Physics · Electric Current and Electromagnetism · Electromagnetic Induction

Mutual and Self Induction

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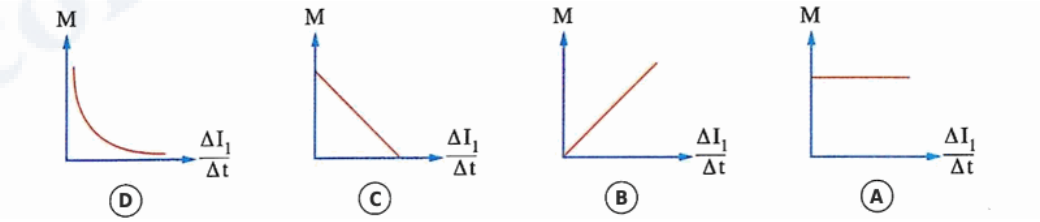
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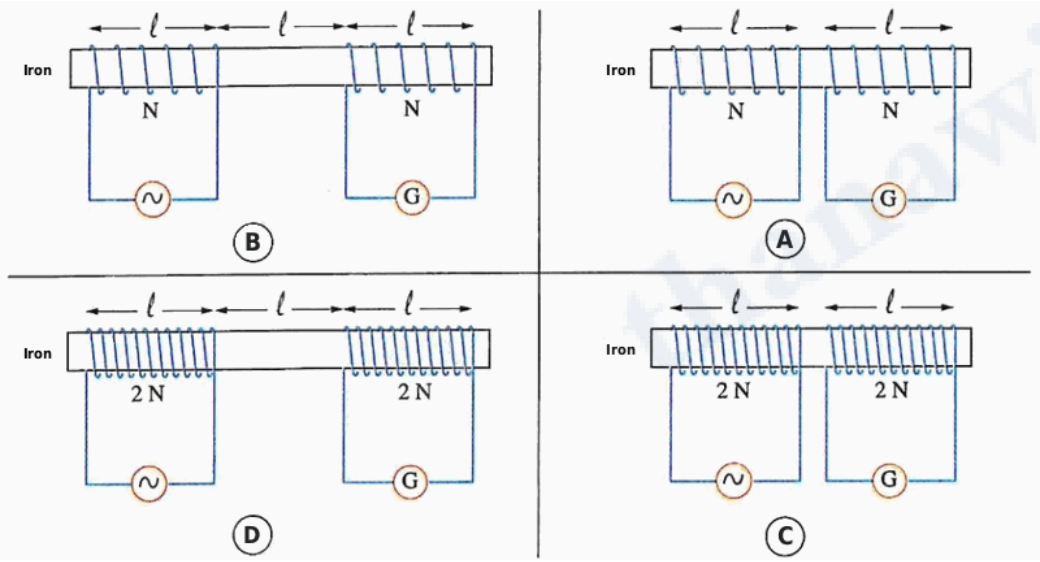
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Multiple choice questions — 76 questions

1 Which of the following graphs represents the relation between the mutual inductance (M) of two coils and the time rate of change of the current in the primary coil $((\Delta I_1)/(\Delta t))$?



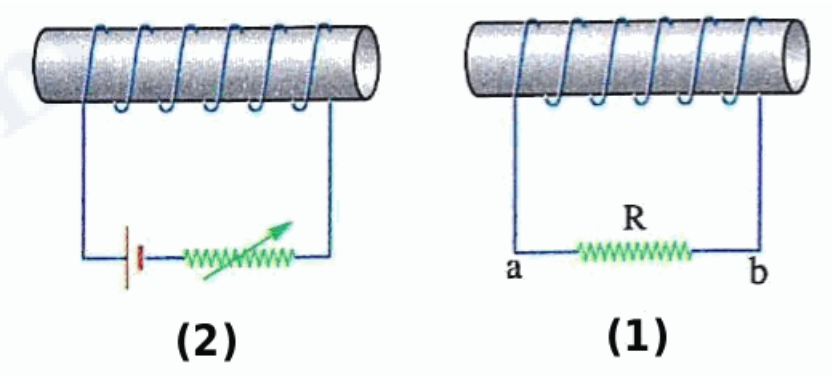
2 Which of the following pairs of coils has the greatest mutual inductance, if all the coils have the same area?



3 A primary coil connected to a DC source is placed inside a secondary coil. When the circuit of the primary coil is opened, the circuit of the secondary coil has .....

(A) a momentary direct induced current
(B) a momentary reverse induced current
(C) an alternating current
(D) a direct current (DC)

4 In the opposite figure, an induced current flows from point a to point b through resistor R in circuit (1) when .....



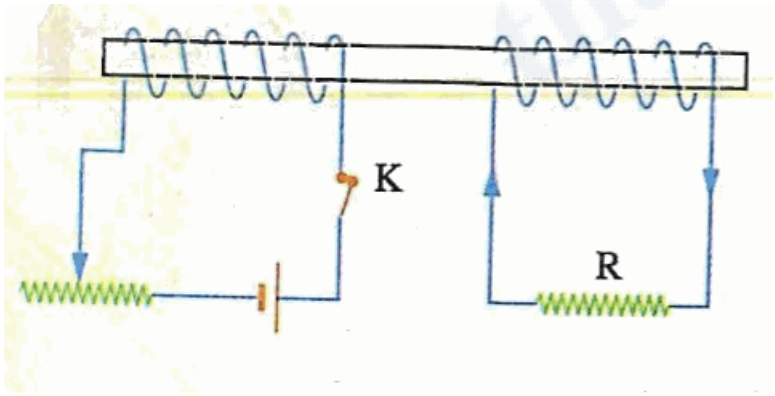
(A) both circuits are moved together to the right at the same speed

(B) one of the circuits is brought closer to the other

(C) the value of the rheostat in circuit (2) is increased

(D) the iron core is removed from one of the circuits

5 In the opposite circuit, an induced current is produced in the secondary coil in the direction shown in the figure as a result of .....



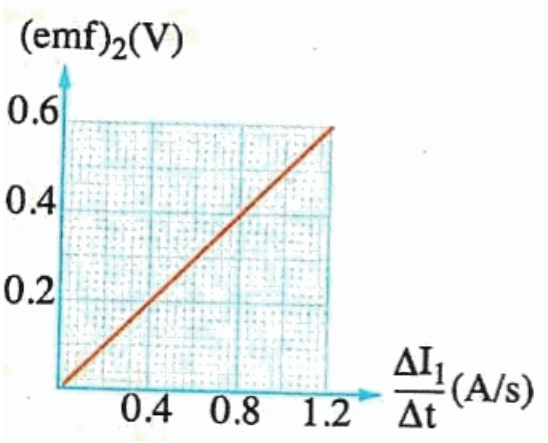
(A) opening switch K

(B) decreasing the resistance of the rheostat

(C) increasing the resistance of the rheostat

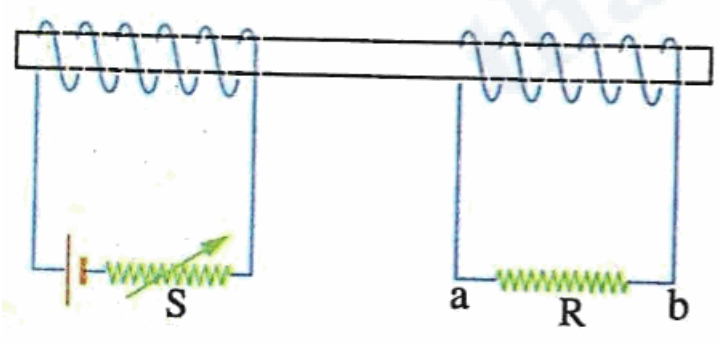
(D) moving the two coils away from each other

6 In an experiment to study mutual induction between two coils (1), (2), the relation between the induced emf $(emf)_2$ in coil (2) and the time rate of change of current $((\Delta I_1)/(\Delta t))$ in coil (1) was as shown in the opposite graph. The mutual inductance of the two coils is .....



(A) 0.1 H (B) 0.2 H (C) 0.4 H (D) 0.5 H

7 In the figure shown, while the variable resistance (S) is being increased, the potential of point a is .....



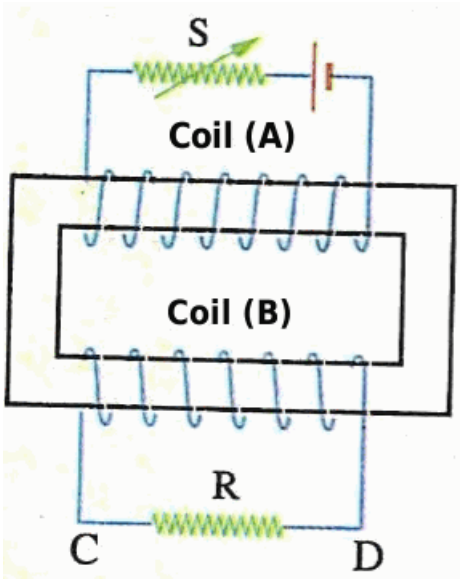
(A) greater than the potential of point b

(B) less than the potential of point b

(C) equal to the potential of point b

(D) The answer cannot be determined without knowing the value of resistance R

8 Two adjacent coils (A), (B): coil (A) is connected to an electric circuit and coil (B) is connected to a resistor (R) as in the opposite figure. When the value of the variable resistance (S) in the circuit of coil (A) is decreased, the electric potential at point (C) is .....



(A) greater than the electric potential at point (D)

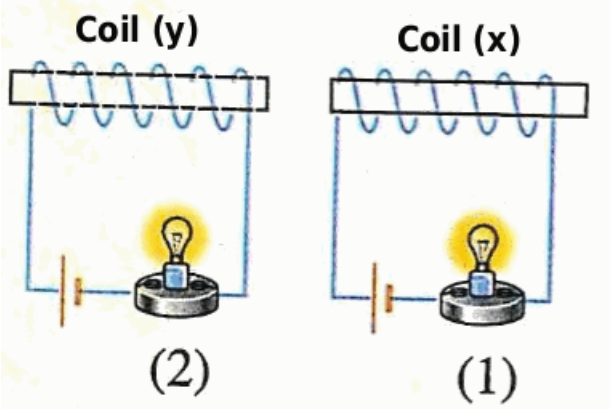
(B) less than the electric potential at point (D)

(C) equal to the electric potential at point (D)

(D) It cannot be determined

---

9 Two solenoids (x), (y) have the same axis, and each is connected to a lamp and a cell as in the opposite figure. While coil (x) is being moved away from coil (y), the brightness of .....



(A) lamp (1): increases, lamp (2): increases

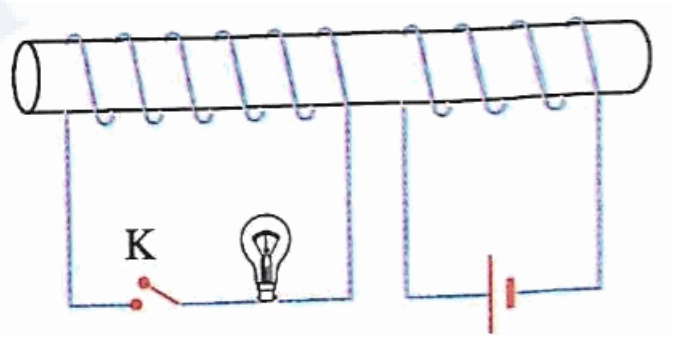
(B) lamp (1): increases, lamp (2): decreases

(C) lamp (1): decreases, lamp (2): increases

(D) lamp (1): decreases, lamp (2): decreases

---

10 Primary and secondary insulated coils are wound around an iron cylinder. The primary coil is connected to a battery, and the secondary coil is connected to an electric lamp and a switch (K) as in the opposite figure. When switch (K) is closed, the lamp .....



(A) lights for a moment then goes off

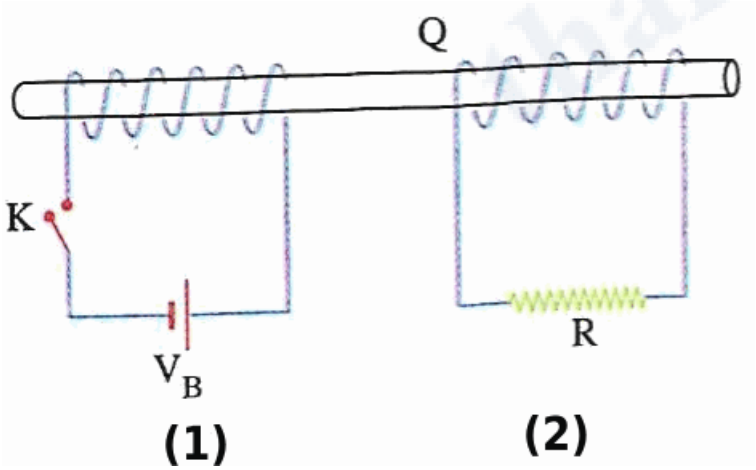
(B) lights and does not go off

(C) lights and its brightness decreases gradually until it goes off

(D) does not light at all

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11 In the opposite figure, at the moment circuit (1) is closed, in circuit (2) .....



(A) end Q: becomes a south pole, current direction: the same as the current in circuit (1)

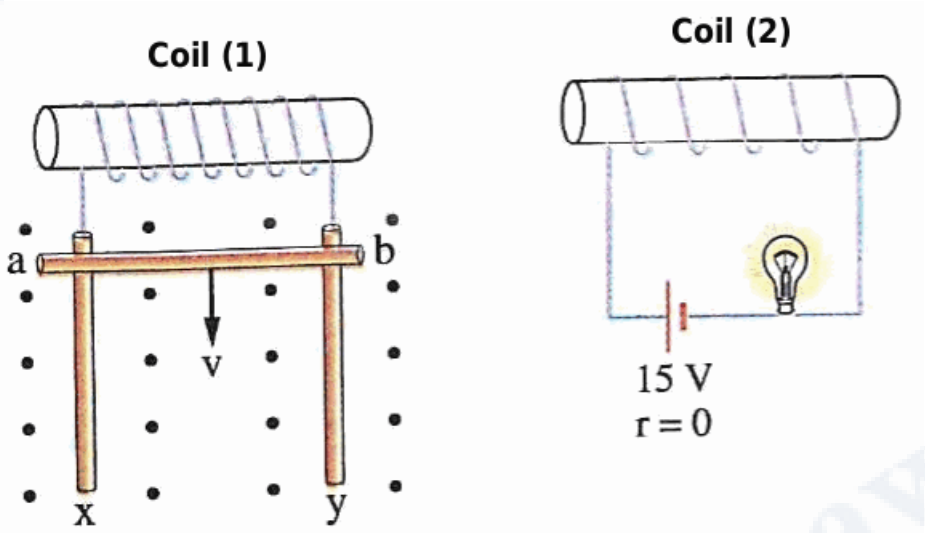
(B) end Q: becomes a north pole, current direction: the same as the current in circuit (1)

(C) end Q: becomes a south pole, current direction: opposite to the current in circuit (1)

(D) end Q: becomes a north pole, current direction: opposite to the current in circuit (1)

---

12 In the opposite figure, two adjacent coils (1), (2): the ends of coil (1) are connected to two metal rails (x), (y), each of resistance (R), and a metal rod (ab) touching them moves at a uniform speed (v) perpendicular to a uniform magnetic field, so an induced emf of 10 V is produced in it. The brightness of the lamp connected to the circuit of coil (2) while the rod is moving ..... compared with its brightness before the rod moved.



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

---

13 If the mutual inductance of two coils is 0.1 H and the current in the primary coil changes from 4 A to zero in 0.01 s, then the induced emf across the secondary coil equals .....

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

---

14 A primary coil 10 cm long with 200 turns carries a current of 4 A, and its core is made of iron with a permeability of 0.002 Wb/A.m. A secondary coil of 10^5 turns and diameter 3.5 cm is wound around it. If the current in the primary coil is cut off in 0.01 s, then:

(1) the emf produced in the secondary coil equals .....

