/0.5 = 1.8\times 10^{-6}\ T$ outwards, and wire $B$: $B_B = (2\times 10^{-7}\times 1.5)/0.5 = 0.6\times 10^{-6}\ T$ inwards, so the resultant is $1.2\times 10^{-6}\ T$ outwards.

The coil must give $1.2\times 10^{-6}\ T$ inwards, i.e. a clockwise current: $I = 2rB/(\mu_0) = (2\times 0.1\pi\times 1.2\times 10^{-6})/(4\pi\times 10^{-7}) = 0.6\ A$

**60** **Answer (D)**

The two wires are on either side of the centre and their currents are opposite, so their fields at $m$ are in the same direction (inwards), giving $2B$.

For a zero resultant the coil must give $2B$ outwards, i.e. an anticlockwise current.

**61** **Answer (B)**

The loop's field is the same at the three positions (inwards, because the current is clockwise).

At position $y$ the two wires are at equal distances and their currents are in the same direction, so their fields are opposite and cancel: $B_y = B_c$

At $x$ the left wire is closer, so its field (inwards) is greater and adds to the loop's field: $B_x > B_c$

At $z$ the right wire is closer and its field is outwards, so it subtracts: $B_z < B_c$

$B_x > B_y > B_z$

**62** **Answer (C)**

The loop's field is outwards, $(\mu I)/2r$, and the straight wire's field is inwards and reduces it: in figure (1) $(\mu I)/(2\pi(2r)) = 0.08(\mu I)/r$, so the resultant is $0.42(\mu I)/r$ outwards.

In figure (2) the vertical wire becomes semi-infinite: $(\mu I)/(4\pi(2r))(1 + \sin 45^\circ) = 0.07(\mu I)/r$, plus the horizontal part $(\mu I)/(4\pi(2r))(2\sin 45^\circ) = 0.06(\mu I)/r$, both inwards.

The total field of the wire is now $0.12(\mu I)/r$ instead of $0.08(\mu I)/r$, so the resultant becomes $0.38(\mu I)/r$: it decreases in magnitude and stays in the same direction.

**63** **Answer (D)**

The current can be reversed, so the polarity reverses; the current or the number of turns can be changed, so the flux density changes; the current can be reversed or switched off, so the field direction changes or the field disappears.

A permanent magnet allows none of this.

**64** **Answer (B)**

$B = (\mu N I)/(\ell) = (\mu N)/(\ell) \text{times} V_B/R$

Doubling $V_B$ doubles $B$, while doubling $\ell$ or $R$ or halving $N$ decreases $B$.

**65** **Answer (D)**

We find the pole of the coil facing the magnet with the right-hand rule: fingers with the current, thumb towards the north pole of the coil.

In figures (2) and (3) the magnet's pole faces an unlike pole of the coil, so they attract.

In (1) and (4) only one polarity is changed (either the magnet or the battery), so the facing poles are like poles and they repel.

**66** **Answer (D)**

The coils are identical and the batteries are connected in the same way, so their fields are in the same direction.

So the facing ends of the two coils are unlike poles (for example, the left one faces the magnet with a south pole and the right one with a north pole).

The magnet is at equal distances, so the two forces are equal: it is either attracted to both with equal and opposite forces or repelled by both in the same way, so the resultant is zero and it stays still.

**67** **Answer (B)**

The current flows downwards in the front face of the coil, so by the right-hand rule the field inside the coil is to the right.

Outside the coil the field returns to the left at the two compasses (above and below the coil).

The Earth's field is to the north (top of the page) and the new field is to the left, so the needles settle between the two directions: the north pole towards the upper left in both compasses.

**68** **Answer (C)**

$B = (\mu_0 N I)/(\ell) = (4\pi \times 10^{-7} \times 200 \times 0.5)/0.2 = 6.28 \times 10^{-4}\ T$

**69** **Answer (D)**

With an iron core, the permeability of air is replaced by that of iron: $B = (\mu N I)/(\ell) = (2 \times 10^{-3} \times 200 \times 0.5)/0.2 = 1\ T$

**70** **Answer (C)**

$I = (B \ell)/(\mu_0 N) = (1.2 \times 10^{-3} \times 0.22)/(4\pi \times 10^{-7} \times 300) \approx 0.7\ A$

**71** **Answer (A)**

Flux $\Phi = B A = 1.2 \times 10^{-3} \times 25 \times 10^{-4} = 3 \times 10^{-6}\ Wb$

