Physics · Electric Current and Electromagnetism

AC Circuits

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questions	sets	pages

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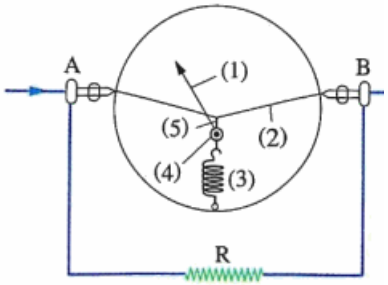
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Multiple choice questions — 119 questions

1 The opposite figure shows the structure of an electrical measuring instrument, then:

(1) The working idea of this instrument depends on .....

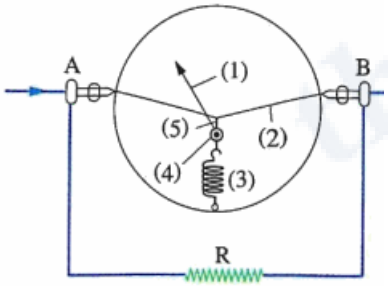


(A) eddy currents
(B) the magnetic effect of electric current
(C) the heating effect of electric current
(D) electromagnetic induction

---

2 The opposite figure shows the structure of an electrical measuring instrument, then:

(2) The resistance R is used for .....

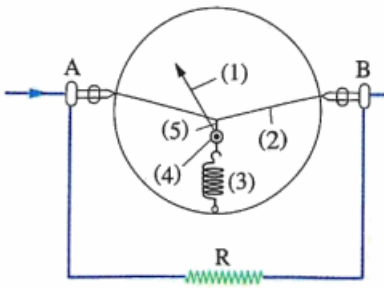


(A) heating the wire faster
(B) keeping the silk thread always taut
(C) increasing the current range of the instrument
(D) increasing the resistance of the instrument

---

3 The opposite figure shows the structure of an electrical measuring instrument, then:

(3) The part made of platinum-iridium is .....

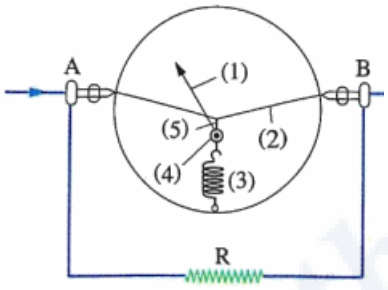


(A) component (1) (B) component (2) (C) component (3) (D) component (4)

---

4 The opposite figure shows the structure of an electrical measuring instrument, then:

(4) The function of component (3) is .....



(A) making the scale of the instrument uniform

(B) increasing the range of the instrument

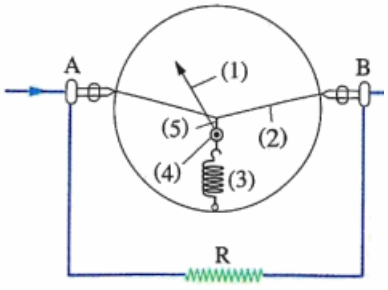
(C) keeping the silk thread always taut

(D) heating the instrument when the current passes

---

5 The opposite figure shows the structure of an electrical measuring instrument, then:

(5) The electric current passes through .....



(A) component (1) and component (3) (B) component (2) and component (5)

(C) component (1) and the resistance R (D) component (2) and the resistance R

---

6 In a hot-wire ammeter, the heat power produced in the platinum-iridium wire by an alternating current passing through it is directly proportional to .....

(A) the effective value of the current

(B) the reciprocal of the effective value of the current

(C) the maximum value of the current

(D) the square of the effective value of the current

---

7 An alternating current of maximum value 14 A passing through the wire of a hot-wire ammeter produces a certain heat power. To produce the same heat power in the wire, a direct current must pass through it of about .....

(A) 7 A (B) 10 A (C) 14 A (D) 20 A

---

8 The platinum-iridium wire of a hot-wire ammeter is connected in parallel with a shunt, and the ammeter is connected to a circuit carrying an alternating current of effective value I. If the shunt resistance is increased and the same current (I) passes in the circuit, the heat power produced in the wire .....

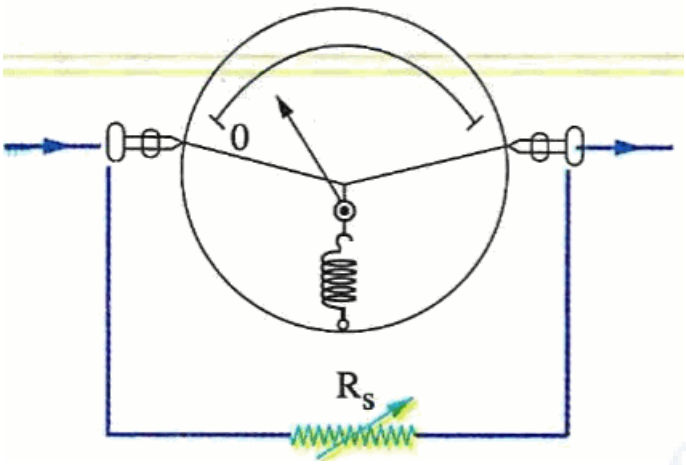
(A) increases (B) decreases

(C) does not change (D) cannot be determined

---

9 In the opposite figure, a hot-wire ammeter carries an electric current (I). When the shunt (R_s) is decreased and the same current (I) passes through the ammeter, what happens to:

(1) the range and the accuracy of the ammeter, respectively?