(A) 1.54×10^5 V
(B) 4.32×10^5 V
(C) 6.21×10^6 V
(D) 8.8×10^6 V

---

15 A primary coil 10 cm long with 200 turns carries a current of 4 A, and its core is made of iron with a permeability of 0.002 Wb/A.m. A secondary coil of 10^5 turns and diameter 3.5 cm is wound around it. If the current in the primary coil is cut off in 0.01 s, then:

(2) the mutual inductance of the two coils equals .....

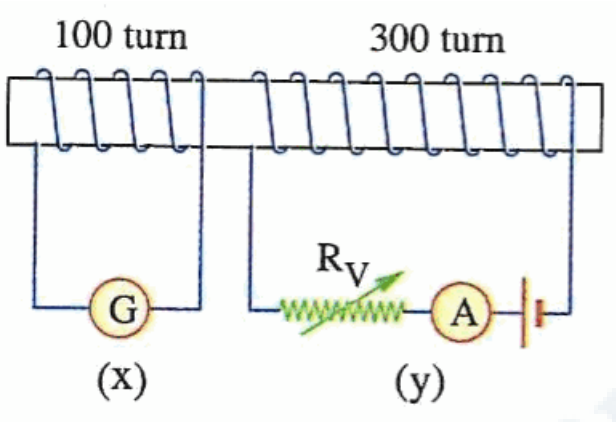
(A) 130 H
(B) 193 H
(C) 385 H
(D) 522 H

---

16 Two adjacent coils X, Y: coil Y has 2000 turns. If a current of 7 A passes through coil X and produces a flux of 2.5×10^{-4} Wb through coil Y, then the mutual inductance of the two coils equals .....

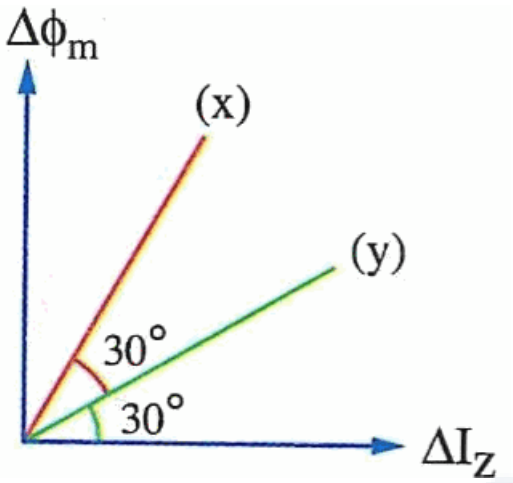
(A) 0.01 H (B) 0.03 H (C) 0.05 H (D) 0.07 H

17 The opposite figure shows two adjacent solenoids with a mutual inductance of 0.01 H. If the current in coil y changes by ΔI, the magnetic flux cutting coil x changes by 2×10^{-3} Wb in the same time. The change in current (ΔI) in coil y is .....



(A) 2 A (B) 5 A (C) 10 A (D) 20 A

18 Two secondary solenoids (x), (y) with N, 2 N turns respectively are each placed separately next to a primary coil (z), so that the primary and secondary coils have a common axis each time. The opposite graph shows the relation between the change in magnetic flux $(\Delta\varphi_m)$ passing through the secondary coil and the change in current (ΔI_z) in the primary coil. The ratio between the mutual inductances in the two cases $((M_{xz})/(M_{yz}))$ equals .....

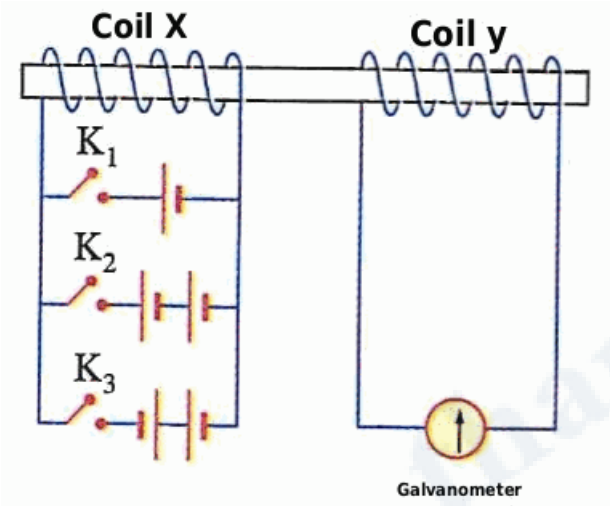


(A) 1/2 (B) 2/3 (C) 3/2 (D) 3

19 A current of 10 A passes through one of two adjacent coils whose mutual inductance is 0.3 H. When this current dies down to zero, an induced emf of 60 V is produced in the other coil. The time for the current in the first coil to die down equals .....

(A) 0.005 s (B) 0.05 s (C) 0.04 s (D) 0.4 s

20 In the opposite figure, two identical coils x, y each have a resistance R. Coil x is connected to identical cells of negligible internal resistance through several switches K_1, K_2, K_3. At the moment switch K_1 is closed, the pointer of the galvanometer connected to coil y deflects by an angle (θ). The deflection angle of the galvanometer pointer at the moment of .....



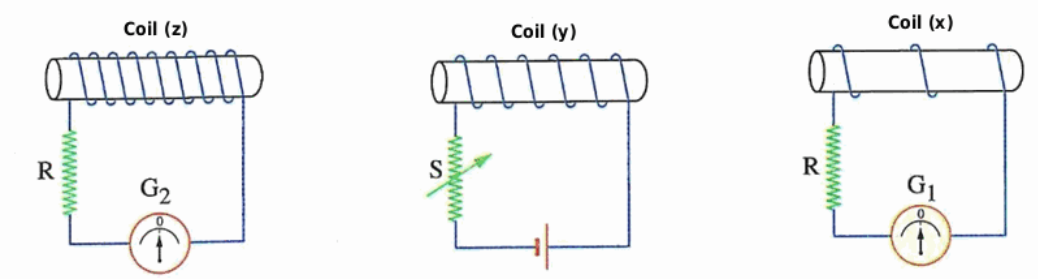
(A) closing switch K_2 only: greater than (θ), closing switch K_3 only: zero

(B) closing switch K_2 only: greater than (θ), closing switch K_3 only: greater than (θ)

(C) closing switch K_2 only: equal to (θ), closing switch K_3 only: zero

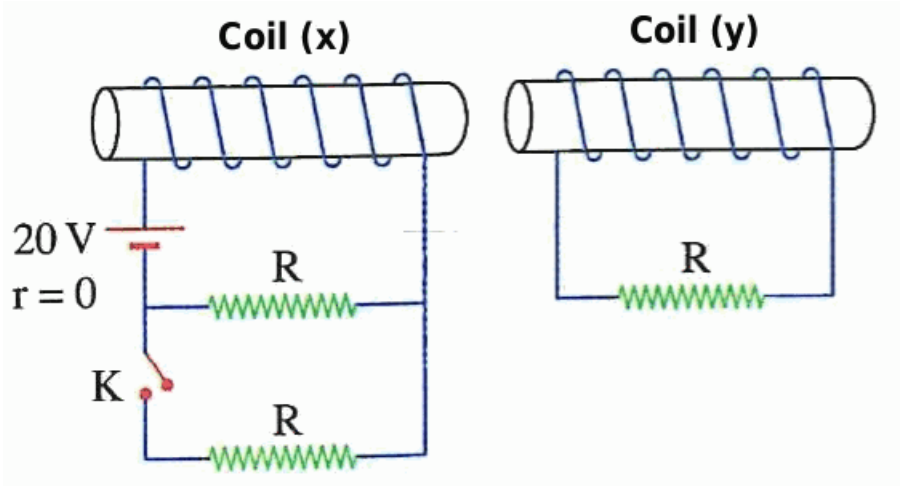
(D) closing switch K_2 only: less than (θ), closing switch K_3 only: less than (θ)

21 Three adjacent coils (x), (y), (z) of negligible resistance have the same length and a common axis, and their numbers of turns are N, 2 N, 3 N respectively. Each of coils (x), (z) is connected to a resistor (R) and a centre-zero galvanometer of resistance (R), and coil (y) is connected to a variable resistance (S) and a battery as shown in the following figure. When the value of the variable resistance (S) is decreased, the pointer of galvanometer (G_1) deflects by an angle (θ) to the right of zero. The pointer of galvanometer (G_2) deflects by an angle .....



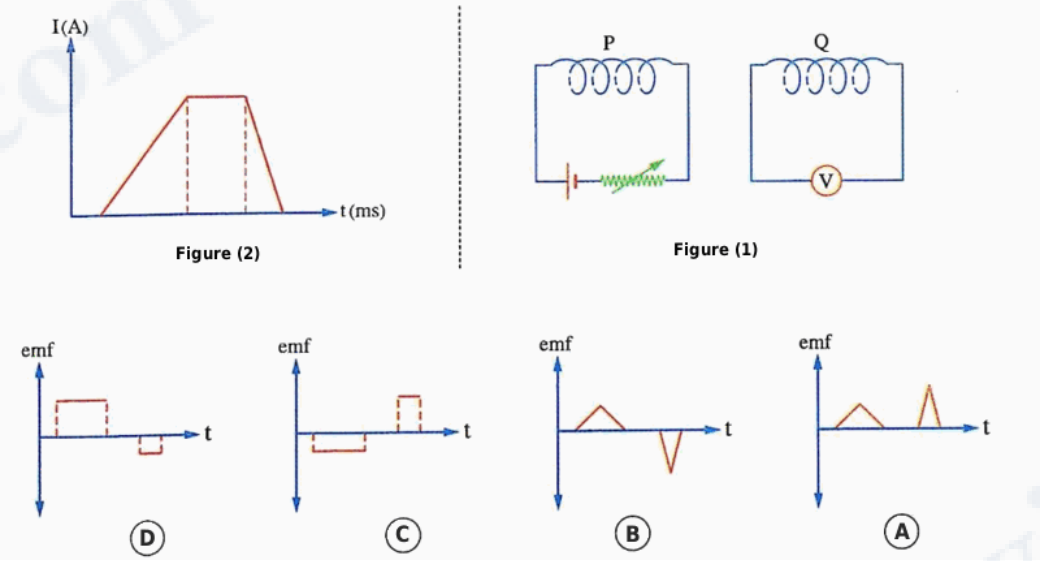
(A) equal to (θ) to the right of zero
(B) equal to (θ) to the left of zero
(C) greater than (θ) to the right of zero
(D) greater than (θ) to the left of zero

22 In the opposite figure, coils (x), (y) have negligible resistance and their mutual inductance is 0.01 H, and coil (x) carries a constant direct current. When switch (K) is closed, the current changes until it becomes steady in 0.25 s, and during that period the average induced emf in coil (y) is 0.04 V. The value of resistance (R) equals .....

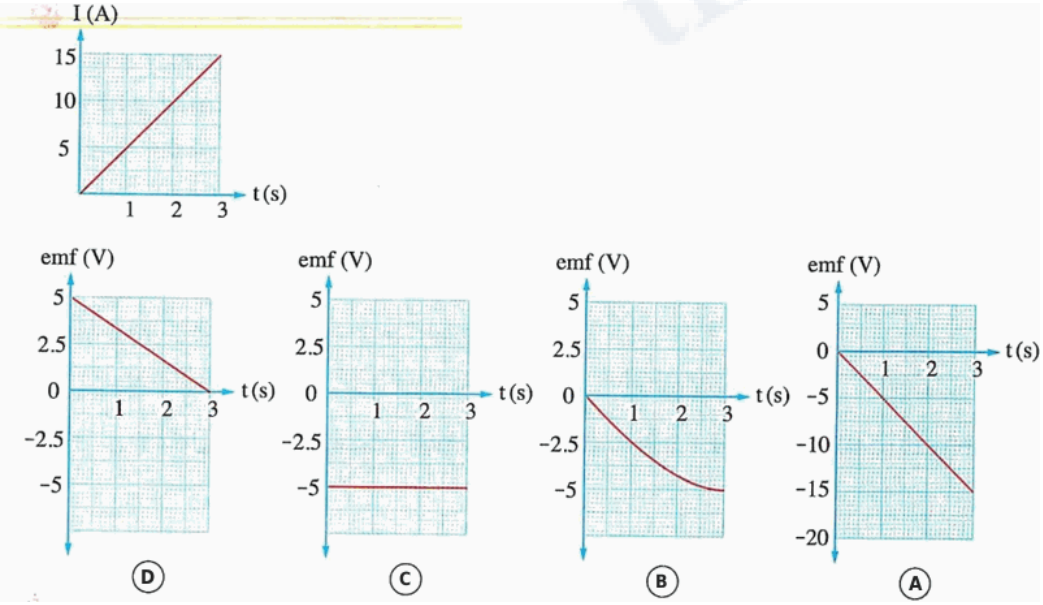


(A) 10 Ω
(B) 20 Ω
(C) 40 Ω
(D) 60 Ω

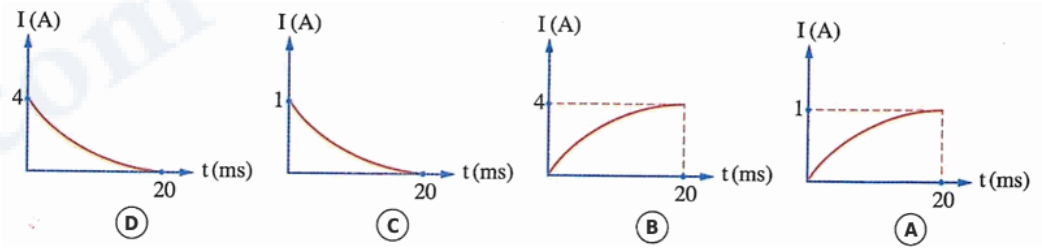
23 In figure (1), two adjacent solenoids P, Q, and figure (2) shows the graph of the relation between the current (I) in coil P and time (t). The graph that represents the relation between the induced emf in coil Q and time is .....



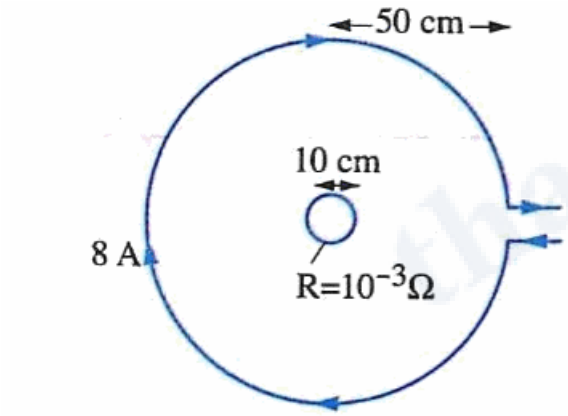
24 Two adjacent coils have a mutual inductance of 1 H. If the current in one of them changes with time as in the opposite graph, then the graph that represents the relation between the induced emf produced in the second coil and time is .....



25 Primary and secondary coils have a mutual inductance of 10 mH. Which of the following graphs represents the change of the primary coil current (I) with time (t) so that a reverse emf is produced in the secondary coil whose average over 20 ms is 2 V?



26 The opposite figure shows a small circular coil of one turn, radius 5 cm and resistance 10^{-3} Ω, placed at the centre of a large coil also of one turn and radius 50 cm. The large coil carries a current that changes uniformly from zero to 8 A in a time of 10^{-6} s. The induced current in the small coil during this time equals .....



(A) 49 A (B) 57 A (C) 66 A (D) 79 A

27 A circular coil x of 7 turns and radius 11 cm carries a current I. At its centre and in its plane is placed a circular coil y of resistance 50 Ω, 10 turns and area 5 cm². While coil x rotates through 180° about an axis in its plane, a charge of 20 nC passes through a cross-section of the wire of coil y. The current I in coil x equals .....