**72** **Answer (C)**

$B = \mu_0 n I \Rightarrow n = B/(\mu_0 I) = 0.05/(4\pi \times 10^{-7} \times 10) \approx 3977$ turns/m

**73** **Answer (B)**

$n = N/(\ell) \Rightarrow N = n \ell = 3978.9 \times 0.6 \approx 2387$ turns

**74** **Answer (D)**

Resistance of the coil $R = 0.01 N$ and $I = V/R = 2/0.01N = 200/N$

$B = (\mu_0 N I)/(\ell) = (4\pi \times 10^{-7} \times 200)/0.5 = 5.03 \times 10^{-4}\ T$ (it does not depend on $N$)

**75** **Answer (A)**

Cutting off half the turns makes the length $(\ell)/2 = 0.25\ m$, the number of turns $N/2$ and the resistance $0.005N$, so the current is $400/N$

$B = (\mu_0(N/2)(400/N))/0.25 = (4\pi\times10^{-7}\times 200)/0.25 = 1.01\times10^{-3}\ T$

**76** **Answer (B)**

With the switch open the coil is alone in the circuit: $I = V_B/(R_c + r) = 60/(6 + 2) = 7.5\ A$

$B = (\mu_0\ N\ I)/(\ell) = (4\pi\times10^{-7}\times 100\times 7.5)/0.2 = 4.71\times10^{-3}\ T$

**77** **Answer (A)**

With the switch closed a $3\ \Omega$ resistor is connected in parallel with the coil: $R_p = (6\times 3)/(6 + 3) = 2\ \Omega$

$I_{total} = 60/(2 + 2) = 15\ A$ and the coil voltage $V = 60 - 15\times 2 = 30\ V$, so the coil current is $30/6 = 5\ A$

$B = (4\pi\times10^{-7}\times 100\times 5)/0.2 = 3.14\times10^{-3}\ T$

**78** **Answer (D)**

The coil's resistance is zero, so the current is $I = V_B/(R_s + r)$

$B \propto I$, so $B$ decreases along a falling curve as $R_s$ increases, and it has a definite value at $R_s = 0$ (it does not go to infinity because of $r$).

**79** **Answer (B)**

Resistance $R_1$ is in series with the coil; increasing it increases the resistance of the coil's branch, so the current in it decreases.

$I_1 = (V_B\ R_2)/(r\ R_2 + (R_1 + R_c)(r + R_2))$ decreases as $R_1$ increases, so $B$ decreases.

**80** **Answer (A)**

Resistance $R_2$ is in parallel with the coil's branch; increasing it decreases the current through it and slightly increases the total resistance.

$I_1 = V_B/(r + (R_1 + R_c)(1 + r/R_2))$ increases as $R_2$ increases, because $r/R_2$ decreases, so $B$ increases.

**81** **Answer (C)**

Slope of the line $= B/I = (16\times10^{-4})/4 = 4\times10^{-4}\ T/A$

$B = \mu_0\ n\ I \Rightarrow n = (4\times10^{-4})/(4\pi\times10^{-7}) \approx 318$ turns/m

**82** **Answer (B)**

Slope of the line $m = B/I = (\mu N)/(\ell)$; from the graph the slope of $x$ $(30^\circ)$ is greater than that of $y$ $(15^\circ)$: $\text{fractan } 30^\circ \tan 15^\circ \approx 2.15$

$(\mu_x)/(\mu_y) = m_x/m_y \times (\ell_x)/(\ell_y) = 2.15 \times 1/4 \approx 0.54$

So the permeability of the core of coil $y$ is greater.

**83** **Answer (A)**

$I = (B\,\ell)/(\mu_0\, N) = (2.4 \times 10^{-2} \times 0.1\pi)/(4\pi \times 10^{-7} \times 500) = 12\ A$

End $D$ is a south pole, so the field inside the coil points towards $C$, which means (by the right-hand rule) that the current enters the coil from the right end.

So it leaves the battery to $a$ and flows in $R$ from $a$ to $b$.

**84** **Answer (D)**

At the middle of the coil the winding direction reverses (the $V$ shape), so the two halves of the coil act as two magnets facing each other.

The field of the left half is to the right and that of the right half is to the left, so a north pole forms at the middle and two south poles at the ends $A$ and $B$.

**85** **Answer (B)**

When either switch is closed a current flows in the coil, so it becomes an electromagnet that magnetises the iron piece and pulls it up; this does not depend on the direction of the current.