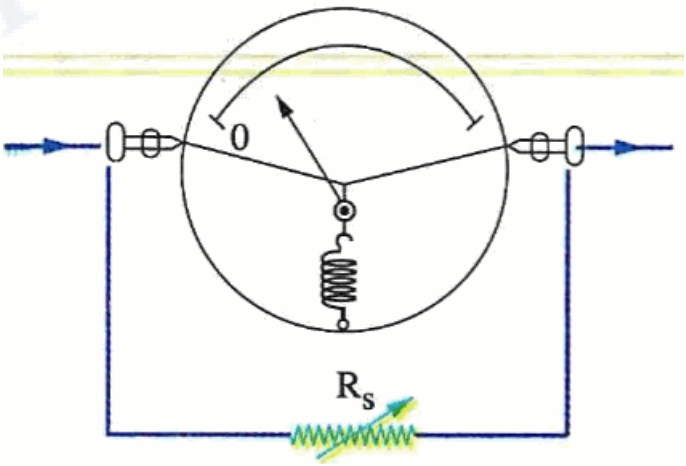
(A) decreases, decreases (B) decreases, increases

(C) increases, decreases (D) increases, increases

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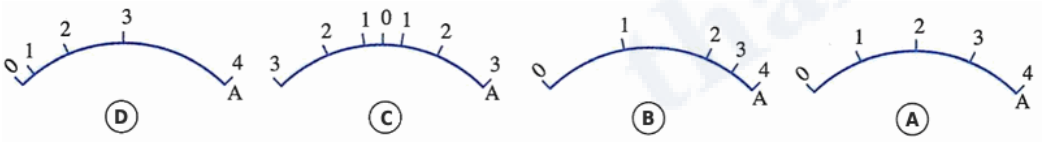
10 In the opposite figure, a hot-wire ammeter carries an electric current (I). When the shunt (R_s) is decreased and the same current (I) passes through the ammeter, what happens to:

(2) the tension in the spring?

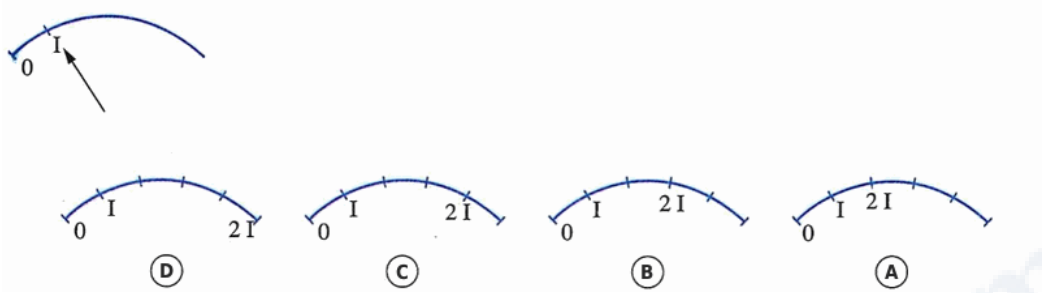


(A) increases
(B) decreases
(C) does not change
(D) cannot be determined

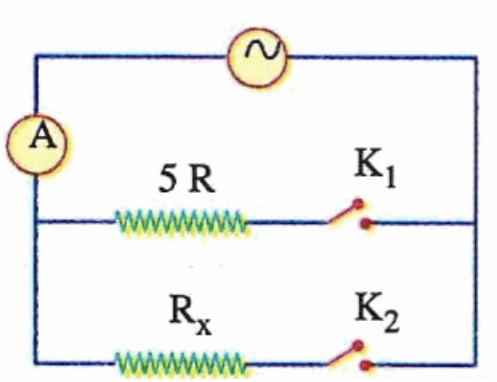
11 Which of the following figures correctly shows the scale of a hot-wire ammeter?



12 If the pointer of a hot-wire ammeter deflects as shown in the opposite figure when an alternating current of effective value I passes, which of the following figures correctly shows the position of the pointer when an alternating current of effective value 2 I passes through the ammeter?

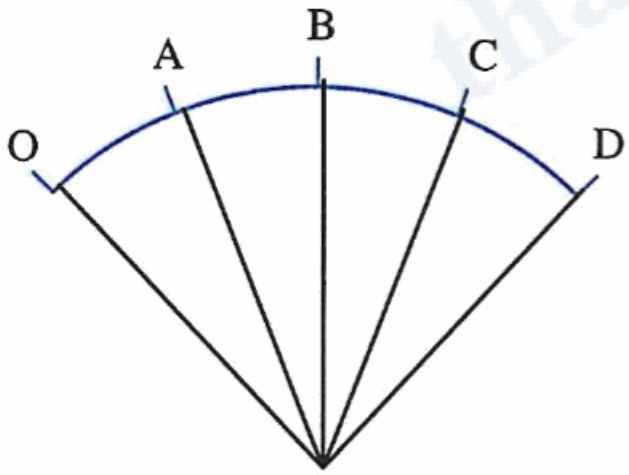


13 In the electric circuit shown, a hot-wire ammeter of resistance R is connected to an AC source of effective voltage V. When only switch K_1 is closed, the pointer deflects by an angle θ from zero, and when only switch K_2 is closed, the pointer deflects by an angle 9θ from zero. The resistance R_x equals .....