(A) 2.5 A (B) 5 A (C) 7.5 A (D) 10 A

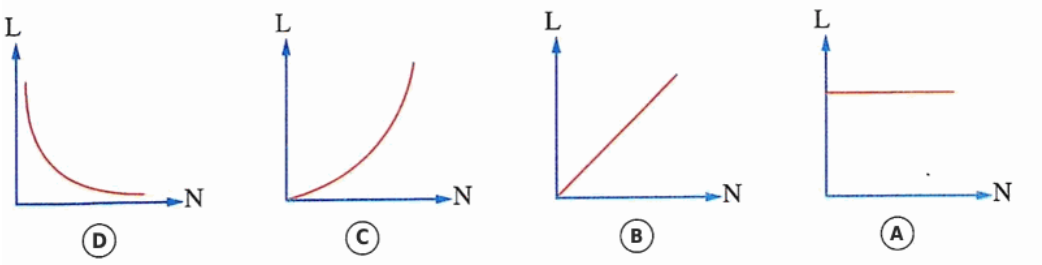
28 A long solenoid of diameter 5 cm has 2100 turns / metre. On its axis is placed a circular coil of 100 tightly wound turns and diameter 2 cm, so that the axes of the two coils coincide. If the current in the solenoid decreases from 1.5 A to zero at a constant rate in a time of 0.05 s, then increases to 1.5 A in the opposite direction in the same time, the average induced emf in the circular coil equals .....

(A) 2.49×10^{-3} V (B) 4.32×10^{-3} V (C) 6.34×10^{-3} V (D) 7.12×10^{-3} V

29 The self-inductance of a coil is measured in henry, which is equivalent to .....

(A) volt.second
(B) ohm.second
(C) ohm/second
(D) volt.second.ampere

30 Which of the following graphs represents the relation between the self-inductance (L) of a coil and the number of turns of the coil (N)?



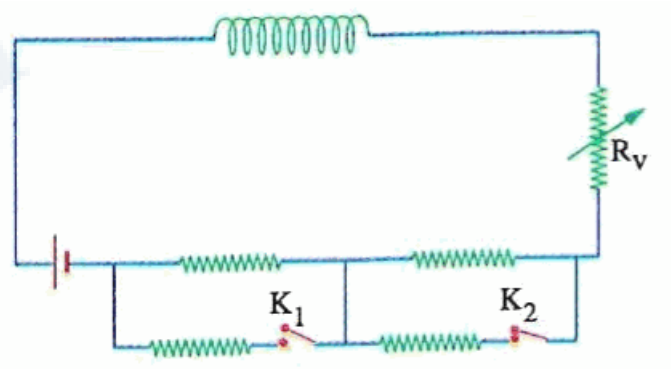
31 Some time after a direct current starts passing through an inductor, the current becomes steady because .....

(A) direct currents are produced
(B) eddy currents are produced
(C) self-induction stops
(D) reverse currents exist

32 The slow rate of growth of the current in a solenoid at the moment its circuit is closed is due to .....

(A) the production of a direct induced current
(B) the production of a reverse induced emf
(C) the electric charges in the coil losing their energy
(D) an increase in the ohmic resistance of the circuit

33 In the circuit shown, which of the following actions, each separately, causes a direct induced emf in the coil?



(A) Closing switch (K_1)

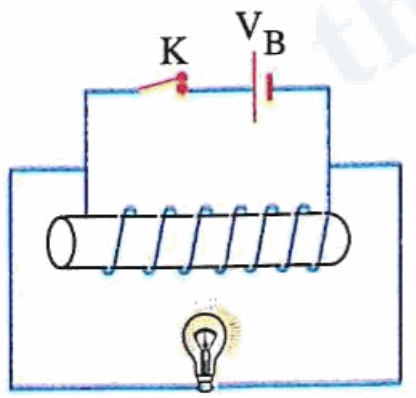
(B) Opening switch (K_2)

(C) Decreasing the value of the rheostat (R_V)

(D) Inserting an iron rod into the coil

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34 In the circuit shown in the figure, when switch (K) is opened, the brightness of the lamp .....



(A) increases gradually

(B) decreases gradually

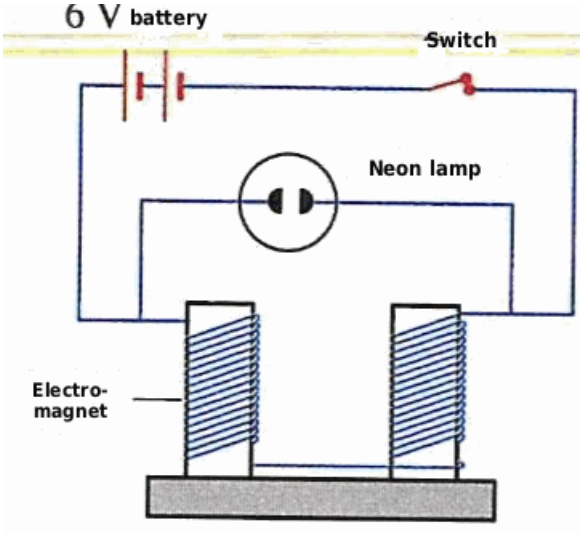
(C) increases for a moment then vanishes

(D) vanishes at once

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35 In the experiment shown in the opposite figure, if the neon lamp works at a voltage of not less than 180 V, then:

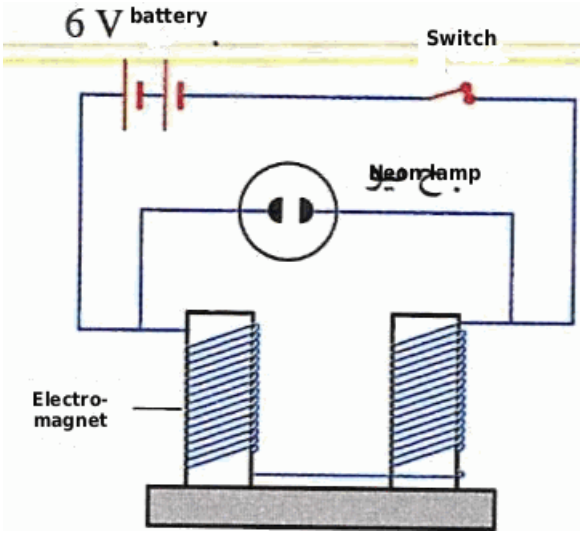
(1) the lamp lights at the moment the switch is opened because of .....



(A) the emf of the battery
(B) the reverse induced emf in the coil
(C) the direct induced emf in the coil
(D) There is no correct answer

36 In the experiment shown in the opposite figure, if the neon lamp works at a voltage of not less than 180 V, then:

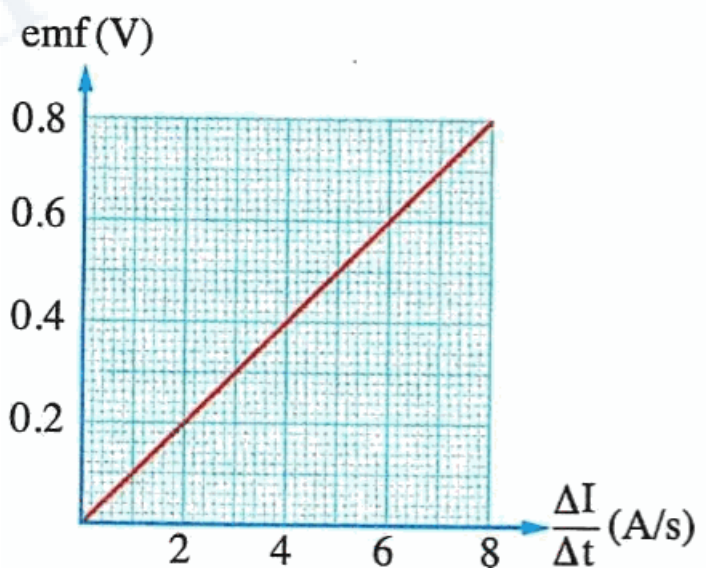
(2) the self-inductance of the coil is .....



(A) greatest at the moment the switch is closed
(B) greatest at the moment the switch is opened
(C) zero at the moment the switch is opened
(D) always constant

37 The opposite graph shows the relation between the self-induced emf in a coil and the rate of change of the current in it $((\Delta I)/(\Delta t))$:

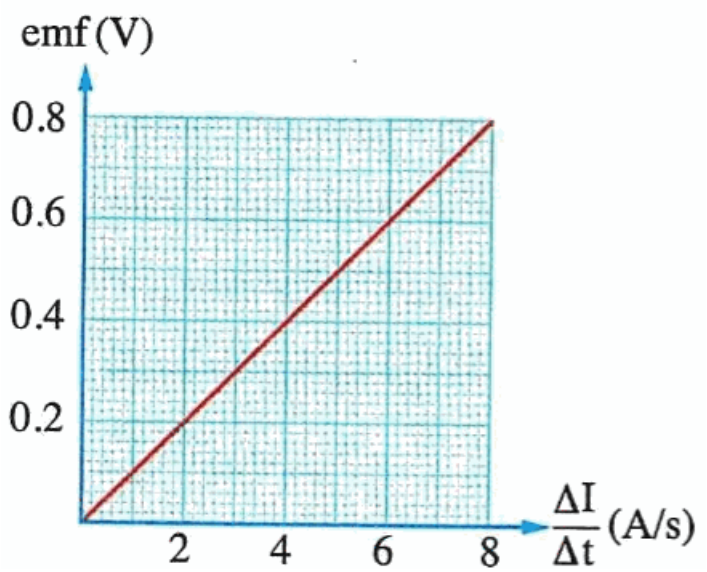
(1) the self-inductance of the coil (L) equals .....



(A) 0.1 H (B) 0.4 H (C) 0.6 H (D) 1 H

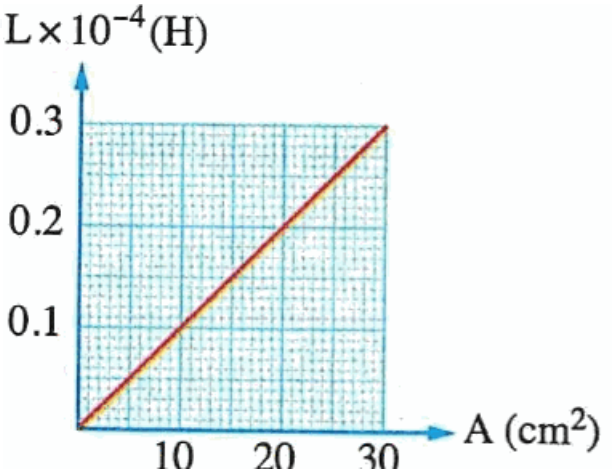
38 The opposite graph shows the relation between the self-induced emf in a coil and the rate of change of the current in it $((\Delta I)/(\Delta t))$:

(2) if the rate of change of current in the coil is 5 A/s, the induced emf in the coil equals .....



(A) 0.45 V (B) 0.5 V (C) 0.55 V (D) 0.6 V

39 Several air-core solenoids have the same length (ℓ). The opposite graph shows the relation between the self-inductance of each coil and the area of its face. If each coil has 100 turns, the length (ℓ) is .....



(A) 0.1 π m (B) 0.2 π m (C) 0.4 π m (D) 0.8 π m

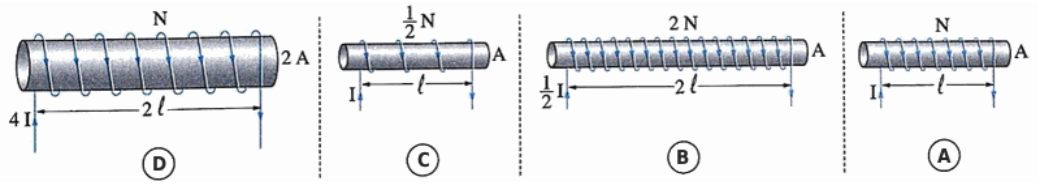
40 An inductor has a self-inductance L. When both its number of turns and its length are doubled while its cross-sectional area is kept constant, its self-inductance becomes .....

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

41 Which of the following changes doubles the self-inductance of a solenoid containing an iron rod, with the other factors kept constant?

(A) Doubling the number of turns
(B) Doubling the length of the coil
(C) Doubling the area of the coil
(D) Taking the iron rod out of the coil

42 In which of the following cases does the self-inductance of the coil have the greatest value, if the core of the coil is iron in all cases?



43 An air-core coil has a self-inductance of 0.1 H. If an iron core is placed in it, its self-inductance .....

(A) equals 0.1 H

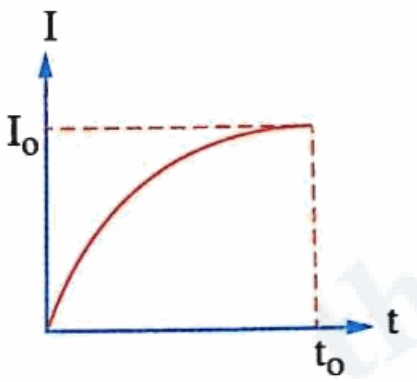
(B) is greater than 0.1 H

(C) is less than 0.1 H

(D) depends on the value of the alternating current in it

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44 The opposite graph shows the growth of the electric current in a hollow inductor from the moment its circuit is closed until it reaches its final value (I_o) after a time (t_o). If a soft iron core is placed inside the coil, the time taken by the current in the coil from the moment its circuit is closed until it reaches its final value (I_o) is .....



(A) greater than t_o

(B) less than t_o

(C) equal to t_o

(D) The answer cannot be determined

---

45 A long inductor has N turns and a self-inductance of 1 H. When a current of 2 A passes through this coil, a flux of 4×10^{-3} Wb is produced. The number of turns N is .....

(A) 200 turns (B) 300 turns (C) 500 turns (D) 1000 turns

---

46 A solenoid has 100 turns. If the current in it changes by 4 A, the flux cutting it changes by 0.05 Wb in the same time. The self-inductance of the coil equals .....

(A) 4 H (B) 0.5 H (C) 1.25 H (D) 0.2 H

---

47 A solenoid has 300 turns and a self-inductance of 6×10^{-3} H. If the current in it changes at a rate of 2 A/s, the rate of change of the magnetic flux produced through the coil equals .....

(A) 2×10^{-5} Wb/s (B) 4×10^{-5} Wb/s (C) 6×10^{-5} Wb/s (D) 8×10^{-5} Wb/s

---

48 A coil of self-inductance 0.03 henry made of 100 turns carries an electric current that produces a magnetic flux of 6×10^{-4} weber through it. If the current in the coil falls to zero in 0.02 of a second, then:

(1) the average induced emf in the coil equals .....

(A) 3 V (B) 6 V (C) 9 V (D) 12 V

49 A coil of self-inductance 0.03 henry made of 100 turns carries an electric current that produces a magnetic flux of 6×10^{-4} weber through it. If the current in the coil falls to zero in 0.02 of a second, then:

(2) the current that was passing through the coil equals .....

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

50 Two solenoids: the first has length ℓ, face area A and N turns, and the second has length $1/2$ ℓ, face area 2 A and $1/4$ N turns. The ratio between their self-inductances (L_1/L_2) equals .....

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

51 A hollow solenoid has a self-inductance of 2×10^{-4} H, and when it is wound around an iron rod its self-inductance becomes 0.3 H. The ratio between the magnetic permeabilities of air and iron respectively is .....

(A) $1/1600$ (B) $1/1000$ (C) $1/1500$ (D) $3/500$

52 A straight wire of length ℓ is wound into a circular coil twice: once as coil (x) of diameter d, and once as coil (y) of diameter 2 d. The ratio between the self-inductances of the two coils (L_x/L_y) equals .....

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

53 A solenoid of 500 turns and length 0.4 m, with each turn having an area of 40 cm², is connected to a current source, so a current of 2 A passes through it. If the current is cut off in 0.1 s, the direct induced emf equals ..... (Given: $\pi = 3.14$)

(A) 8.2×10^{-2} V (B) 6.28×10^{-2} V (C) 9.4×10^{-3} V (D) 6.28×10^{-3} V

54 A solenoid 10 cm long has 40 uniformly wound turns, and the area of each turn is $70/22$ cm², then:

(1) its self-inductance equals .....