The upward pull reduces the force of the iron piece on the balance, so its reading drops below $w$ in both cases.

**86** **Answer (B)**

The tension decreases when the coil pushes the magnet up, i.e. when the upper end of the coil is a north pole (repelling the $N$ pole of the magnet).

The batteries have opposite polarity: the $K_1$ battery gives a current that makes the upper end of the coil a south pole (attraction, so the tension increases), and the $K_2$ battery reverses the current, so the upper end becomes a north pole (repulsion).

Closing both switches connects the two opposing batteries in parallel, which does not help, so the answer is closing $K_2$ only.

**87** **Answer (B)**

The turns touch, so the number of turns per metre is $n = 1/d = 1/(0.2 \times 10^{-2}) = 500$ turns/m

$B = \mu\, n\, I = 2 \times 10^{-3} \times 500 \times 1 = 1\ T$

**88** **Answer (D)**

When the coil is cut, the wire length (and resistance) is proportional to the number of turns: $R \propto N'$, so $I = V/R \propto 1/(N')$

$B = (\mu N' I)/(\ell') \propto (N')/(\ell') \times 1/(N') = 1/(\ell')$, i.e. $B$ is inversely proportional to the length of the part.

$B_x/B_y = (\ell_y)/(\ell_x) = (3\ell_1)/(\ell_1) = 3$

**89** **Answer (A)**

The coils are identical, so their resistances differ only because of resistivity: $R = (\rho L)/A$, and copper has the lower resistivity, so the first coil has the lower resistance.

At the same potential difference $I_1 = V/R_1 > I_2$ and $B = (\mu N I)/(\ell) \propto I$, so $B_1 > B_2$

**90** **Answer (C)**

$B = (\mu N I)/(\ell)$, and they have the same $N$ and the same core.

$B_x/B_y = I_x/I_y \times (\ell_y)/(\ell_x) = I/2I \times (2\ell)/(\ell) = 1/1$

**91** **Answer (B)**

$B = \mu n I$ and they have the same $n$, so $B$ is proportional to $I$: $B_X/B_Y = I_X/I_Y = 9$

At the same potential difference $I = V/R$ and $R = (\rho L)/A$, so $I \propto A$

$A_X/A_Y = 9$: the cross-sectional area of the wire of $X$ is nine times that of $Y$ (and the resistance of $X$ is one ninth of that of $Y$).

**92** **Answer (A)**

Field of the coil: $B_c = (\mu_0 N I)/(\ell) = (4\pi \times 10^{-7} \times 60 \times 3.5)/0.11 = 2.4 \times 10^{-3}\ T$

The current flows upwards in the front face, so the coil's field is to the left, opposite to the external field.

$B = 5.2 \times 10^{-3} - 2.4 \times 10^{-3} = 2.8 \times 10^{-3}\ T$ in the direction of the external field

**93** **Answer (D)**

For a zero resultant the coil's field must be equal and opposite to the external field (to the left).

$I = (B \ell)/(\mu_0 N) = (1.2 \times 10^{-3} \times 1.1)/(4\pi \times 10^{-7} \times 210) = 5\ A$

A field to the left inside the coil means the current enters from the right end of the coil, i.e. it leaves terminal $b$ (positive) to $R$ and then the coil, so $a$ is negative.

**94** **Answer (C)**

The two coils are wound in opposite directions, so their fields outside the coils are in opposite directions at $x$.

The left coil carries $2I$, so its field at $x$ is greater, and it points up (because its field inside the coil points down).

The resultant at $x$ is in the direction of the left coil's field: towards the top of the page.

**95** **Answer (A)**

The coils are connected in parallel across the battery: the current of coil $y$ enters from its right end and the current of $x$ enters from its left end.

So the facing ends are like poles (south poles), and the two coils repel.

**96** **Answer (A)**

The coils have the same axis and their currents are in the same direction, so their fields add: $B = \mu_0 (n_1 I_1 + n_2 I_2)$

$B = 4\pi \times 10^{-7} \times (10 \times 2 + 20 \times 4) = 4\pi \times 10^{-5} = 125.7 \times 10^{-6}\ T$

**97** **Answer (C)**

The currents are in opposite directions, so the fields subtract: $B = \mu_0 |n_1 I_1 - n_2 I_2|$

$B = 4\pi \times 10^{-7} \times |10 \times 2 - 20 \times 4| = 4\pi \times 10^{-7} \times 60 = 75.4 \times 10^{-6}\ T$

**98** **Answer (A)**

The batteries are identical and connected to two parallel windings with the same winding direction, and the current enters both circuits from the right end of the coil.