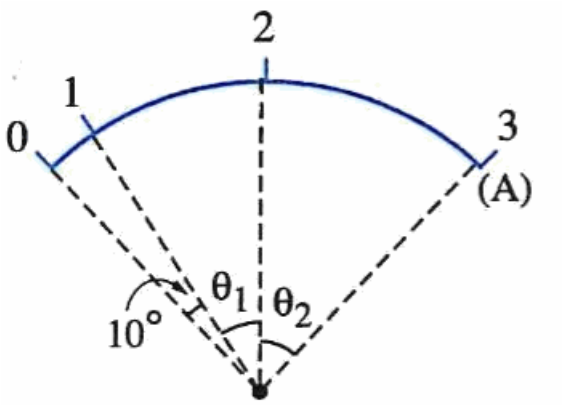
(A) 4 R (B) 2 R (C) R (D) 0.5 R

14 A student divided the distance between the zero position (O) and the position of the maximum possible reading (D) on the scale of a hot-wire ammeter into four equal parts, as in the opposite figure. The part that shows the largest change in current is .....



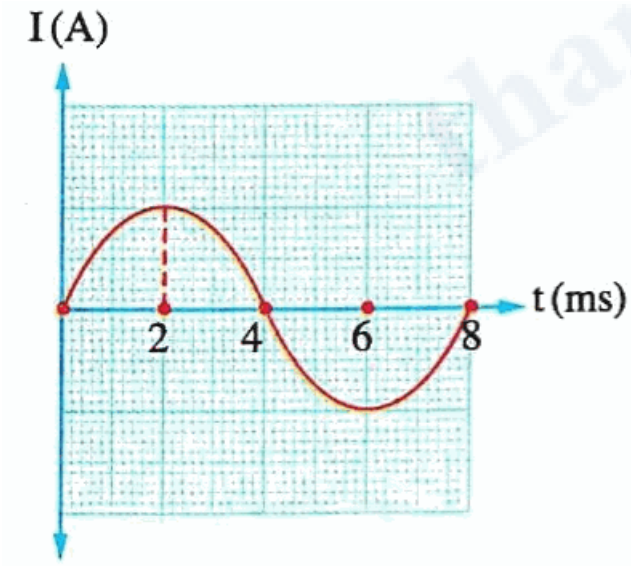
(A) OA (B) AB (C) BC (D) CD

15 The opposite figure shows the scale of a hot-wire ammeter. The values of the two angles (θ_1) and (θ_2) shown in the figure are, respectively, ...



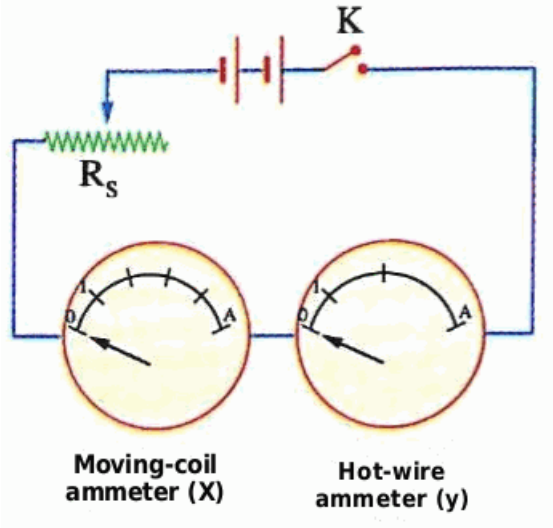
(A) 20°, 40° (B) 40°, 50° (C) 30°, 50° (D) 30°, 40°

16 The opposite graph shows the alternating current in a circuit containing a hot-wire ammeter. The reading of the hot-wire ammeter equals the instantaneous value of the current after a time from the start of the cycle equal to .....



(A) 0.5 ms (B) 1 ms (C) 2 ms (D) 4 ms

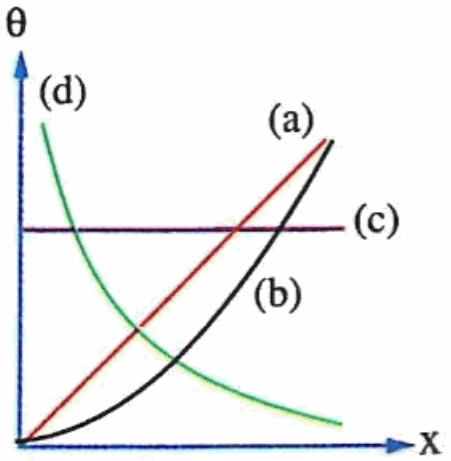
17 In the electric circuit shown, when switch K is closed a current of 1 A passes and the pointer of each ammeter deflects by the same angle. When a current of 2 A passes, the pointer of ammeter x deflects by an angle θ, so the pointer of ammeter y deflects by an angle .....



(A) smaller than θ
(B) greater than θ
(C) equal to θ
(D) cannot be determined

18 The opposite graph shows the relation between the deflection angle of the pointer of a hot-wire ammeter (θ) and the quantity (x). Which of the curves (a), (b), (c), (d) shown represents this relation correctly, if the quantity (x) is:

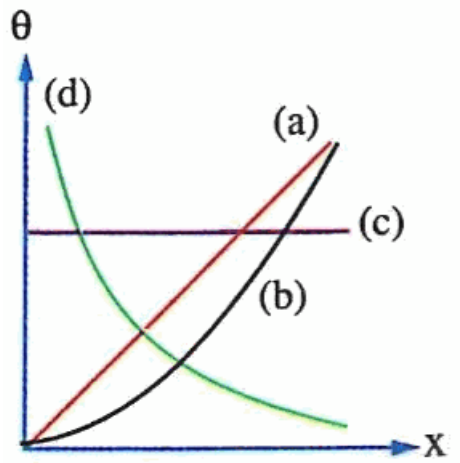
(1) the electric power consumed in the platinum-iridium wire?