(A) 3.2×10^{-6} H (B) 4.8×10^{-6} H (C) 6.4×10^{-6} H (D) 7.6×10^{-6} H

55 A solenoid 10 cm long has 40 uniformly wound turns, and the area of each turn is $70/22$ cm², then:

(2) its self-inductance if 10 turns are cut off equals .....

(A) 1.5×10^{-6} H (B) 2.2×10^{-6} H (C) 3.4×10^{-6} H (D) 4.8×10^{-6} H

56 When the current in an inductor changes at a rate of 20 A/s, an induced emf of 5 V is produced in it. Its self-inductance is .....

(A) 0.18 H (B) 0.2 H (C) 0.22 H (D) 0.25 H

57 A coil has a self-inductance of 0.005 H. An induced emf of 5 V is produced across its ends when the current changes from 10 A to zero. The time of the change in current equals .....

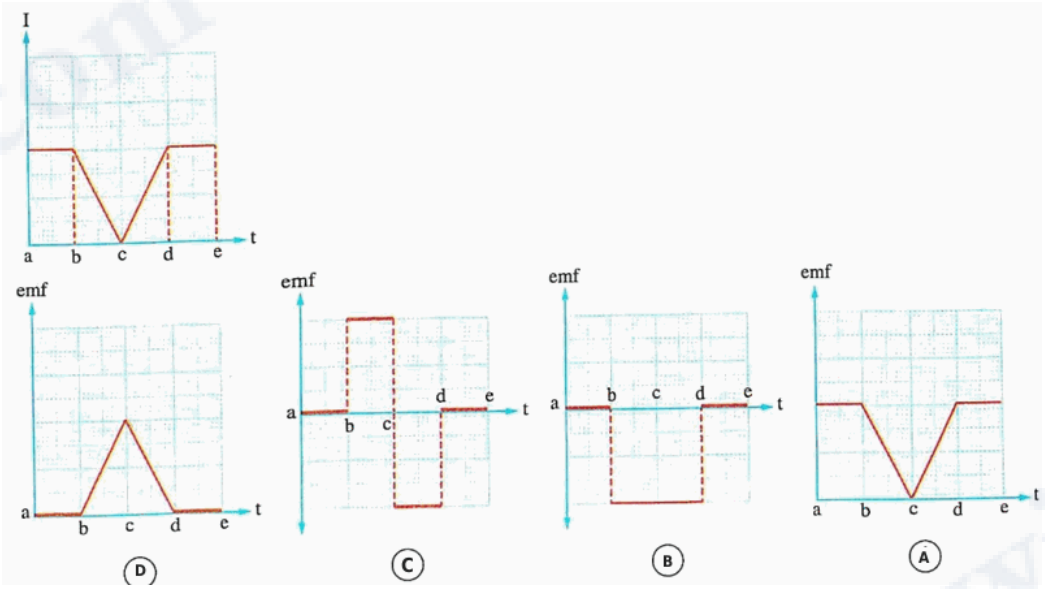
(A) 0.01 s (B) 0.02 s (C) 0.03 s (D) 0.04 s

58 Resistors are made of double-wound wires .....

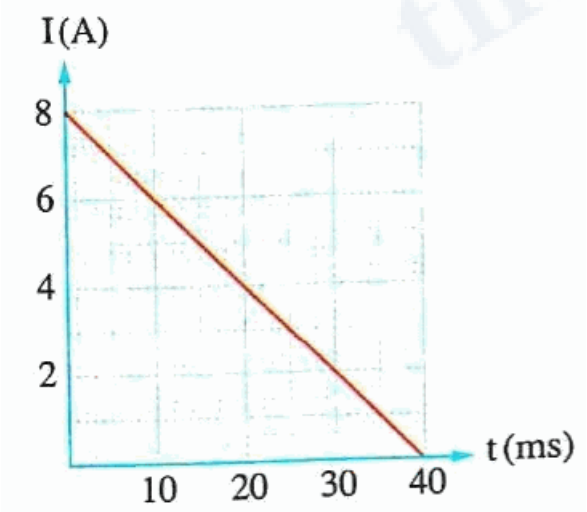
(A) to decrease the resistance of the wire (B) to increase the resistance of the wire

(C) to avoid self-induction (D) to make the resistance of the wire zero

59 The opposite figure shows the relation between the current (I) in an inductor and time (t). Which of the following figures expresses the relation between the induced emf in the coil and time (t)?

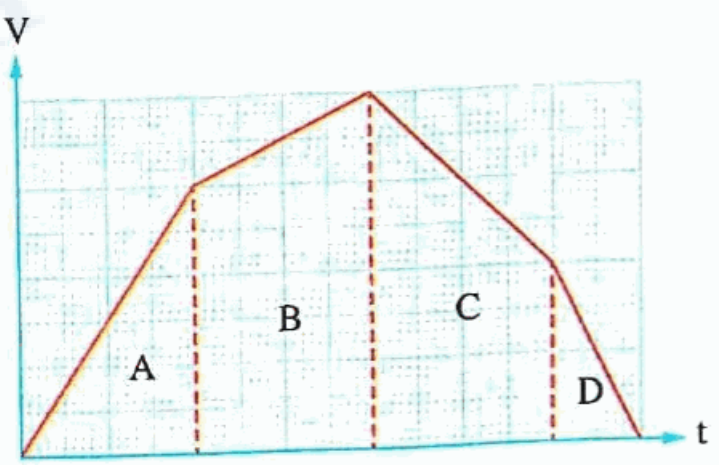


60 The opposite graph shows the relation between the current (I) in a solenoid and time (t). If the self-inductance of the coil is 60 mH, the induced emf in it equals .....

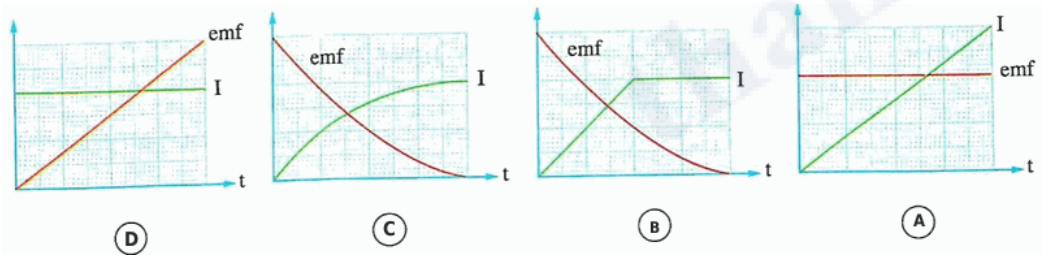


(A) 10 V (B) 12 V (C) 20 V (D) 24 V

61 An inductor of ohmic resistance (R) is connected in a closed electric circuit, and the potential difference (V) across it is changed with time (t) as in the opposite graph. The greatest direct induced emf is produced in the coil during stage .....



62 An electric circuit consists of an inductor of ohmic resistance (R), a battery and a switch, all connected in series. The graph that represents the change of both the induced emf in the coil and the current (I) in it with time (t) when the circuit is closed is .....



63 In the circuit shown in figure (1), when switches K_1, K_2 are each closed separately, the current in the circuit grows as in curves (1), (2) respectively, shown in figure (2), then:
(1) the relation between the values of the two resistances (R_1), (R_2) is .....

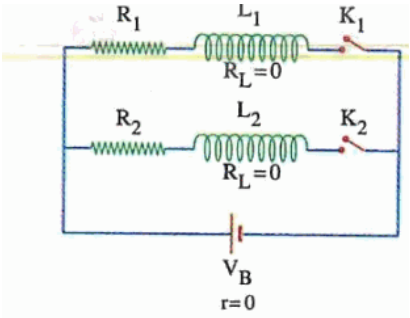


Figure (1)

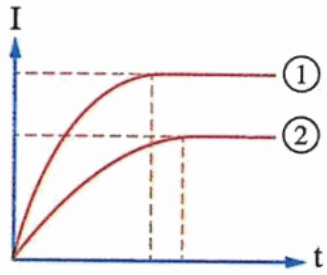


Figure (2)

(A) $R_1 > R_2$
(B) $R_1 < R_2$
(C) $R_1 = R_2$
(D) The answer cannot be determined

64 In the circuit shown in figure (1), when switches K_1, K_2 are each closed separately, the current in the circuit grows as in curves (1), (2) respectively, shown in figure (2), then:
(2) the relation between the self-inductances of the two coils (L_1), (L_2) is .....

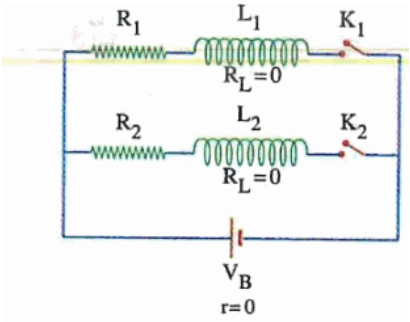


Figure (1)

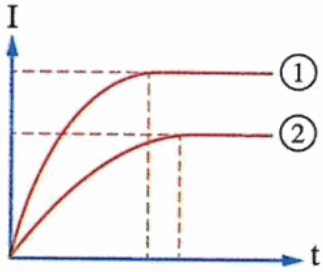


Figure (2)

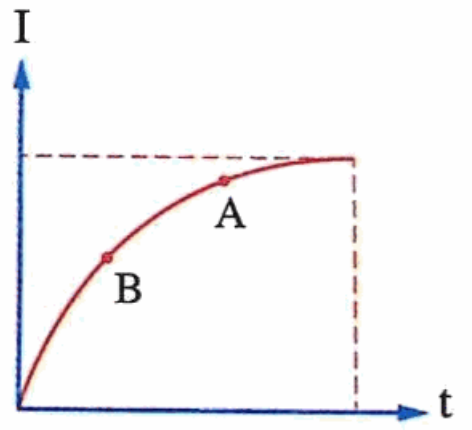
(A) $L_1 > L_2$

(B) $L_1 < L_2$

(C) $L_1 = L_2$

(D) The answer cannot be determined

65 The opposite graph shows the curve of current growth in an inductor connected to a battery from the moment its circuit is closed. The physical quantity whose value at point B is less than its value at point A is .....



(A) the self-inductance of the coil

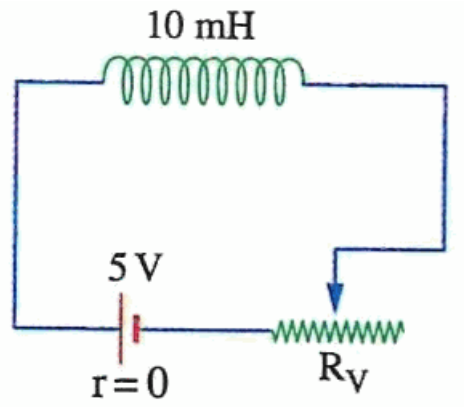
(B) the reverse induced emf in the coil

(C) the time rate of change of current in the coil

(D) the net emf in the circuit

---

66 The opposite figure shows an electric circuit containing a battery of emf 5 V and negligible internal resistance, an inductor of self-inductance 10 mH and negligible ohmic resistance, and a variable resistance (R_V). If the variable resistance (R_V) is increased gradually and its value at a certain moment is 10 Ω, then the current in the circuit at that moment is .....



(A) equal to 0.5 A

(B) greater than 0.5 A

(C) less than 0.5 A and not zero

(D) equal to zero

---

67 A coil of resistance 15 Ω and self-inductance 0.6 H is connected to a DC source giving 120 V. The rate at which the current grows in the following cases:

(1) at the moment of connection equals .....

(A) 50 A/s (B) 100 A/s (C) 175 A/s (D) 200 A/s

68 A coil of resistance 15 Ω and self-inductance 0.6 H is connected to a DC source giving 120 V. The rate at which the current grows in the following cases:

(2) at the moment the current reaches 80% of its maximum value equals .....

(A) 20 A/s (B) 40 A/s (C) 60 A/s (D) 80 A/s

69 Two adjacent coils A, B have 500 turns and 2000 turns respectively. If the current in coil A changes by 10 A, the magnetic flux in coil A changes by 2×10^{-3} Wb and in coil B by 10^{-4} Wb, then:

(1) the self-inductance of coil A equals .....

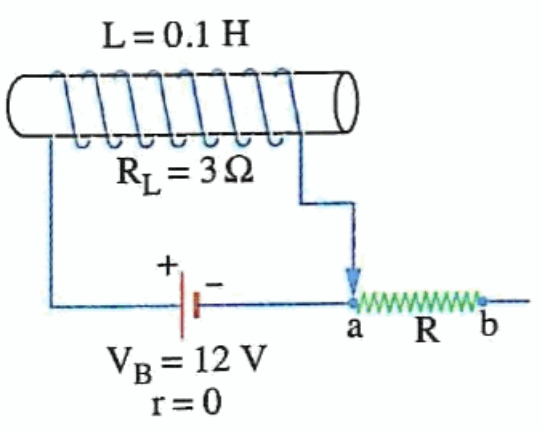
(A) 0.1 H (B) 0.4 H (C) 0.6 H (D) 0.8 H

70 Two adjacent coils A, B have 500 turns and 2000 turns respectively. If the current in coil A changes by 10 A, the magnetic flux in coil A changes by 2×10^{-3} Wb and in coil B by 10^{-4} Wb, then:

(2) the mutual inductance of the two coils equals .....

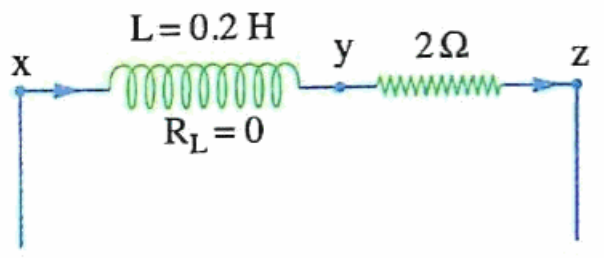
(A) 0.08 H (B) 0.05 H (C) 0.02 H (D) 0.01 H

71 An electric circuit contains a battery of emf 12 V and negligible internal resistance, an inductor of self-inductance 0.1 H and ohmic resistance 3 Ω, and a rheostat (R) as in the opposite figure. When the slider is moved from position (a) to position (b) in a time of 0.02 s, an induced emf of 15 V is produced in the coil. The resistance of the rheostat (R) when the slider is at position (b) equals .....



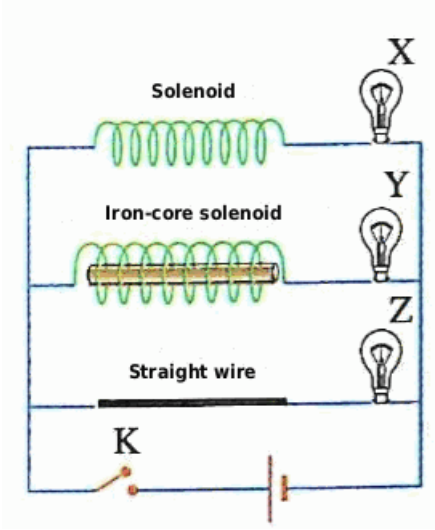
(A) 3 Ω (B) 6 Ω (C) 9 Ω (D) 12 Ω

72 The opposite figure shows part of an electric circuit containing a 2 Ω resistor and an inductor of self-inductance 0.2 H with negligible ohmic resistance. If at a certain moment the current in the coil is increasing at a rate of 20 A/s and the current at that moment is 2 A, then the potential difference between points x and z equals .....



(A) 0 (B) 4 V (C) 8 V (D) 12 V

73 A straight wire and two solenoids with the same ohmic resistance are connected with three identical lamps (X, Y, Z), a battery and a switch as in the opposite figure. The correct order of the lamps according to the time needed to reach maximum brightness when switch (K) is closed is .....