When $K$ is closed a new field is added in the same direction as the first, so the resultant increases.

**99** **Answer (B)**

Before stretching: $B = (\mu N I)/2r$

After stretching it becomes a solenoid of length $\ell = 20r$: $B' = (\mu N I)/(\ell) = (\mu N I)/20r$

$(B')/B = 2r/20r = 1/10 \Rightarrow B' = B/10$

**100** **Answer (D)**

Before: $B = (\mu N I)/2r$ and after: $B' = (\mu N I)/(\ell)$

$(B')/B = 2r/(\ell) = (2 \times 2.2)/110 = 0.04 \Rightarrow B' = 0.04B$

**101** **Answer (C)**

$B_{sol} = (\mu N I)/(\ell) = 4\times10^{-6} \Rightarrow \mu N I = 4\times10^{-6}\times 2 = 8\times10^{-6}$

After pressing it becomes a circular coil of radius $r = 5\ cm$ with the same number of turns: $B' = (\mu N I)/2r = (8\times10^{-6})/(2\times 0.05) = 8\times10^{-5}\ T$

**102** **Answer (C)**

Field of the solenoid: $B_s = (\mu_0 N I)/(\ell) = (4\pi\times10^{-7}\times 100\times 2)/0.5 = 5.03\times10^{-4}\ T$

Field of the circular coil: $B_c = (\mu_0 N I)/2r = (4\pi\times10^{-7}\times 20\times 1)/(2\times 0.15) = 0.84\times10^{-4}\ T$

The plane of the circular coil is perpendicular to the solenoid's axis, so the two fields are along the same line; in the same direction they add: $B = 5.03\times10^{-4} + 0.84\times10^{-4} = 5.87\times10^{-4}\ T$

**103** **Answer (A)**

The fields of the two coils are in opposite directions, so they subtract: $B = 5.03\times10^{-4} - 0.84\times10^{-4} = 4.19\times10^{-4}\ T$

**104** **Answer (D)**

The solenoid's field is parallel to its axis (to the left in the figures where the current enters from the right end).

A wire parallel to the plane of the page gives a field perpendicular to the page, so the resultant will not be in the plane of the page (A, B, C).

A wire perpendicular to the page (current into the page) gives at $c$ a field in the plane of the page and to the left, in the same direction as the coil's field, so the resultant is to the left in figure (D).

**105** **Answer (C)**

The wire perpendicular to the page gives at $p$ a field in the plane of the page, perpendicular to the line joining the point to the wire (i.e. perpendicular to the axis of the coil).

The coil's field is along the axis, so the two fields are perpendicular: $B_{total} = \sqrt{(B^2 + B^2)} = \sqrt{(2)}\ B$

**106** **Answer (B)**

Field of the wire: $B_w = (\mu_0 I)/(2\pi d) = (2\times10^{-7}\times 15)/0.15 = 2\times10^{-5}\ T$

Field of the coil: $B_s = (\mu_0 N I)/(\ell) = (4\pi\times10^{-7}\times 10\times7/22)/0.15 = 2.67\times10^{-5}\ T$

The two fields are perpendicular: $B = \sqrt{(B_w^2 + B_s^2)} = \sqrt{((2)^2 + (2.67)^2)}\times10^{-5} \approx 3.34\times10^{-5}\ T$

**107** **Answer (C)**

Field of the coil on its axis: $B_s = \mu_0 n I = 4\pi \times 10^{-7} \times 50 \times 1.4 = 8.8 \times 10^{-5}\ T$ to the left

At $z$ the wire's field is horizontal, so it can cancel the coil's field: $(\mu_0 I)/(2\pi d) = B_s \Rightarrow I = (8.8 \times 10^{-5} \times 0.02)/(2 \times 10^{-7}) = 8.8\ A$

The wire's field at $z$ must be to the right, which an outward current in the wire gives.

**108** **Answer (B)**

The wire is in the plane of the page next to the coil: its field at $X$ is perpendicular to the page, so it is perpendicular to the coil's field (along the axis).