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

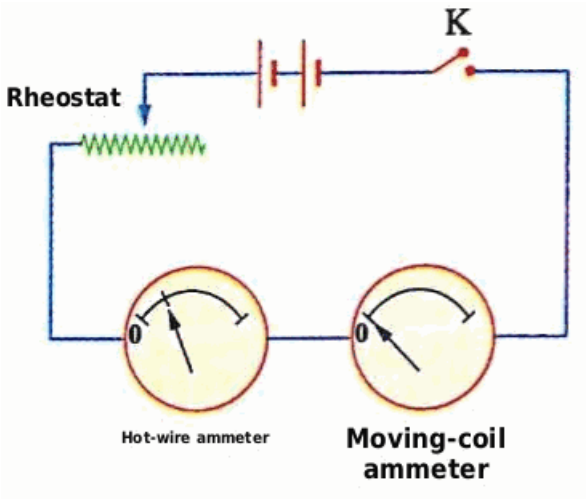
19 The opposite graph shows the relation between the deflection angle of the pointer of a hot-wire ammeter (θ) and the quantity (x). Which of the curves (a), (b), (c), (d) shown represents this relation correctly, if the quantity (x) is:

(2) the electric current passing through the platinum-iridium wire?



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

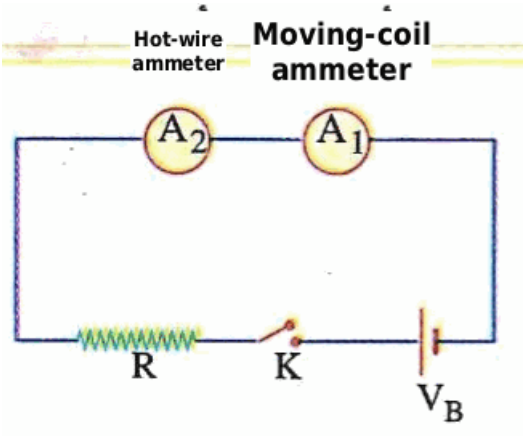
20 The opposite circuit is used to calibrate a hot-wire ammeter. It was noticed that the pointer of the moving-coil ammeter points exactly to zero while the pointer of the hot-wire ammeter shows a reading greater than zero. This means that the expansion coefficient of the plate on which the platinum-iridium wire is fixed is ..... the expansion coefficient of the wire.



(A) greater than (B) less than

(C) equal to (D) cannot be determined

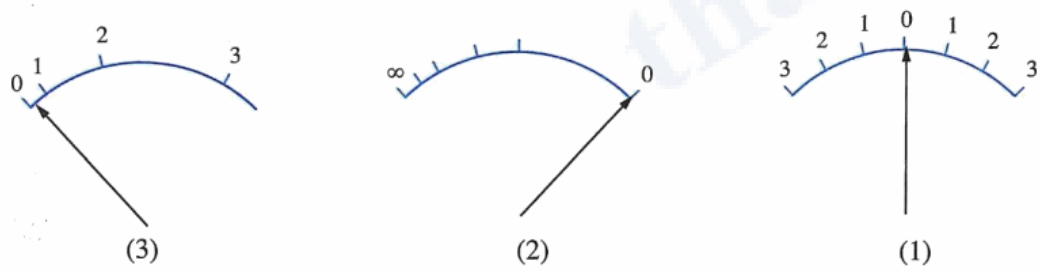
21 A hot-wire ammeter and a moving-coil ammeter are connected in a circuit as in the opposite figure. When switch (K) is closed, which ammeter's pointer settles first at a definite reading?



(A) the hot-wire ammeter
(B) the moving-coil ammeter
(C) both pointers settle together
(D) neither pointer moves from zero

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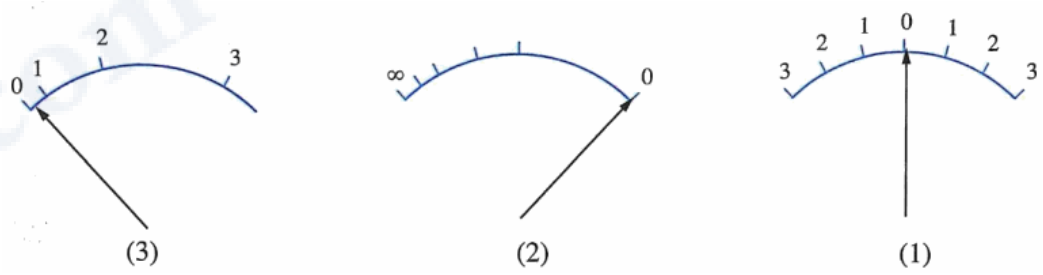
22 Each of the following figures shows the scale of one of three electrical measuring instruments (1), (2), (3). Which of these instruments is used:
(1) to measure direct current only?