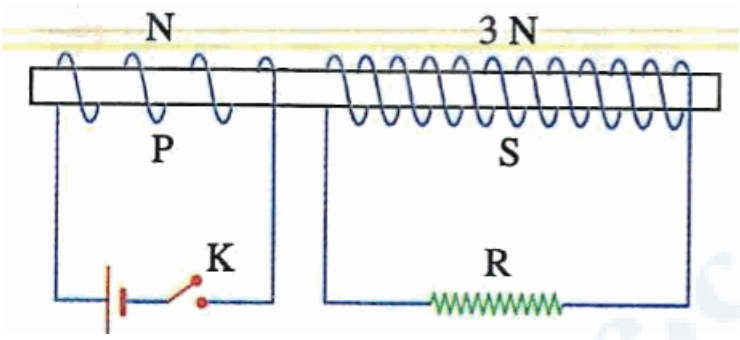


(A) $Z = Y = X$ (B) $Z > X > Y$ (C) $Y > X > Z$ (D) $Y = X > Z$

74 Two insulated solenoids x, y, one inside the other, are equal in length and cross-sectional area, with N_x, N_y turns respectively, wound around a soft iron core. Coil (x) is connected to a cell and a rheostat and has a self-inductance (L_x), and coil (y) is connected to a galvanometer and wound around coil (x). The mutual inductance of the two coils (M) equals .....

(A) $L_x\, N_x/N_y$ (B) $L_x\, N_y/N_x$ (C) $L_x(N_x/N_y)^2$ (D) $L_x(N_y/N_x)^2$

75 In the opposite figure, two adjacent solenoids P, S have N, 3 N turns respectively. When the circuit of coil P is closed, the change in magnetic flux through coil S equals 60% of the change in magnetic flux through coil P. The ratio between the mutual inductance of the two coils and the self-inductance of coil P respectively equals .....



(A) 0.2 (B) 0.6 (C) 1.2 (D) 1.8

76 Two adjacent coils are wound around a soft iron rod. The ends of the primary coil are connected in series to a battery of emf 20 V and a switch, and an induced emf of 5 V is produced across the secondary coil at the moment the primary circuit is closed. If the self-inductance of the primary coil is 0.04 H, then the mutual inductance of the two coils equals .....

(A) 10^{-3} H (B) 0.01 H (C) 0.05 H (D) 0.1 H

Essay questions — 12 questions

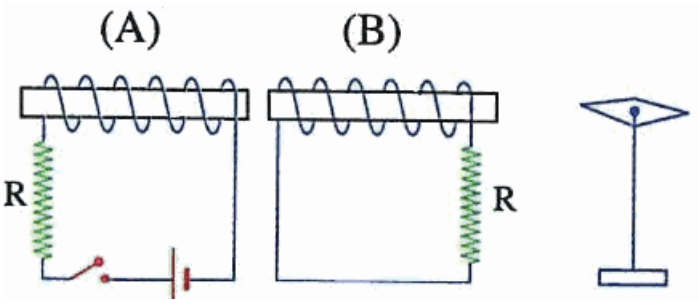
1 In the opposite figure, what kind of magnetic pole of the magnetic needle faces coil B in the following cases:

(1) at the moment the circuit of coil A is closed?

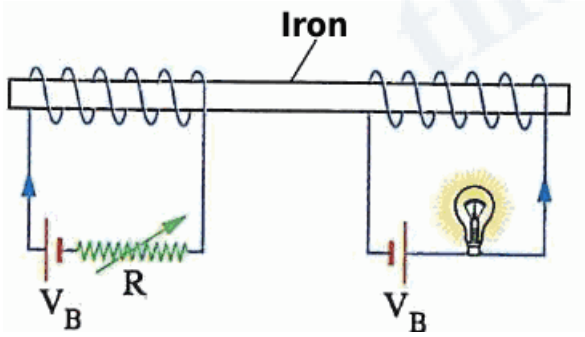
(2) while coil A, with its circuit closed, is brought closer to coil B?

(3) while coil A, with its circuit closed, is moved away from coil B?

(4) at the moment the circuit of coil A is opened?



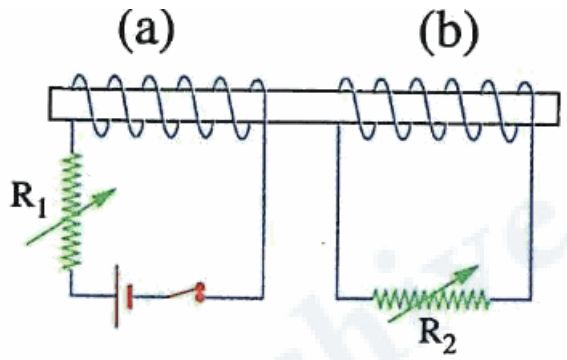
2 In the opposite figure, what happens to the brightness of the lamp while the value of resistance R is increased uniformly? Give a reason.



3 In the opposite figure, two electric circuits each contain a variable resistance R_1, R_2. In which of the following two cases is an emf produced in coil b? Give the reason:

(1) while R_1 is increased?

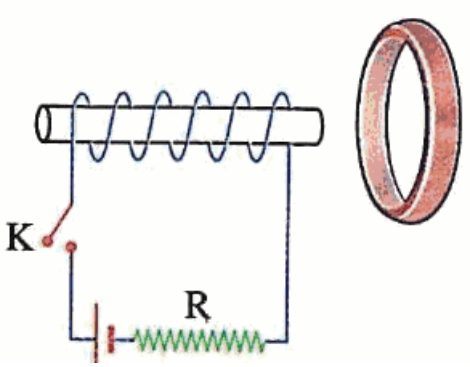
(2) while R_2 is increased?



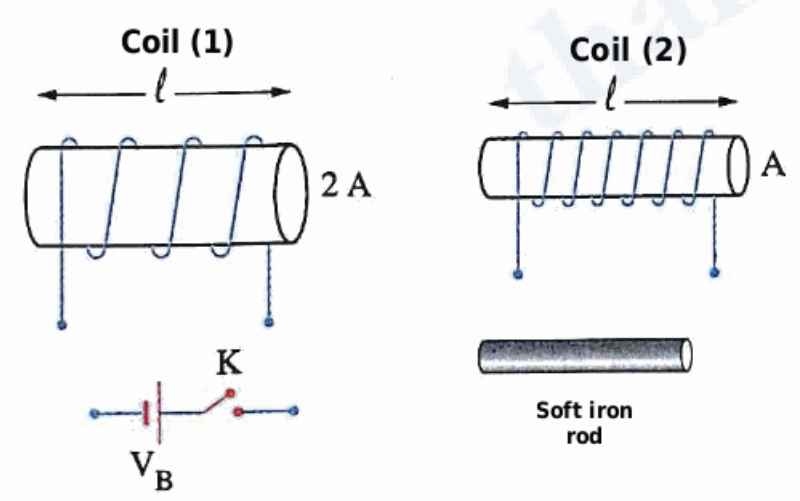
4 The opposite figure shows a metal ring placed in front of one face of a solenoid, so that the plane of the ring is perpendicular to the axis of the solenoid. Determine the direction of the induced current (if any) on the face of the metal ring facing the coil:

(1) at the moment switch K is closed

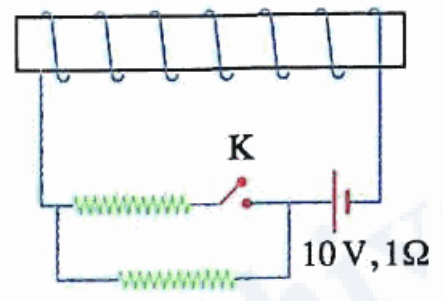
(2) after the current reaches its steady value (given by Ohm's law) in the circuit of the coil.



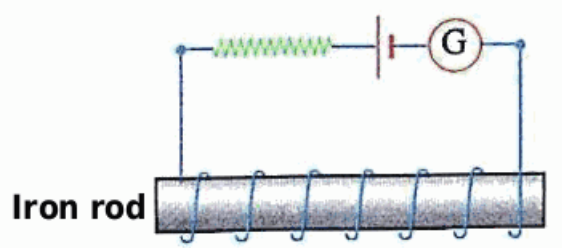
5 The opposite figure shows two solenoids (1), (2), a battery V_B, a switch K and a soft iron rod. Describe how you can arrange these tools so that the mutual inductance of the two coils is as large as possible.



6 In the circuit shown, is the induced emf in the coil direct or reverse at the moment switch K is closed? Explain your answer.



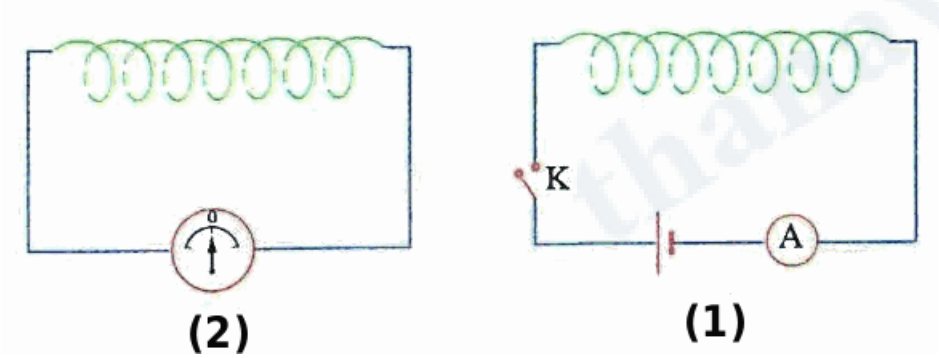
7 In the opposite circuit, describe with explanation what happens to the galvanometer reading when the iron rod is pulled out of the coil very quickly.



8 In the opposite figure, coil (1) is connected in series with a cell, a switch (K) and an ammeter (A), and coil (2) is connected to a sensitive centre-zero galvanometer. State with explanation what you will notice about the reading of each of the ammeter and the galvanometer in the following two cases:

(1) when switch (K) is closed.

(2) when switch (K) is closed with a soft iron rod in each of the two coils.



9 A solenoid 1.1 m long has 700 turns and a face area of $10\ cm^2$, and carries a current of 2 A. Calculate:

(1) the induced emf in the coil if the current falls to zero in 0.01 s

(2) the self-inductance of the coil.

10 When the self-inductance of an inductor is increased, what happens, with explanation, to the time of each of:

(1) the growth of the current from the moment the coil circuit is closed?

(2) the decay of the current from the moment the coil circuit is opened?

11 State the physical quantities measured by the following units, and give the equivalent unit of each:

(1) Ω.s

(2) $T.m^2/s$

(3) V.s

(4) Ω.C

(5) V.s/A.m

(6) $V.s/m^2$

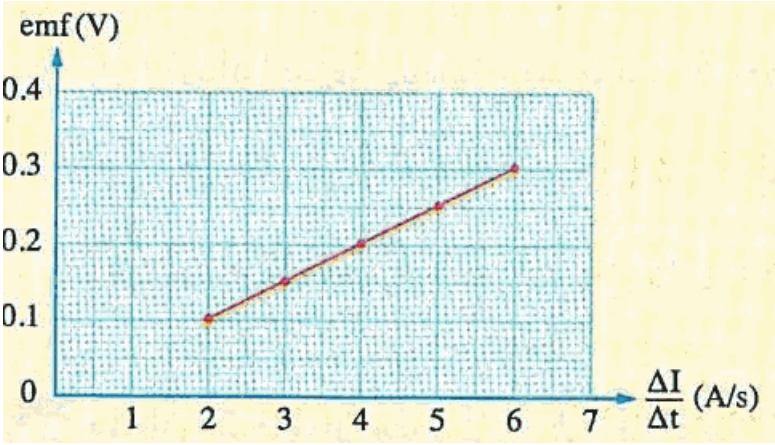
(7) J.s/A.C

(8) Wb/A

12 Why are the wires of standard resistors double-wound?

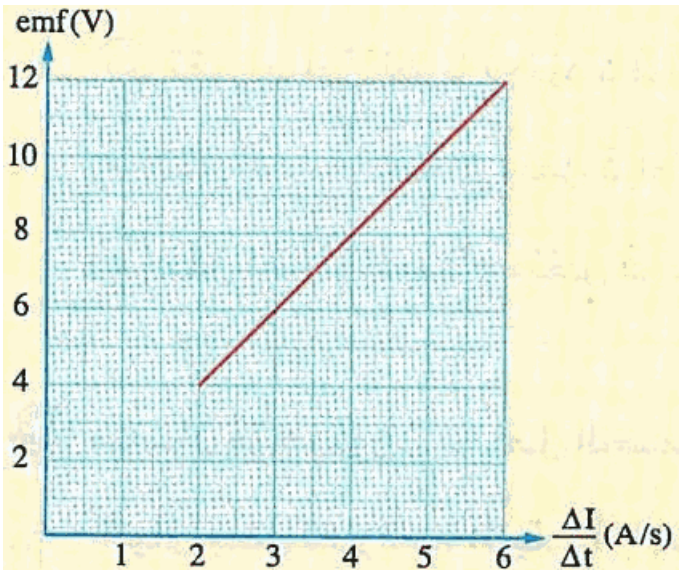
Past exam questions — 21 questions

1 The opposite graph shows the relation between the induced emf in a secondary coil and the rate of change of current in a primary coil $((\Delta I)/(\Delta t))$. The mutual inductance of the two coils equals ..... (Trial exam / June 2021)



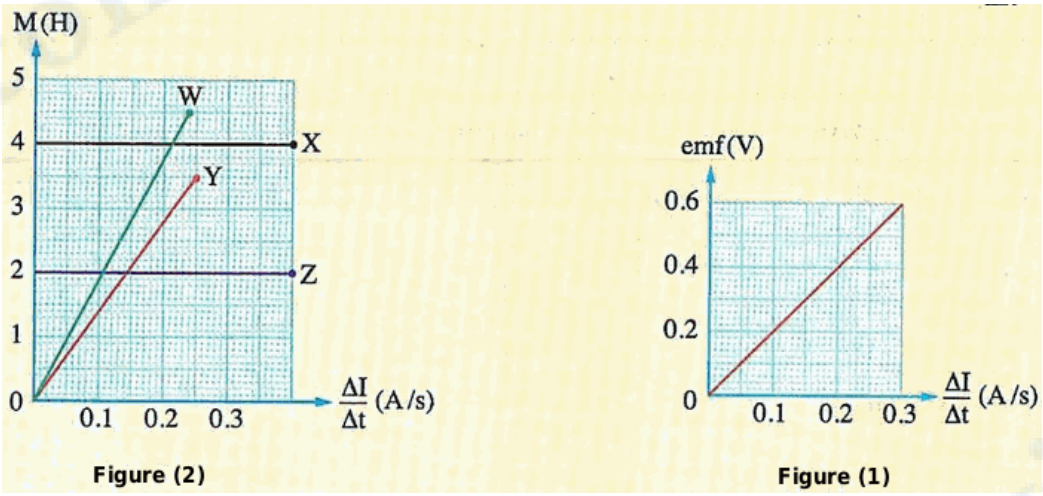
(A) 0.05 mH (B) 50 mH (C) 0.04 mH (D) 40 mH

2 The opposite graph shows the relation between the induced emf in a secondary coil and the rate of change of current in a primary coil next to it $((\Delta I)/(\Delta t))$. The mutual inductance between them is ..... (1st session 2021)



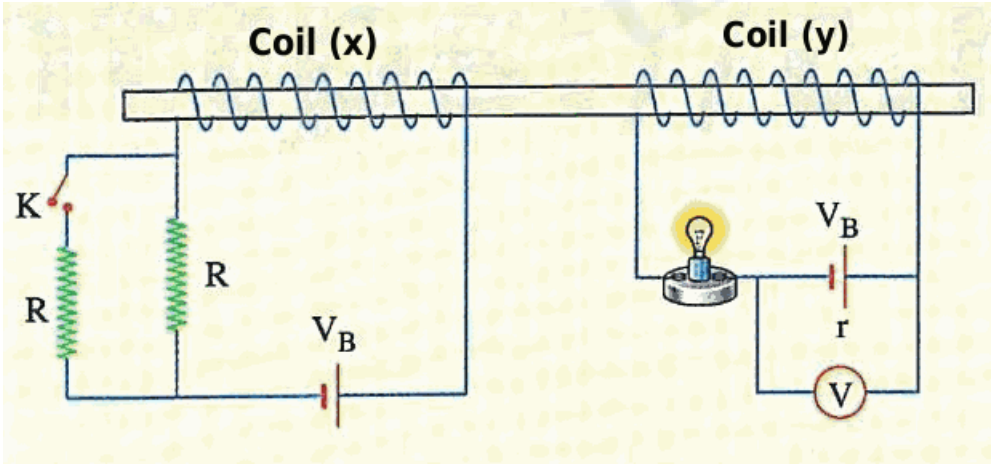
(A) 1.6 H (B) 6 H (C) 0.5 H (D) 2 H

3 Figure (1) shows the graph of the relation between the induced emf in a secondary coil and the rate of change of current $((\Delta I)/(\Delta t))$ in a primary coil next to it. Which of the lines W, X, Y, Z in figure (2) represents the relation between the mutual inductance of the two coils (M) and the rate of change of current in the primary coil? (2nd session 2021)