$B = \sqrt{((3 \times 10^{-6})^2 + (4 \times 10^{-6})^2)} = 5 \times 10^{-6}\ T$

## Essay questions

**1** **Model answer**

$B = (\mu NI)/2r$

$B_1 = (\mu \times 1/2 \times 1/2I)/2r - (\mu \times 1/2 \times 1/2I)/2r = 0$

$B_2 = (\mu I)/4r - (\mu I)/8r = (\mu I)/8r$

$B_3 = (\mu I)/4r + (\mu I)/8r = (3\mu I)/8r$

$B_4 = (\mu I)/4r = (2\mu I)/8r$

$B_1 < B_2 < B_4 < B_3$

**2** **Model answer**

$B = (\mu NI)/2r$ , $I = V/R$ , $R = (\rho_e \ell)/A$

$B = (\mu NVA)/(2r\rho_e \ell)$

μ, N, V, r, ℓ and ρe are all constant, so $B \propto A$

$B_x/B_y = A_x/A_y = A/2A = 1/2$

**3** **Model answer**

$B = (\mu NI)/2r$ and μ and I are constant, so $B \propto N/r$ (1)

The length of the wire is the same in both cases: $2\pi r_1 N_1 = 2\pi r_2 N_2$

$r_1/r_2 = N_2/N_1$ (2)

From (1) and (2): $B_1/B_2 = N_1 r_2/N_2 r_1 = (N_1^2)/(N_2^2) = (N_1/N_2)^2$

**4** **Model answer**

$B = (\mu NI)/2r$ , $I = V/R_1 N$ where $R_1$ is the resistance of one turn

$B = (\mu V)/2rR_1$

$B = (4\pi \times 10^{-7} \times 4)/(2 \times 3.14 \times 10^{-2} \times 2) = 4 \times 10^{-5}\ T$

**5** **Model answer**

$B = (\mu NI)/2r$

$2.4 \times 10^{-5} = (4 \times 3.14 \times 10^{-7} \times 0.5 \times I)/(2 \times 3.14 \times 10^{-2})$

$I = 2.4\ A$

$V_B = I(R' + r) : 24 = 2.4(R + 3.72 + 2)$

$R = 4.28\ \Omega$

**6** **Model answer**

$B_t = B_{ext} - B_{ring}$

$4 \times 10^{-5} = 6 \times 10^{-5} - (4\pi \times 10^{-7} \times 1 \times I)/(2 \times 2\pi \times 10^{-2})$

$I = 2\ A$

**7** **Model answer**

Decrease the current in the inner loop to half, because at the neutral point:

$(\mu N_1 I_1)/2r_1 = (\mu N_2 I_2)/2r_2$

$(\mu \times 1 \times I_1)/2d = (\mu \times 1 \times I)/(2 \times 2d)$

$I_1 = I/2$

**8** **Model answer**

According to Ampère's right-hand rule, both the upper face of coil X and the lower face of coil Y act as south magnetic poles, so they repel each other, and the repulsive force between coil Y and coil X equals the weight of coil Y.

**9** **Model answer**

Applying Ampère's right-hand rule at the centre of the loop (c), the direction of the magnetic field due to:

the loop: perpendicular to the page and inwards; wire x: perpendicular to the page and inwards; wire y: perpendicular to the page and outwards.

$B_t = B_{ring} + B_x - B_y$

(1) When the current in wire x is doubled, $B_x$ increases, so the resultant flux density at the centre of the loop increases.

(2) When the current in wire y is doubled, $B_y$ increases, so the resultant flux density at the centre of the loop decreases but does not become zero.

**10** **Model answer**

$B = (\mu\ NI)/(\ell)$

$I = V/(R_{coil}) = V/RN$

$B = (\mu\ NV/RN)/(\ell) = (\mu\ V)/(\ell\ R)$

**11** **Model answer**

1- Increasing the number of turns of the solenoid (N).

2- Increasing the current (I) in the solenoid.

3- Decreasing the length of the solenoid $(\ell)$.

4- Placing an iron core inside the coil.

**12** **Model answer**

(1) Relation: $B = (\mu\ NI)/2r$ , slope: $slope = (\Delta\ B)/(\Delta(1/r)) = (\mu\ NI)/2$

(2) Relation: $B = (\mu\ NI)/(\ell)$ , slope: $slope = (\Delta\ B)/(\Delta\ N) = (\mu\ I)/(\ell)$

(3) Relation: $B = (\mu\ NI)/(\ell)$ , slope: $slope = (\Delta\ B)/(\Delta(1/(\ell))) = \mu\ NI$

**13** **Model answer**

(1) The magnetic flux density decreases because the length of the coil increases, since $B = (\mu\ NI)/(\ell)$

(2) The magnetic flux density stays the same because the number of turns per unit length stays the same: doubling the diameter of the turns halves the number of turns (the wire length is constant) and halves the length of the coil.