(A) instrument 1
(B) instrument 2
(C) instrument 3
(D) instruments 1 and 3

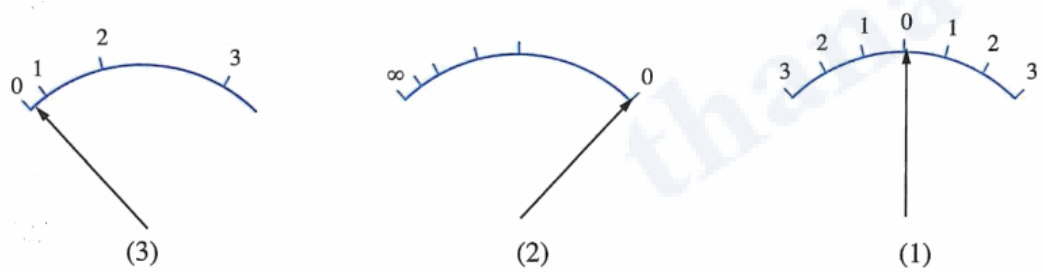
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23 Each of the following figures shows the scale of one of three electrical measuring instruments (1), (2), (3). Which of these instruments is used:
(2) to measure the effective value of an alternating current?



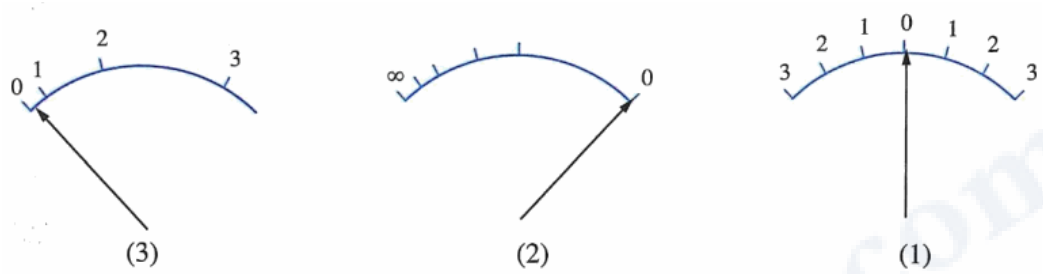
(A) instrument 1
(B) instrument 2
(C) instrument 3
(D) instruments 1 and 3

24 Each of the following figures shows the scale of one of three electrical measuring instruments (1), (2), (3). Which of these instruments is used:
(3) to measure an unknown ohmic resistance?



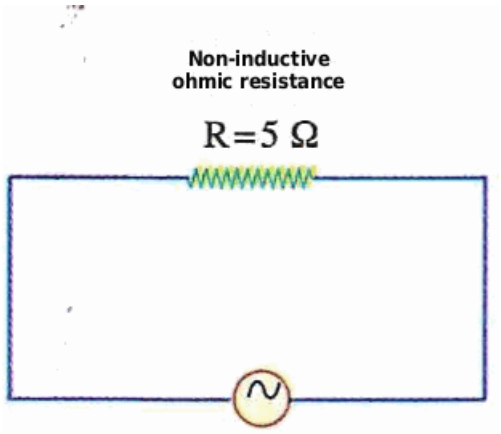
(A) instrument 1
(B) instrument 2
(C) instrument 3
(D) instruments 1 and 3

25 Each of the following figures shows the scale of one of three electrical measuring instruments (1), (2), (3). Which of these instruments is used:
(4) to find the direction of the current in the circuit?



(A) instrument 1
(B) instrument 2
(C) instrument 3
(D) instruments 1 and 3

26 In the opposite circuit, the alternating voltage across the resistance (R) is .....



(A) in phase with the current

(B) leading the current by a phase angle of 90°

(C) lagging behind the current by $3/4$ of a cycle

(D) numerically equal to the current

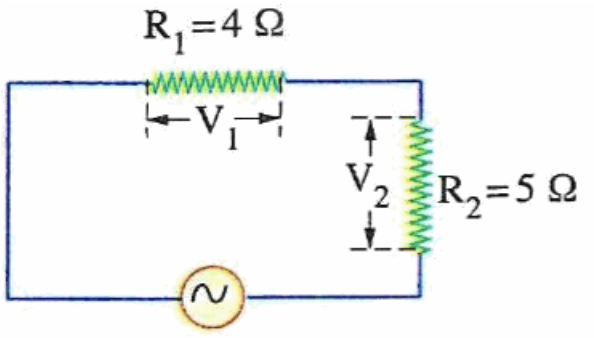
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27 An AC source is connected to an ohmic resistance of 100 Ω. If the instantaneous emf of the source is given by $V = 424.27 \sin \omega t$, the power consumed in the ohmic resistance equals .....

(A) 760 W (B) 820 W (C) 850 W (D) 900 W

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28 In the opposite circuit, the voltage across the resistance R_1 ..... the voltage across the resistance R_2