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

4 The opposite figure shows two identical adjacent coils (y), (x). At the moment switch (K) in the circuit of coil (x) is closed, ... (1st session 2022)



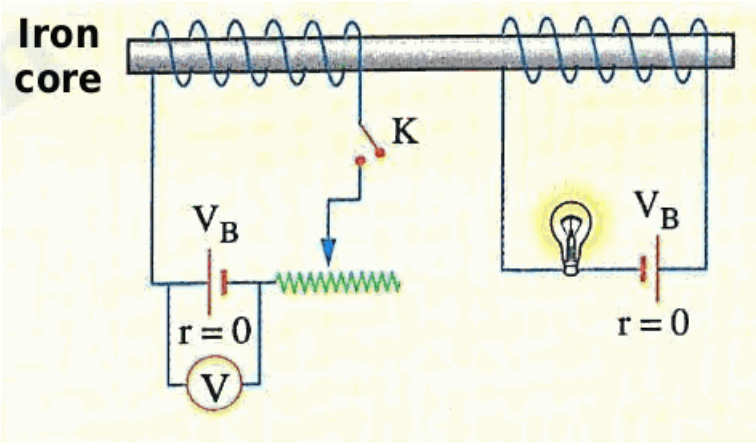
(A) the brightness of the lamp decreases while the voltmeter reading increases

(B) the brightness of the lamp increases while the voltmeter reading decreases

(C) both the brightness of the lamp and the voltmeter reading decrease

(D) both the brightness of the lamp and the voltmeter reading increase

5 Two adjacent coils are wound on an iron core as in the figure. At the moment switch K is closed, ... (2nd session 2022)



(A) the brightness of the lamp increases and the voltmeter reading stays constant

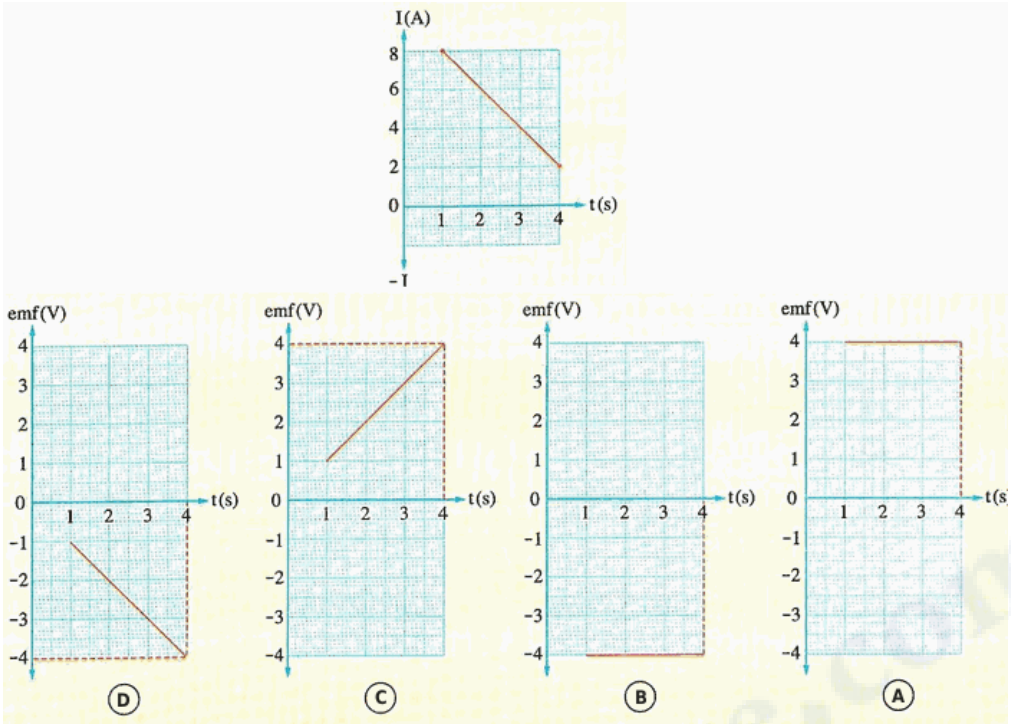
(B) the brightness of the lamp decreases and the voltmeter reading increases

(C) the brightness of the lamp decreases and the voltmeter reading decreases

(D) the brightness of the lamp decreases and the voltmeter reading stays constant

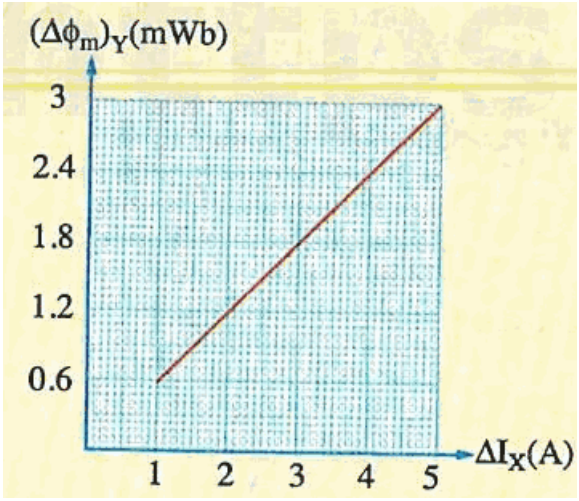
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6 Two adjacent coils have a mutual inductance of 2 H, and the graph shows the change of the current (I) in the primary coil with time (t). Which of the following graphs represents the relation between the induced emf in the secondary coil and time (t)? (1st session 2023)



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7 Two coils (X), (Y) have 500 turns and 1000 turns respectively. The graph shows the relation between the change in magnetic flux through coil (Y) and the change in the current in coil (X). The mutual inductance of the two coils equals ..... (2nd session 2023)



(A) 0.3 H (B) 0.6 H (C) 0.9 H (D) 1.2 H

8 Two coils, one inside the other: when the current in one of them changes from 4 A to zero in 0.01 s, an induced emf of 40 V is produced across the second coil. The mutual inductance of the two coils equals ..... (Sample exam 2025)

(A) 0.1 H (B) 0.15 H (C) 0.2 H (D) 0.25 H

9 The unit $(Henry.m^{-1})$ is the unit of measuring ..... (Sample exam 2025)

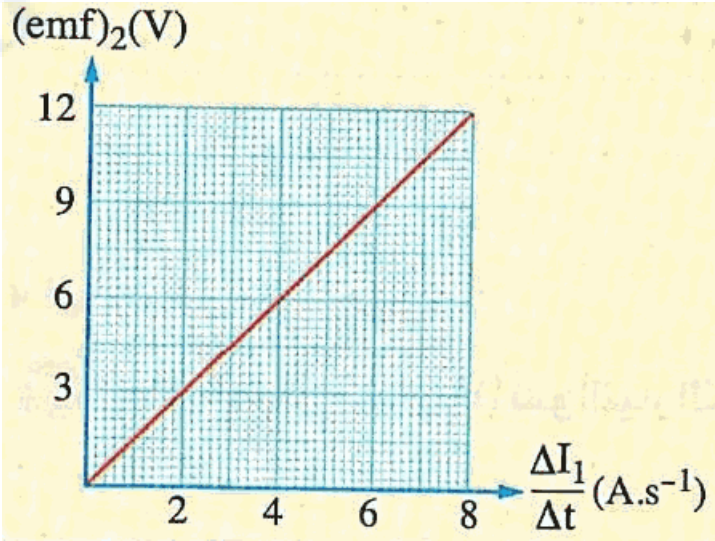
(A) the magnetic permeability of the medium (μ)

(B) the magnetic dipole moment (m_d)

(C) the magnetic flux density (B)

(D) the magnetic flux (φ_m)

10 Two adjacent coils (X, Y): the graph shows the relation between the induced emf $(emf)_2$ in coil (Y) and the rate of change of current $((\Delta I_1)/(\Delta t))$ in coil (X). What is the mutual inductance of the two coils? (1st session 2025)

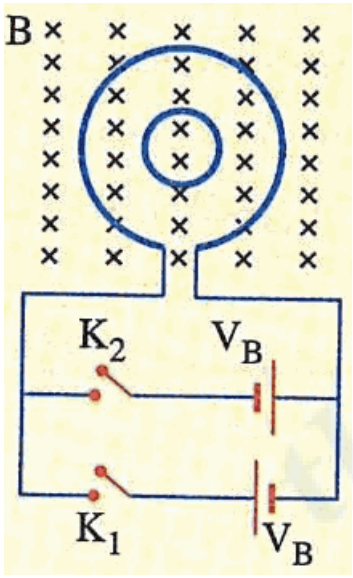


(A) 0.5 H (B) 3 H (C) 1.5 H (D) 0.25 H

11 Two adjacent coils L_1, L_2: coil L_1 carries an alternating current of frequency 50 Hz whose value changes from zero to 2 A during a quarter of a cycle. If the mutual inductance of the two coils is 1.5 H, then the average induced emf in coil L_2 during this time equals ..... (2nd session 2025)

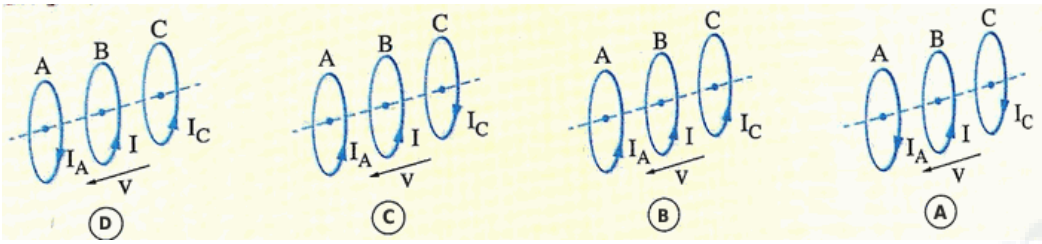
(A) 600 V (B) 500 V (C) 400 V (D) 300 V

12 Two concentric metal rings in the same plane are in a uniform external magnetic field of flux density (B) directed perpendicularly into the page. The large ring is connected to two batteries with the same emf (V_B) and negligible internal resistance, and two open switches K_1, K_2, as shown in the figure. When only switch (K_1) is closed, the large ring produces a magnetic field of flux density (2 B) at the centre, and an average induced emf (emf) is produced in the small ring. When only switch (K_2) is closed with switch (K_1) open, the average induced emf produced in the small ring is ..... (Sample exam 2026)
(Assume that the magnetic field produced by the large ring is uniform over the whole area of the small ring)

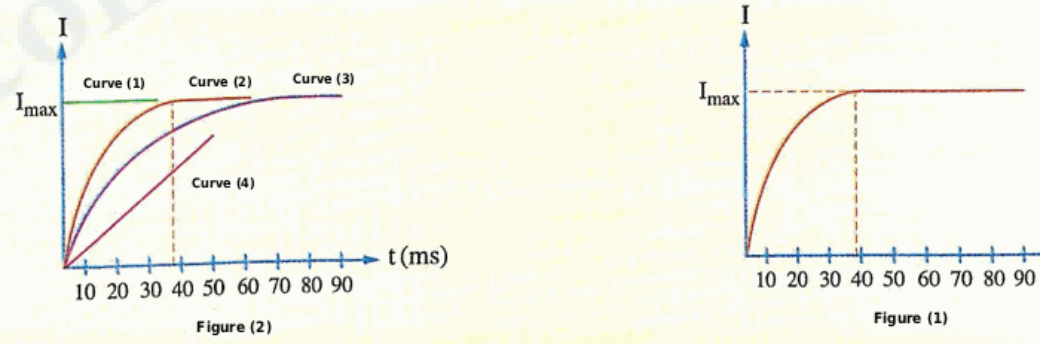


(A) 0.5 emf (B) emf (C) 2 emf (D) 3 emf

13 Three rings A, B, C are made of conducting materials. Ring B carries a current (I) and moves with a velocity (v) as in the following figures. The figure that shows the correct direction of the induced current in the two rings (A, C) is ..... (Sample exam 2026)

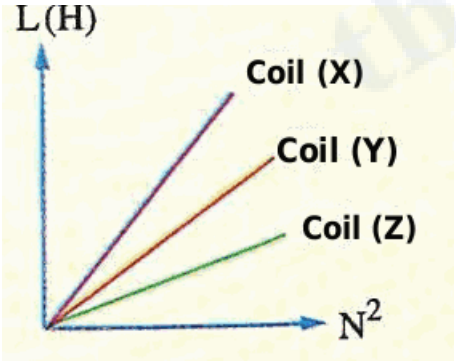


14 Graph (1) shows the growth of the electric current in a coil of self-inductance L connected to a battery when the circuit is closed. Which of the curves shown in figure (2) represents the growth of the current in the same coil, with a soft iron rod inside the coil, when the circuit is closed? (Trial exam / May 2021)



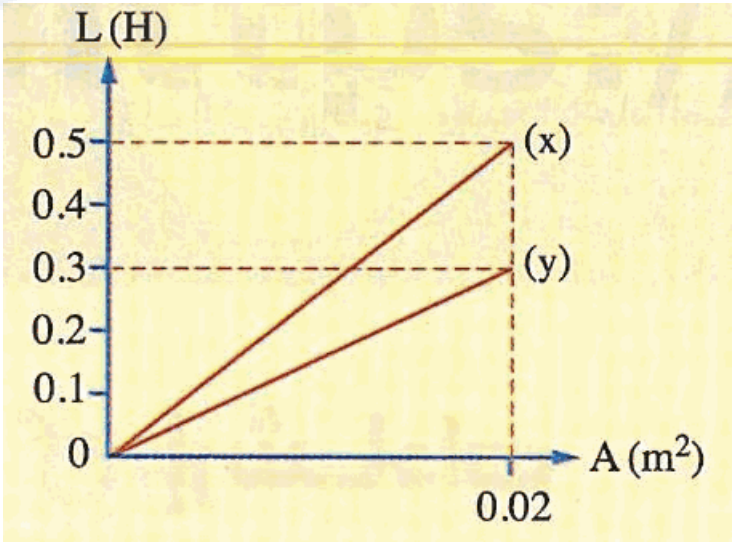
(A) Curve 1 (B) Curve 2 (C) Curve 3 (D) Curve 4

15 Three solenoids (Z), (Y), (X) have the same cross-sectional area, and the number of turns of each can be changed. The opposite graph shows the relation between the self-inductance (L) and the square of the number of turns (N^2). What is the correct order of these coils according to their lengths (ℓ)? (2nd session 2021)



(A) $\ell_X > \ell_Y > \ell_Z$ (B) $\ell_Y > \ell_X > \ell_Z$ (C) $\ell_Z > \ell_Y > \ell_X$ (D) $\ell_Z > \ell_X > \ell_Y$

16 A group of solenoids (x), each of length ℓ with N_x turns, and another group of solenoids (y), each of length $(\ell)/15$ with N_y turns. The opposite graph shows the relation between the self-inductance (L) of each coil and the cross-sectional area (A). If all the coils have the same magnetic permeability, then the ratio (N_y/N_x) equals ..... (1st session 2024)