(3) The magnetic flux density is halved, because the number of turns per unit length $N/(\ell)$ stays the same while the current is halved because the resistance of the coil is doubled.

**14** **Model answer**

(1) Outside the coil the flux lines leave the left end of the coil (north pole) and enter its right end, and inside the coil they go from right to left (according to the current direction shown).

(2) Because the magnetic flux lines spread out at the ends of the coil to complete their closed paths, so they are less crowded outside than at the point at the middle of the coil on its axis, where the flux lines are parallel and closer together.

**15** **Model answer**

When switch K is closed, a current flows through the solenoid, so it acts as an electromagnet that attracts the iron strip, so circuit (1) becomes open and the lamp goes out.

**16** **Model answer**

Because the coil is double wound, so the magnetic field due to the current in one direction in each turn is equal in magnitude and opposite in direction to the magnetic field due to the current in the opposite direction in the neighbouring turn, so each cancels the effect of the other.

**17** **Model answer**

(1) A force of attraction.

(2) The magnetic flux density increases because iron has a high magnetic permeability, so the magnetic force between the coil and the magnet increases.

(3) The direction of the current in the coil reverses, so the poles formed at the ends of the coil reverse, and a force of repulsion arises between the coil and the magnet.

**18** **Model answer**

The balance reading increases, because after closing switch K the current in the lower face of the solenoid is anticlockwise, i.e. the magnetic pole formed at this face is a north pole, so it repels the north pole of the magnet on the balance and the balance reading increases.

**19** **Model answer**

Before closing switch K, the magnetic field due to the current in coil x at point p is in the plane of the page and to the left.

After closing switch K, the two fields due to the currents in coils x and y are in opposite directions; the current in coil x is less than that in coil y because the resistance of the wire of coil x is greater, so the flux density due to coil x is less.

So the resultant is in the direction of the field due to the current of coil y, i.e. the direction of the resultant flux density reverses after closing switch K and becomes in the plane of the page and to the right.

**20** **Model answer**

$B_{solenoid} = 1/4 B_{circle}$

$(\mu\ NI)/(\ell) = 1/4 \times (\mu\ NI)/2r$

$\ell = 8r = 8 \times 6 \times 10^{-2} = 0.48\ m$

## Past exam questions

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| D | A | A | D | A | A | A | C | B | B |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| B | D | B | D | A | B | D | C | B | B |

| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|
| C | D | B | A | C | D | A | A | C | B |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| D | B | C | C | C | D | D | A | B | D |
| 41 | 42 | 43 | | | | | | | |
| B | A | A | | | | | | | |

**1** **Answer (D)**

The straight parts of conductor (y) are in line with point M, so they produce no field there.

The half loop: $(\mu \times 2)/4d$ and wire (x): $(\mu I)/(2\pi d)$ in the opposite direction

$(2\mu)/4d = (\mu I)/(2\pi d)$, so $I = \pi A$

**2** **Answer (A)**

$B = (\mu I)/4r$ for a half loop, so B decreases as the radius increases.

Loop A has the largest radius.

**3** **Answer (A)**

The wire length is constant: $2\pi rN$ is constant, so if N drops to a quarter, r becomes four times as large.

$B = (\mu NI)/2r$ drops to $1/4 \times 1/4 = 1/16$

**4** **Answer (D)**

$N' = 2/3N$, so $r' = 3/2r$

$B' = 2/3 \times 2/3B = 4/9B$

**5** **Answer (A)**

$B = (\mu NI)/2r$, and with equal I and r, B is directly proportional to N

$B_x = 2B_y$

**6** **Answer (A)**

Inner loop: $(\mu I)/2r$, outer loop: $(\mu I)/4r$, wire: $(\mu I)/(2\pi \times 2r)$, all in the same direction.

$B = (\mu I)/r(0.5 + 0.25 + 0.08) = (0.83\mu I)/r$

**7** **Answer (A)**

$B \propto I$, so $B_2 = 3B_1$

**8** **Answer (C)**

$B = (\mu I)/2r + (\mu I)/4r = (3\mu I)/4r$

Reversing one current: $(\mu I)/2r - (\mu I)/4r = (\mu I)/4r = B/3$

**9** **Answer (B)**

Cutting off a quarter of the turns reduces N to $3/4N$ with r constant

$B' = 3/4B$

**10** **Answer (B)**

$(\mu NI_1)/2r = (\mu NI_2)/(2 \times 2r)$, so $I_2 = 2I_1$

For the resultant to be zero the two currents are in opposite directions: $B_t = 0$

**11** **Answer (B)**

For the resultant to remain B, the fields of the two wires must cancel each other.