(A) leads by a phase angle of 40°

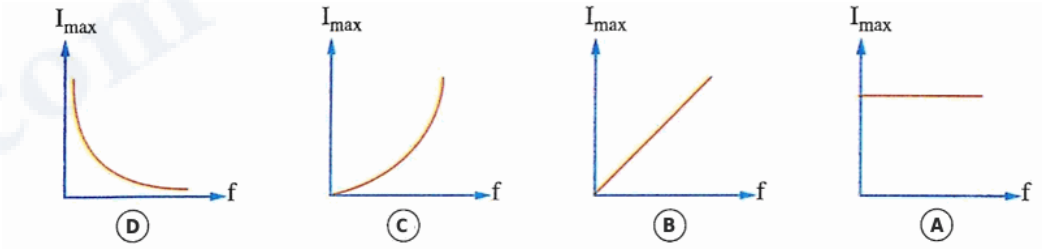
(B) leads by a phase angle of 50°

(C) lags by a phase angle of 50° behind

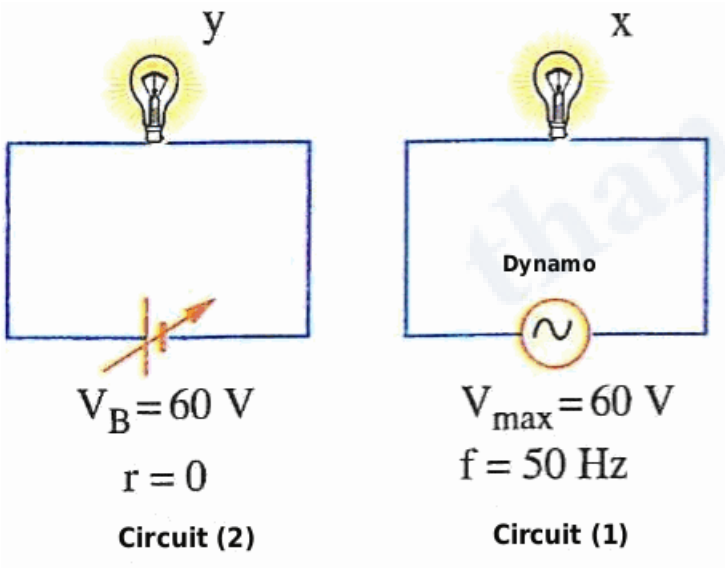
(D) is in phase with

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29 Which of the following graphs shows the relation between the maximum value of the alternating current (I_{max}) in an ohmic resistance connected to a dynamo of negligible internal resistance and the frequency of rotation of the dynamo coil (f)?



30 Two identical lamps (x) and (y): lamp (x) is connected to a dynamo of maximum voltage 60 V and frequency 50 Hz as shown in circuit (1), and lamp (y) is connected to a DC source of emf 60 V, negligible internal resistance and adjustable voltage, as shown in circuit (2). To make the two lamps equally bright, we can .....



(A) increase (V_B) to $60\sqrt{(2)}$ V

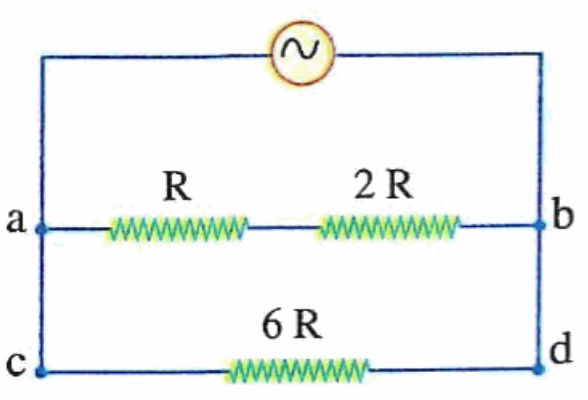
(B) decrease (V_B) to 30 V

(C) increase the dynamo frequency to $50\sqrt{(2)}$ Hz

(D) decrease the dynamo frequency to $50/(\sqrt{(2)})$ Hz

31 Three resistances R, 2 R and 6 R are connected to an AC source as shown in the opposite circuit. If the instantaneous potential difference across the source is given by $V = 300\sqrt{(2)}\ sin\ (100\ \pi\ t)$, and the effective current in branch (cd) equals 1 A, then:

(1) The instantaneous value of the total current in the circuit is given by .....



(A) $I = 3\ sin\ (100\ \pi\ t)$

(B) $I = 3\sqrt{(2)}\ sin\ (100\ \pi\ t)$

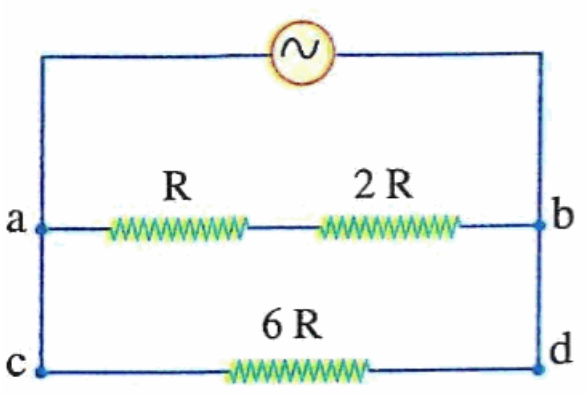
(C) $I = 3\ sin\ (100\ \pi\ t + (\pi)/2)$

(D) $I = 3\sqrt{(2)}\ sin\ (100\ \pi\ t + (\pi)/2)$

---

32 Three resistances R, 2 R and 6 R are connected to an AC source as shown in the opposite circuit. If the instantaneous potential difference across the source is given by $V = 300\sqrt{(2)}\ sin\ (100\ \pi\ t)$, and the effective current in branch (cd) equals 1 A, then:

(2) The resistance (R) equals .....