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

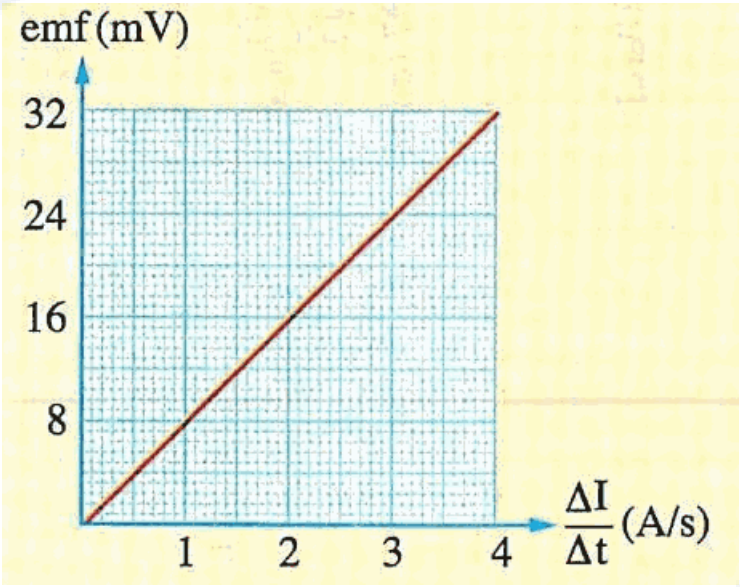
17 Two solenoids: the first has (N) turns, length (ℓ), face area (A) and self-inductance (L), and the second has (2 N) turns and the same length (ℓ). The face area of the second coil that makes its self-inductance (4 L) is ..... (2nd session 2024)
(Given: the cores of the two coils have the same magnetic permeability)

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

18 A solenoid 40 cm long consists of 200 turns of insulated wire, each with a cross-sectional area of $4\ cm^2$, wound around a soft iron cylinder of magnetic permeability $2 \times 10^{-3}\ T.m/A$. While the current in the coil changes at a constant rate, a self-induced emf of 2 V is produced across its ends. What is the rate of change of the current in the coil? (1st session 2025)

(A) 4 A/s (B) 500 A/s (C) 25 A/s (D) 0.08 A/s

19 An inductor of length (ℓ) consists of 800 turns, each with a cross-sectional area of $20\ cm^2$. The opposite graph shows the relation between the induced emf across the coil and the rate of change of the current $((\Delta I)/(\Delta t))$ in it. What is the length of the coil (ℓ)? (2nd session 2025)



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

20 A long solenoid of diameter 0.1 m has 2000 turn/m. At its centre is placed a circular coil of 100 turns and diameter 0.02 m, so that its axis coincides with the axis of the solenoid. If the current in the solenoid decreases at a constant rate from 4 A to zero in a time of 0.5 s, calculate the total induced charge in the circular coil that flows through a cross-section of its wire during this time. (Sample exam 2025)
(Given: the resistance of the wire of the circular coil $= 10\pi^2\ \Omega$)

21 An electromagnet whose coil wire has a resistance of $2\ \Omega$ and a self-inductance of 2 H is connected with a switch and a battery in a closed electric circuit. When the circuit is opened, the current dies away in a time of 0.1 s and an induced emf of 150 V is produced across the coil. Calculate: (2nd session 2023)

(1) the current in the coil before the circuit was opened.

(2) the potential difference across the coil before the circuit was opened.

Answer key and solutions

Multiple choice questions

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

1 **Answer (A)**

The mutual inductance $M = (\mu N_1 N_2 A)/(\ell)$ depends on the two coils only, so it does not change with $(\Delta I_1)/(\Delta t)$ and the line is horizontal.

2 **Answer (C)**

$M = (\mu N_1 N_2 A)/(\ell)$, so it increases with the number of turns and when the two coils are closer on the iron core.

Pair (C) has the greatest number of turns ($2N$ for each coil) and the coils are next to each other.

3 **Answer (A)**

When the primary circuit is opened, the flux through the secondary decreases to zero, so a momentary induced current is produced in the same direction as the primary current (direct) to oppose the decrease (Lenz's rule).

4 **Answer (B)**

A current from a to b means that the induced field opposes the field of circuit (2), so the flux through coil (1) is increasing.

The flux increases when one of the circuits is brought closer to the other.

Increasing the resistance or removing the iron core decreases it, and moving the two circuits together does not change the flux.

5 **Answer (B)**

The induced current in the secondary is opposite to the direction of the primary current (relative to the winding), so the flux is increasing,

that is, the primary current increases, which happens by decreasing the resistance of the rheostat.

6 **Answer (D)**

$(emf)_2 = M\,(\Delta I_1)/(\Delta t)$, so the slope of the line $= M$

$M = 0.6/1.2 = 0.5$ H

7 **Answer (B)**

Increasing S decreases the primary current, so the flux through the secondary decreases.

A current is produced in the secondary in the same direction as the primary current to oppose the decrease, so end b is the positive terminal of the coil (as a source).

The potential of a is less than the potential of b.

8 **Answer (A)**

Decreasing S increases the current of coil (A), so the flux in the common core increases.

A current is produced in coil (B) that opposes the increase (Lenz's rule); it leaves from end C, so C is the positive terminal of the coil.

The potential of C is greater than the potential of D.

9 **Answer (A)**

The two coils are similar and connected with the same polarity, so their fields are in the same direction.

Moving (x) away decreases the flux passing through each of the two coils.

The induced current opposes the decrease, so it is in the direction of the battery current, and the brightness of both lamps increases.

10 **Answer (D)**

The primary current is constant (battery), so the flux through the secondary is constant.
An induced emf is produced only when the flux changes, so the lamp does not light at all when K is closed.

11 **Answer (D)**

At the moment circuit (1) is closed, the flux through circuit (2) increases,
so an induced current is produced opposite to the current of circuit (1) (Lenz's rule),
and at end Q a pole similar to the pole facing it in the primary is formed (repulsion), so it is a north pole.

12 **Answer (A)**

The rod moves at a uniform speed in a uniform field, so the emf is constant $= 10$ V.
So the current of coil (1) is constant and the flux through coil (2) is constant, and the brightness of the lamp does not change.

13 **Answer (B)**

$emf_2 = M\,(\Delta I_1)/(\Delta t) = 0.1 \times 4/0.01 = 40$ V

14 **Answer (A)**

$B = (\mu N_1 I)/(\ell) = (0.002 \times 200 \times 4)/0.1 = 16$ T
$A = \pi r^2 = \pi\,(0.0175)^2 = 9.62 \times 10^{-4}$ m^2 and $\varphi_m = BA = 0.0154$ Wb
$emf_2 = N_2\,(\Delta\varphi_m)/(\Delta t) = 10^5 \times 0.0154/0.01 = 1.54 \times 10^5$ V

15 **Answer (C)**

$M = (emf_2\,\Delta t)/(\Delta I_1) = (1.54 \times 10^5 \times 0.01)/4 \approx 385$ H

16 **Answer (D)**

$M = (N_Y\,\varphi_Y)/I_X = (2000 \times 2.5 \times 10^{-4})/7 \approx 0.07$ H

17 **Answer (D)**

$emf_x = N_x\,(\Delta\varphi_m)/(\Delta t) = M\,(\Delta I_y)/(\Delta t)$, so $M\,\Delta I_y = N_x\,\Delta\varphi_m$
$\Delta I_y = (100 \times 2 \times 10^{-3})/0.01 = 20$ A

18 **Answer (C)**

$M = (N\,\Delta\varphi_m)/(\Delta I_z)$ and the ratio $(\Delta\varphi_m)/(\Delta I_z)$ is the slope of the line $= tan\theta$
$(M_{xz})/(M_{yz}) = fracNtan60^\circ 2Ntan30^\circ = (\sqrt{(3)})/(2 \times 1/(\sqrt{(3)})) = 3/2$

19 **Answer (B)**

$emf = M(\Delta I)/(\Delta t) \Rightarrow \Delta t = (M \Delta I)/emf = (0.3 \times 10)/60 = 0.05$ s

20 **Answer (A)**

$(\Delta I)/(\Delta t) = V/L$ at the moment of closing, proportional to the emf of the source.

With K_2 and K_3 the number of cells is greater than with K_1, so the rate of change of current increases and the induced emf in y increases,

so the deflection angle is greater than θ in both cases.

21 **Answer (C)**

Decreasing S increases the current of coil (y), so an induced current is produced in each of (x) and (z) in the same direction.

$emf \propto N$, so $((emf)_z)/((emf)_x) = 3N/N = 3$ and the resistance is the same,

so G_2 deflects to the right of zero by an angle greater than θ.

22 **Answer (B)**

Before closing $I_1 = 20/R$, and after closing R and R are in parallel, so $I_2 = 20/(R/2) = 40/R$

$\Delta I = 20/R$ and $emf = M(\Delta I)/(\Delta t) \Rightarrow 0.04 = 0.01 \times (20/R)/0.25$

$20/R = 1 \Rightarrow R = 20\ \Omega$

23 **Answer (C)**

$emf = -M(\Delta I)/(\Delta t)$, that is, the slope of the line in figure (2).

Rising stage: a small constant slope, so a small constant negative emf, then zero while the current is steady.

Falling stage: a greater slope in a shorter time, so a greater constant emf with the opposite sign.

24 **Answer (C)**

From the graph $(\Delta I)/(\Delta t) = 15/3 = 5$ A/s, constant.

$emf = -M(\Delta I)/(\Delta t) = -1 \times 5 = -5$ V, constant (a horizontal line).

25 **Answer (B)**

$|emf| = M(\Delta I)/(\Delta t) \Rightarrow \Delta I = (2 \times 20 \times 10^{-3})/(10 \times 10^{-3}) = 4$ A

A reverse emf is produced when the primary current increases, so it increases from zero to 4 A in 20 ms.

26 **Answer (D)**

$B = (\mu I)/2r = (4\pi \times 10^{-7} \times 8)/(2 \times 0.5) \approx 1.005 \times 10^{-5}$ T

$\varphi_m = BA = 1.005 \times 10^{-5} \times \pi\,(0.05)^2 \approx 7.9 \times 10^{-8}$ Wb

$emf = (\Delta\varphi_m)/(\Delta t) = (7.9 \times 10^{-8})/(10^{-6}) = 0.079$ V

$I = emf/R = 0.079/(10^{-3}) \approx 79$ A

27 **Answer (A)**

When the coil rotates $180°$, the flux changes from BA to $-BA$, so $\Delta\varphi_m = 2BA$

$Q = (N_y\,\Delta\varphi_m)/R \Rightarrow B = QR/2N_yA = (20 \times 10^{-9} \times 50)/(2 \times 10 \times 5 \times 10^{-4}) = 10^{-4}$ T

$B = (\mu\, N_x\, I)/2r \Rightarrow I = 2rB/(\mu\, N_x) = (2 \times 0.11 \times 10^{-4})/(4\pi \times 10^{-7} \times 7) = 2.5$ A

28 **Answer (A)**

The current changes at a constant rate: $(\Delta I)/(\Delta t) = 1.5/0.05 = 30$ A/s

$emf = N\,\mu\,n\,A\,(\Delta I)/(\Delta t) = 100 \times 4\pi \times 10^{-7} \times 2100 \times \pi\,(0.01)^2 \times 30$

$emf \approx 2.49 \times 10^{-3}$ V

29 **Answer (B)**

$L = emf/(\Delta I/\Delta t)$, so its unit is $(V \cdot s)/A = \Omega \cdot s$

30 **Answer (C)**

$L = (\mu N^2 A)/(\ell)$, so $L \propto N^2$

The relation is a second-degree curve starting from zero.

31 **Answer (C)**

When the current is steady, $(\Delta I)/(\Delta t) = 0$, so the self-induced emf vanishes,
and the current becomes steady at $I = V/R$

32 **Answer (B)**

When the circuit is closed, the current starts to grow, so the flux in the coil itself changes, and a reverse induced emf is produced that opposes the growth of the current (Lenz's rule), so it grows slowly.

33 **Answer (B)**

A direct self-induced emf is produced when the current decreases (it opposes the decrease).
Opening K_2 increases the total resistance, so the current decreases, while the other actions increase the current, so a reverse emf is produced.

34 **Answer (C)**

The lamp is in parallel with the coil. When K is opened, the coil current keeps passing through it because of the self-induced emf,
and it decreases gradually, so the brightness of the lamp decreases gradually.

35 **Answer (C)**

At the moment the switch is opened, the current decreases very quickly, so a large self-induced emf is produced.
The direct induced emf (in the direction of the current) is what lights the lamp; it needs a voltage ≥ 180 V, much greater than the battery voltage 6 V.

36 **Answer (D)**

$L = (\mu N^2 A)/(\ell)$ depends only on the dimensions of the coil and its core,
so the self-inductance is always constant and is not affected by opening or closing the switch.

37 **Answer (A)**

$emf = L(\Delta I)/(\Delta t)$, so the slope of the line $= L$
$L = 0.8/8 = 0.1$ H

38 **Answer (B)**

$L = 0.1$ H from the slope
$emf = L(\Delta I)/(\Delta t) = 0.1 \times 5 = 0.5$ V

39 **Answer (C)**

$L = (\mu N^2 A)/(\ell)$, and from the graph at $A = 30\ cm^2$, $L = 0.3 \times 10^{-4}$ H
$\ell = (\mu N^2 A)/L = (4\pi \times 10^{-7} \times 100^2 \times 30 \times 10^{-4})/(0.3 \times 10^{-4}) = 0.4\pi$ m

40 **Answer (C)**

$L = (\mu N^2 A)/(\ell)$, so $(L')/L = ((2N)^2/2\ell)/(N^2/\ell) = 2$
$L' = 2L$

41 **Answer (C)**

42 **Answer (B)**

$L = (\mu N^2 A)/(\ell)$ and the core is iron in all cases, so compare $(N^2A)/(\ell)$ (the current does not affect L)
(A) 1 , (B) $((2N)^2A)/(2\ell) = 2$, (C) $1/4$, (D) $(N^2(2A))/(2\ell) = 1$, so the greatest is (B).

43 **Answer (B)**

Inserting a soft iron core increases the magnetic permeability μ,
so $L = (\mu N^2 A)/(\ell)$ increases and becomes greater than 0.1 H.

44 **Answer (A)**

The final current $I_0 = V/R$ does not change when the core is placed.
L increases, so the reverse emf and the growth time of the current $\tau = L/R$ increase, and the time is greater than t_0.

45 **Answer (C)**

$L = (N \varphi_m)/I \Rightarrow N = (L\, I)/(\varphi_m) = (1 \times 2)/(4 \times 10^{-3}) = 500$ turns

46 **Answer (C)**

$L = (N \Delta\varphi_m)/(\Delta\, I) = (100 \times 0.05)/4 = 1.25$ H

47 **Answer (B)**

$emf = L\, (\Delta\, I)/(\Delta\, t) = N\, (\Delta\varphi_m)/(\Delta\, t)$
$(\Delta\varphi_m)/(\Delta\, t) = (6 \times 10^{-3} \times 2)/300 = 4 \times 10^{-5}$ Wb/s

48 **Answer (A)**

$I = (N \varphi_m)/L = (100 \times 6 \times 10^{-4})/0.03 = 2$ A
$emf = L\, (\Delta\, I)/(\Delta\, t) = 0.03 \times 2/0.02 = 3$ V

49 **Answer (C)**

$L = (N \varphi_m)/I \Rightarrow I = (100 \times 6 \times 10^{-4})/0.03 = 2$ A

50 **Answer (C)**

$L \propto (N^2 A)/(\ell)$, so $L_1/L_2 = (N^2 A/\ell)/((N/4)^2\, 2A/(\ell)/2)$
$L_1/L_2 = 1/(1/16 \times 4) = 4$

51 **Answer (C)**

$L = (\mu N^2 A)/(\ell) \Rightarrow L \propto \mu$ with the rest constant
$(\mu_{air})/(\mu_{iron}) = (L_{air})/(L_{iron}) = (2 \times 10^{-4})/0.3 = 1/1500$

52 **Answer (B)**

The wire length $\ell = N\pi d \Rightarrow N = (\ell)/(\pi d)$, the area $A = (\pi d^2)/4$, and the length of the coil is its circumference πd

$L = (\mu N^2 A)/(\pi d) = (\mu \ell^2)/(4\pi d) \Rightarrow L \propto 1/d$

$L_x/L_y = 2d/d = 2/1$

53 **Answer (B)**

$L = (\mu N^2 A)/(\ell) = (4\times 3.14\times 10^{-7}\times 500^2\times 40\times 10^{-4})/0.4 = 3.14\times 10^{-3}$ H

$emf = L(\Delta I)/(\Delta t) = 3.14\times 10^{-3}\times 2/0.1 = 6.28\times 10^{-2}$ V

54 **Answer (C)**

$L = (\mu N^2 A)/(\ell) = (4\times 22/7\times 10^{-7}\times 40^2\times 70/22\times 10^{-4})/0.1 = 6.4\times 10^{-6}$ H

55 **Answer (D)**

Cutting 10 turns reduces the number to 30 turns, and the length decreases in the same ratio $3/4$

$L \propto (N^2)/(\ell)$, so $L' = ((3/4)^2)/(3/4)\, L = 3/4\times 6.4\times 10^{-6} = 4.8\times 10^{-6}$ H

56 **Answer (D)**

$L = emf/(\Delta I/\Delta t) = 5/20 = 0.25$ H

57 **Answer (A)**

$emf = L(\Delta I)/(\Delta t) \Rightarrow \Delta t = (L\Delta I)/emf = (0.005\times 10)/5 = 0.01$ s

58 **Answer (C)**

In a double-wound coil, the current in its two halves flows in opposite directions, so their fields cancel,

and the self-inductance of the resistor becomes zero.