The two wires are on opposite sides at the same distance, so wire $(2)$ carries a current I in the same direction as the current of wire $(1)$, i.e. towards the bottom of the page.

**12** **Answer (D)**

$B_{C_1} = (\mu(2I - I))/(2\pi r) = (\mu I)/(2\pi r)$

$B_{C_2} = (\mu \times 2I)/2r - (\mu I)/4r = (3\mu I)/4r$

$B_{C_1} < B_{C_2}$

**13** **Answer (B)**

Inner loop: $(\mu I_1)/2r$ and outer loop: $(\mu I_2)/4r$

(B) The two currents are in the same direction: $(\mu I)/2r + (\mu \times 2I)/4r = (\mu I)/r$, which is the greatest.

**14** **Answer (D)**

$B = (\mu NI)/2r = (4\pi \times 10^{-7} \times 100 \times 5)/(2 \times 2\pi \times 10^{-2}) = 5 \times 10^{-3}\ T$

**15** **Answer (A)**

$B_1 = (4\pi \times 10^{-7} \times 100 \times 4)/(2 \times 0.2) = 12.56 \times 10^{-4}\ T$

$B_2 = (4\pi \times 10^{-7} \times 50 \times 2)/(2 \times 0.1) = 6.28 \times 10^{-4}\ T$

The two currents are opposite: $B = 6.28 \times 10^{-4}\ T$

**16** **Answer (B)**

The straight parts are in line with the centre C, so they produce no field there.

Three quarters of a loop: $B = 3/4 \times (4\pi \times 10^{-7} \times 10)/(2\pi \times 10^{-2}) = 1.5 \times 10^{-4}\ T$ in the direction of the external field.

$B_t = 1.5 \times 10^{-4} + 1.5 \times 10^{-4} = 3 \times 10^{-4}\ T$

**17** **Answer (D)**

Before turning over: $B_c$-$B_e$, and after: $B_c + B_e$

$B_c + B_e = 2(B_c - B_e)$, so $B_c = 3B_e = 1.5 \times 10^{-4}\ T$

$r = (\mu\ NI)/2B_c = (12.56 \times 10^{-7} \times 50 \times 1.4)/(2 \times 1.5 \times 10^{-4}) = 0.293\ m$

**18** **Answer (C)**

$(\mu\ I)/(2 \times 0.1) = (\mu\ I)/(2\pi\ d)$

$d = 0.1/(\pi) = 0.0318\ m = 3.18\ cm$

**19** **Answer (B)**

The loop's field $(\mu\ I)/2r$ is greater than the wire's field $(\mu\ I)/(2\pi\ r)$, and they are opposite.

So the resultant is in the direction of the loop's field: perpendicular to its plane, into it.

**20** **Answer (B)**

The current divides between the two arcs of the loop in inverse proportion to their lengths, so their fields cancel at the centre.

Only the wire's flux density remains: $B = (2 \times 10^{-7} \times 2)/0.05 = 8 \times 10^{-6}\ T$

**21** **Answer (C)**

$B = (\mu\ NI)/2r$ is directly proportional to I, so it doubles when the current is doubled.

**22** **Answer (D)**

Field of the half loop at Y: $(\mu\ I)/4r$ into the page.

For the resultant to be outwards, $B > (\mu\ I)/4r$

**23** **Answer (B)**

Half loop: $(\mu\ I)/4r = 0.25(\mu\ I)/r$ inwards.

Wire: $(\mu \times 2I)/(2\pi\ r) = 0.32(\mu\ I)/r$ outwards, which is greater.

The resultant is perpendicular to the page, outwards.

**24** **Answer (A)**

$B = (\mu\ NI)/(\ell)$, and with N and I constant it is inversely proportional to $\ell$

$B' = 1/3B$

**25** **Answer (C)**

X: two perpendicular loops, each $(\mu\ I)/2r$: $X = \sqrt{(2)}(\mu\ I)/2r$

Y: $(\mu \times 6I)/12r = (\mu\ I)/2r$

Z: the fields of the two wires are opposite and cancel: $Z = (\mu\ I)/2r$

So $Y < X$

**26** **Answer (D)**

$B = (\mu\ NI)/(\ell) = 88/7 \times 10^{-7} \times (100 \times 4.9)/0.2 = 3.08 \times 10^{-3}\ T$

$\varphi_m = BA = 3.08 \times 10^{-3} \times 22/7 \times (0.1)^2 = 9.68 \times 10^{-5}\ Wb$

**27** **Answer (A)**

To restore B with the length four times as large, the current must become four times as large:

$I + 3 = 4I$, so $I = 1\ A$

**28** **Answer (A)**

Slope $= B/I = (\mu\ N)/(\ell)$, which is inversely proportional to the length.