(A) 25 Ω

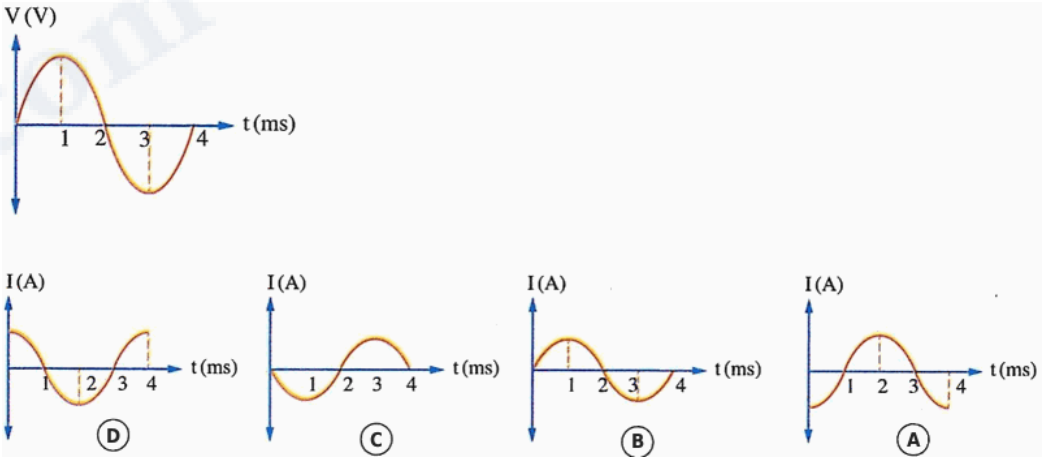
(B) 50 Ω

(C) 100 Ω

(D) 200 Ω

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33 If the potential difference (V) across an inductor of no ohmic resistance connected to an AC source changes with time (t) as in the opposite graph, the graph that shows how the current (I) in the coil changes with time (t) during the same period is .....



34 If the inductive reactance of a coil connected to an AC source is $(440\ L)\ \Omega$, where (L) is the self-inductance of the coil, the frequency of the current is .....

(A) 140 Hz (B) 400 Hz (C) 70 Hz (D) 44 Hz

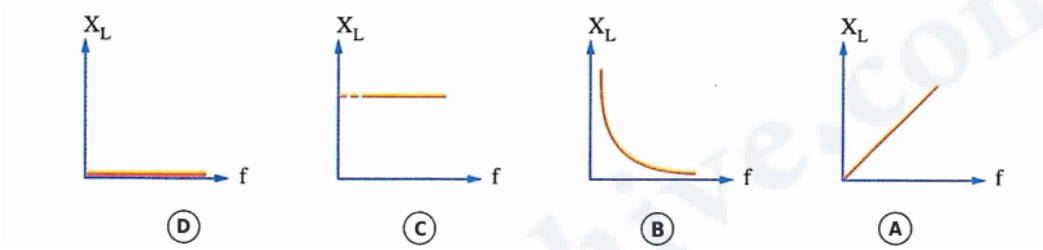
35 An inductor has an inductive reactance of 1000 Ω. If both the self-inductance of the coil and the frequency of the current in it are doubled, its inductive reactance becomes .....

(A) 2000 Ω (B) 500 Ω (C) 250 Ω (D) 4000 Ω

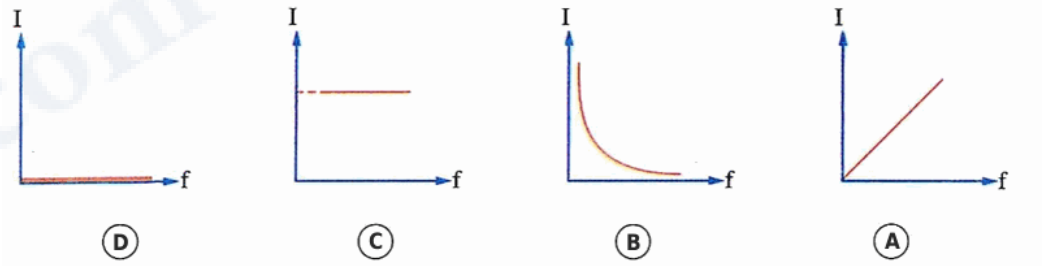
36 An alternating current of effective value 100 mA passes through an inductor of no ohmic resistance and self-inductance 0.1 H. If the frequency of the current is 50 Hz, the effective potential difference across the coil equals .....

(A) 3.14 V (B) 31.4 V (C) 314 V (D) 3140 V

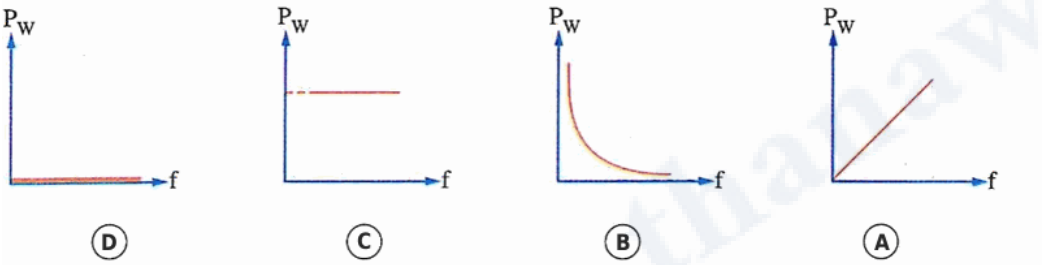
37 An AC dynamo of negligible internal resistance has its terminals connected to an inductor of negligible ohmic resistance. Which of the following graphs shows the relation between:
(1) the inductive reactance (X_L) of the coil and the frequency (f) of rotation of the dynamo coil?