59 **Answer (C)**

$emf = -L(\Delta I)/(\Delta t)$, that is, the slope of the line in the upper figure.

$a \rightarrow b$ and $d \rightarrow e$: I is constant, so $emf = 0$

$b \rightarrow c$: the current decreases, so the emf is constant and positive (direct), and $c \rightarrow d$: it increases, so the emf is constant and negative (reverse).

60 **Answer (B)**

$(\Delta I)/(\Delta t) = 8/(40\times 10^{-3}) = 200$ A/s

$emf = L(\Delta I)/(\Delta t) = 60\times 10^{-3}\times 200 = 12$ V

61 **Answer (D)**

The current $I = V/R$ is proportional to V, and a direct emf is produced when the current decreases.

It is greatest when the current decreases at the fastest rate, which is the steepest slope, that is, stage D.

62 **Answer (C)**

When the circuit is closed, the current increases from zero to V/R at a decreasing rate,

so $emf = L\,(\Delta I)/(\Delta t)$ decreases from its greatest value to zero, which is shown in figure (C).

63 **Answer (B)**

The final current $I = V_B/R$ because the coil has no resistance and the battery has no internal resistance.

The final current in (1) is greater than in (2), so $R_1 < R_2$

64 **Answer (B)**

The rate of growth of the current at the moment of closing $(\Delta I)/(\Delta t) = V_B/L$ does not depend on R.

Curve (1) is steeper at the start, so $L_1 < L_2$

65 **Answer (D)**

Point A is after B and its current is greater, and the slope of the growth curve decreases with time, so the reverse emf and $(\Delta I)/(\Delta t)$ decrease while the net V_B - $emf_{back} = IR$ increases, and L is constant.

So the quantity that increases from B to A is the net emf in the circuit.

66 **Answer (B)**

Increasing R_V decreases the current, so a direct induced emf is produced in the coil in the direction of the current.

$I = (V_B + emf_L)/R_V = (5 + emf_L)/10 > 0.5$ A

67 **Answer (D)**

At the moment of connection $I = 0$, so there is no voltage drop across the resistance, and all the voltage is across the coil.

$(\Delta I)/(\Delta t) = V/L = 120/0.6 = 200$ A/s

68 **Answer (B)**

$I_{max} = V/R = 120/15 = 8$ A and $I = 0.8 \times 8 = 6.4$ A

$(\Delta I)/(\Delta t) = (V - IR)/L = (120 - 6.4 \times 15)/0.6 = 40$ A/s

69 **Answer (A)**

$L_A = (N_A \Delta\varphi_A)/(\Delta I_A) = (500 \times 2 \times 10^{-3})/10 = 0.1$ H

70 **Answer (C)**

$M = (N_B \Delta\varphi_B)/(\Delta I_A) = (2000 \times 10^{-4})/10 = 0.02$ H

71 **Answer (C)**

At position a, $R = 0$, so $I_a = 12/3 = 4$ A

$(\Delta I)/(\Delta t) = emf/L = 15/0.1 = 150$ A/s, so $\Delta I = 150 \times 0.02 = 3$ A

The current decreases: $I_b = 4 - 3 = 1$ A, so $R_b = 12/1 - 3 = 9\ \Omega$

72 **Answer (C)**

$V_{xz} = IR + L(\Delta I)/(\Delta t) = 2 \times 2 + 0.2 \times 20$

$V_{xz} = 4 + 4 = 8$ V

73 **Answer (C)**

The straight wire has almost no self-induction, so the current reaches its maximum at once (lamp Z).

The air-core coil delays the growth of the current by $\tau = L/R$, and the iron-core coil has a greater L, so it delays it more.

So the time needed to reach maximum brightness: $Y > X > Z$

74 **Answer (B)**

$M = (\mu N_x N_y A)/(\ell)$ and $L_x = (\mu N_x^2 A)/(\ell)$ (two coils one inside the other on the same core)

$M = L_x N_y/N_x$

75 **Answer (D)**

$M = (N_S \Delta\varphi_S)/(\Delta I_P) = (3N \times 0.6\, \Delta\varphi_P)/(\Delta I_P)$ and $L_P = (N \Delta\varphi_P)/(\Delta I_P)$

$M/L_P = 3 \times 0.6 = 1.8$

76 **Answer (B)**

At the moment the primary is closed, $(\Delta I_1)/(\Delta t) = V/L_1 = 20/0.04 = 500$ A/s

$M = emf_2/(\Delta I_1/\Delta t) = 5/500 = 0.01$ H

Essay questions

1 **Model answer**

(1) A north pole.

(2) A north pole.

(3) A south pole.

(4) A south pole.

2 **Model answer**

The brightness of the lamp decreases, because while resistance R is increased uniformly, the current in its circuit decreases according to the relation $(I = V/R)$, so the magnetic flux produced by the coil and cutting the turns of the coil connected to the lamp decreases. A direct induced emf is produced in this coil by mutual induction, opposite to the emf of the battery connected to the lamp, so the brightness of the lamp decreases.

3 **Model answer**

(1) An induced emf is produced in coil b, because while resistance R_1 is increased, the resistance of the circuit of coil a increases, so the current in coil a decreases and the magnetic flux it produces, which cuts coil b, decreases. According to Lenz's rule, a direct induced emf is produced in coil b.

(2) No induced emf is produced in coil b, because there is no change in the magnetic flux cutting the turns of coil b.

4 **Model answer**

(1) At the moment switch K is closed, the current in the coil grows, so the flux produced by the coil and cutting the ring increases gradually. An induced emf is produced in the ring, which produces an induced current whose direction on the face of the ring facing the coil is clockwise.

(2) After the current reaches its steady value in the circuit of the solenoid, the magnetic flux cutting the ring no longer changes, so no induced current is produced in it.

5 **Model answer**

These tools are arranged as follows:

(1) The soft iron rod is placed inside coil (2), and coil (1), which has the larger cross-sectional area, is placed around coil (2) as a secondary coil.

(2) The battery V_B and switch K are connected across the ends of coil (2) so that it works as a primary coil.

6 **Model answer**

A momentary reverse induced emf is produced in the coil, because at the moment switch K is closed the total resistance of the circuit decreases, so the current in the coil increases and a reverse induced emf is produced in the coil by self-induction.

7 **Model answer**

The galvanometer reading increases for a moment and then returns to its first reading, because while the iron rod is pulled out of the coil the flux cutting the coil decreases, so a direct induced emf is produced in the coil and the current in the circuit increases for a moment.

8 **Model answer**

(1) The ammeter pointer moves, showing the growth of the current in the first circuit, until it reaches a reading that gives the battery current. The growth of the current is slow because of the reverse emf produced by self-induction.

The galvanometer pointer moves for a moment in a certain direction, showing the current produced by mutual induction between coils (1), (2), then returns to zero when the ammeter pointer becomes steady.

(2) The ammeter pointer deflects more slowly than in the first case, because the reverse emf produced by self-induction in the coil increases, then it settles at the same reading as in the first case.

The momentary deflection of the galvanometer increases because of the iron rod, which increases the rate of change of the magnetic flux, so the emf induced by mutual induction increases. Then the pointer returns to zero again when the ammeter pointer becomes steady.

9 **Model answer**

(1) $B = \mu NI/(\ell) = 4\pi \times 10^{-7} \times (700 \times 2)/1.1 = 1.6 \times 10^{-3}\ T$

$emf = -N\,(\Delta\,(BA))/(\Delta\,t) = -700 \times ((0 - 1.6) \times 10^{-3} \times 10 \times 10^{-4})/0.01 = 0.112\ V$

(2) $L = (emf\ \Delta\,t)/(\Delta\,I) = (0.112 \times 0.01)/2 = 5.6 \times 10^{-4}\ H$

Another solution: $L = (\mu\ A\ N^2)/(\ell) = (4\pi \times 10^{-7} \times 10 \times 10^{-4} \times (700)^2)/1.1 = 5.6 \times 10^{-4}\ H$

10 **Model answer**

(1) The growth time of the current increases, because the reverse emf induced in the coil by self-induction increases, so it opposes the growth of the current more.

(2) The decay time of the current increases, because the direct induced emf increases, so it opposes more the collapse of the current and its reaching zero.

11 **Model answer**

(1) Ω.s : self-inductance or mutual inductance, equivalent unit: henry.

(2) $T.m^2/s$: induced emf, equivalent unit: volt.

(3) V.s : magnetic flux, equivalent unit: weber.

(4) Ω.C : magnetic flux, equivalent unit: weber.

(5) V.s/A.m : magnetic permeability, equivalent unit: weber/ampere.metre.

(6) $V.s/m^2$: magnetic flux density, equivalent unit: tesla.

(7) J.s/A.C : self-inductance or mutual inductance, equivalent unit: henry.

(8) Wb/A : self-inductance or mutual inductance, equivalent unit: henry.

12 **Model answer**

To avoid the effect of self-induction of the coil: in each turn, the magnetic field produced by the current in one direction cancels the field produced by the current in the opposite direction, so the opposition of the coil to the current depends only on its ohmic resistance.

Past exam questions

1	2	3	4	5	6	7	8	9	10
B	D	D	A	A	A	B	A	A	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	B	D	C	C	C	D	C	D	—
21									
—									

1 **Answer (B)**

$M = emf/(\Delta I / \Delta t)$ = the slope of the line $= (0.3 - 0.1)/(6 - 2) = 0.05\ H = 50\ mH$

2 **Answer (D)**

M = the slope of the line $= (12 - 4)/(6 - 2) = 2\ H$

3 **Answer (D)**

From figure (1): $M = 0.6/0.3 = 2\ H$

The mutual inductance depends only on the two coils and does not change with the rate of change of current, so it is represented by a horizontal line at 2 H, which is line Z.

4 **Answer (A)**

When K is closed, the two resistors are connected in parallel, so the total resistance decreases and the current in coil (x) increases. The flux through coil (y) changes, and an induced emf opposite to the battery's emf is produced in it.

So the current in circuit (y) decreases and the brightness of the lamp decreases, and the voltmeter reading increases because $V = V_B - I r$ and $I r$ decreases.

5 **Answer (A)**

When K is closed, the current in the primary coil grows, so an induced emf is produced in the secondary coil in the same direction as the battery, and the brightness of the lamp increases.

The voltmeter is connected across a battery of internal resistance $r = 0$, so its reading $= V_B$ always and stays constant.

6 **Answer (A)**

$(\Delta I)/(\Delta t) = (2 - 8)/(4 - 1) = -2\ A/s$

$emf = -M\ (\Delta I)/(\Delta t) = -2 \times (-2) = 4\ V$, constant from t = 1 s to t = 4 s

7 **Answer (B)**

$emf_Y = -N_Y\ (\Delta \varphi_m)/(\Delta t) = -M\ (\Delta I_X)/(\Delta t)$, so $M = N_Y\ (\Delta \varphi_m)/(\Delta I_X)$

$M = 1000 \times ((3 - 0.6) \times 10^{-3})/(5 - 1) = 0.6\ H$

8 **Answer (A)**

$M = emf/(\Delta I / \Delta t) = 40/(4 / 0.01) = 0.1\ H$

9 **Answer (A)**

$\mu = B/H$ and its unit is $Wb/A.m = H/m$

10 **Answer (C)**

M = the slope of the line $= 12/8 = 1.5\ H$

11 **Answer (A)**

$\Delta t = T/4 = 1/(4 \times 50) = 0.005\ s$

$emf = M\ (\Delta I)/(\Delta t) = 1.5 \times 2/0.005 = 600\ V$

12 **Answer (B)**

The external field B is constant, so it does not contribute to the change in flux; the change comes only from the field of the large ring.

In both cases the field of the large ring changes from zero to 2 B (by the same magnitude even though the direction differs), so the change in flux and its time are the same, and the same emf is produced: emf

13 **Answer (D)**

Ring B approaches A, so the flux in A increases and a current opposite to I is produced in it (repulsion).

It moves away from C, so the flux in C decreases and a current in the same direction as I is produced in it (attraction). This is shown in figure (D).

14 **Answer (C)**

The iron core increases the self-inductance, so the time needed for the current to grow increases, but the maximum value of the current (V_B/R) does not change. This is represented by curve 3.

15 **Answer (C)**

$L = (\mu A N^2)/(\ell)$, so the slope of the line $= (\mu A)/(\ell)$ is inversely proportional to the length.

The slope of X is greatest, then Y, then Z, so $\ell_Z > \ell_Y > \ell_X$

16 **Answer (C)**

$L = (\mu N^2)/(\ell) A$, so the slope $= (\mu N^2)/(\ell)$

(x) : $(\mu N_x^2)/(\ell) = 0.5/0.02 = 25$, (y) : $(15 \mu N_y^2)/(\ell) = 0.3/0.02 = 15$

$(N_y^2)/(N_x^2) = 1/25$, so $N_y/N_x = 1/5$

17 **Answer (D)**

$L \propto N^2 A$ (for the same length and permeability): $(4 L)/L = ((2 N)^2 A_2)/(N^2 A)$

$4 = 4 A_2/A$, so $A_2 = A$

18 **Answer (C)**

$L = (\mu A N^2)/(\ell) = (2 \times 10^{-3} \times 4 \times 10^{-4} \times (200)^2)/0.4 = 0.08\ H$

$(\Delta I)/(\Delta t) = emf/L = 2/0.08 = 25\ A/s$

19 **Answer (D)**

L = the slope of the line $= (32 \times 10^{-3})/4 = 8 \times 10^{-3}\ H$

$\ell = (\mu A N^2)/L = (4\pi \times 10^{-7} \times 20 \times 10^{-4} \times (800)^2)/(8 \times 10^{-3}) = 0.2\ m = 20\ cm$

20 **Model answer**

$M = (\mu N_1 N_2 A_2)/(\ell_1) = \mu n N A$, where A is the area of the circular coil

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

$M = 4\pi \times 10^{-7} \times 2000 \times 100 \times \pi \times 10^{-4} = 7.9 \times 10^{-5} H$

$Q = I t = emf/R\, t = (M \Delta I)/R = (7.9 \times 10^{-5} \times 4)/(10 \pi^2) = 3.2 \times 10^{-6} C$

21 **Model answer**

(1) $emf = -L (\Delta I)/(\Delta t) : 150 = 2 \times I/0.1$, so $I = 7.5 A$

(2) $V = I R = 7.5 \times 2 = 15 V$