Coil N has the greatest slope, so it is the shortest.

**29** **Answer (C)**

The coil's field is along its axis, and the wire's field at M is perpendicular to the axis.

$B = \sqrt{(B_w^2 + B_s^2)}$

**30** **Answer (B)**

The two fields are perpendicular: $B_1 = \sqrt{(B^2 + (4/3B)^2)} = 5/3B$

At 2d the wire's field becomes $2/3B$: $B_2 = \sqrt{(B^2 + 4/9B^2)} = 1.2B$

$B_2/B_1 = 0.72$

**31** **Answer (D)**

Applying the right-hand rule to the coil, a pole like the facing pole of the magnet forms at each end, so the coil repels both magnets.

**32** **Answer (B)**

$B = (\mu\ NI)/(\ell) = 88/7 \times 10^{-7} \times (14 \times 2)/0.22 = 1.6 \times 10^{-4}\ T$

**33** **Answer (C)**

The fields of the two wires are opposite at A and cancel, so the resultant is the coil's B.

Reversing the current in one wire: the fields of the two wires give $2B$, perpendicular to the coil's field.

$B_t = \sqrt{((2B)^2 + B^2)} = \sqrt{(5)}B$

**34** **Answer (C)**

Solenoid: $\mu nI = 4\pi \times 10^{-7} \times 500 \times 4 = 2.5 \times 10^{-3}\ T$

Circular coil: $(4\pi \times 10^{-7} \times 10 \times 4)/(2 \times (\pi)/5 \times 10^{-2}) = 4 \times 10^{-3}\ T$

The two fields are opposite: $B = 1.5 \times 10^{-3}\ T$

**35** **Answer (C)**

Coil: $\mu nI = 4\pi \times 10^{-7} \times 300 \times 1.75 = 6.6 \times 10^{-4}\ T$

The wire's field is perpendicular to the axis of the coil:

$B = \sqrt{((6.6)^2 + (2.33)^2)} \times 10^{-4} = 7 \times 10^{-4}\ T$

**36** **Answer (D)**

Applying the right-hand rule to the direction of the current in the coil (from the positive terminal of the battery), the direction of the field lines inside and outside the coil is as in figure (D).

**37** **Answer (D)**

$B \propto I$ and $I = V/(R_{total})$

$K_1 : V_B/1.5R$ , $K_2 : 3V_B/3.5R$ , $K_3 : 0.5V_B/0.5R$ , $K_4 : 2V_B/R$

The greatest current is when $K_4$ is closed.

**38** **Answer (A)**

$(\mu NI_1)/(2\ell) = (\mu NI_2)/(\ell)$, so $I_1 = 2I_2$

$((V_B)_1)/R = 2((V_B)_2)/3R$

$((V_B)_1)/((V_B)_2) = 2/3$

**39** **Answer (B)**

Cutting off half the coil halves the length of the wire, so its resistance is halved.

The number of turns per unit length stays the same and the current doubles.

**40** **Answer (D)**

Circular coil: $(4\pi \times 10^{-7} \times 14 \times 2)/(2 \times 0.1) = 1.76 \times 10^{-4}\ T$

Solenoid: $4\pi \times 10^{-7} \times 28/0.1 \times I = 1.76 \times 10^{-4}$

$I = 0.5\ A$ opposite to the current in the circular coil.

**41** **Answer (B)**

The coil and the lamp are in parallel, and together in series with R.

Before: coil current $= 1/2 \times V_B/1.5R = V_B/3R$

After the lamp burns out: $V_B/2R$, so the flux density increases.

**42** **Answer (A)**

The coil's field (B) is opposite to the external field: the resultant is $0.5B$

Increasing the resistance by one third reduces the current to $3/4$ of its value, so the coil's field becomes $0.75B$

The resultant is $1.5B - 0.75B = 0.75B$, so it increases.

**43** **Answer (A)**

Moving the slider to Y decreases the resistance connected to the coil, so the current in it increases and the flux density increases.