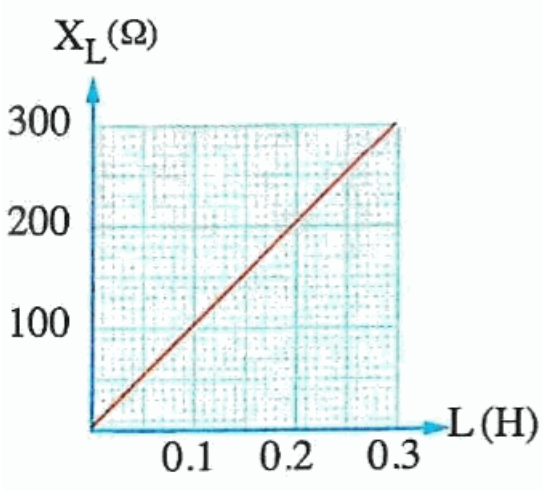
38 An AC dynamo of negligible internal resistance has its terminals connected to an inductor of negligible ohmic resistance. Which of the following graphs shows the relation between:
(2) the current (I) in the coil and the frequency (f) of rotation of the dynamo coil?



39 An AC dynamo of negligible internal resistance has its terminals connected to an inductor of negligible ohmic resistance. Which of the following graphs shows the relation between:
(3) the electric power (P_w) consumed in the coil and the frequency (f) of rotation of the dynamo coil?

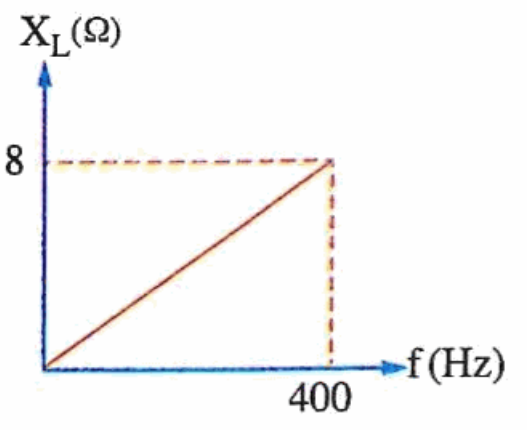


40 An inductor of no resistance and adjustable self-inductance is connected to an AC source of frequency f. The opposite graph shows the relation between the inductive reactance of the coil (X_L) and its self-inductance (L). The frequency of the current (f) equals .....



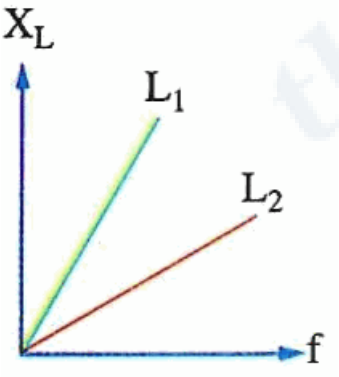
(A) 150.1 Hz (B) 159.1 Hz (C) 162.1 Hz (D) 165.1 Hz

41 The opposite figure shows the graph of the inductive reactance of a coil against the frequency of the current in it. The self-inductance of the coil is .....



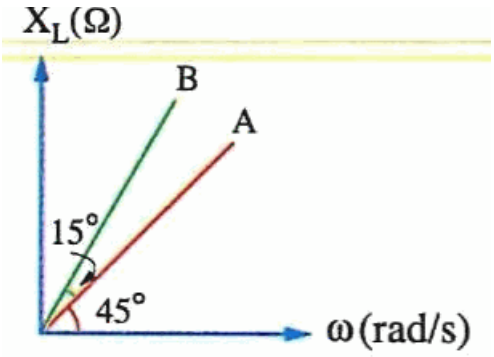
(A) 0.01 H (B) 0.02 H (C) $1/(100\pi)$ H (D) $1/(50\pi)$ H

42 The opposite graph shows the relation between the inductive reactance (X_L) of two inductors of self-inductances L_1 and L_2 and the frequency (f) of the alternating current in each. The relation between them is .....



(A) $L_1 = L_2 \neq 0$ (B) $L_1 > L_2$ (C) $L_1 < L_2$ (D) $L_1 = L_2 = 0$

43 Two solenoids A and B are connected together in series to an AC dynamo whose coil speed can be changed. The opposite figure shows the graph of the inductive reactance (X_L) of each coil against the angular velocity (ω) of the dynamo coil. The ratio between the self-inductances of the two coils (L_A/L_B) equals .....



(A) 0.02 (B) 0.15 (C) $(\sqrt{3})/2$ (D) $(\sqrt{3})/3$

---

44 An inductor of no ohmic resistance is connected to an AC source, and the instantaneous potential difference across the coil is given by $V = 66 \sin(116\ \pi\ t)$. If the maximum current in the circuit is 2 A, the self-inductance of the coil is about .....

(A) 0.02 H (B) 0.05 H (C) 0.06 H (D) 0.09 H

---

45 An inductor is connected to an AC source. The instantaneous values of the potential difference across the coil and of the current in it are given by the two equations:

(1) $V = 200 \sin(50\ \pi\ t)$

(2) $I = 2 \sin(50\ \pi\ t - (\pi)/2)$

The self-inductance of the coil and the frequency of the source are .....

(A) self-inductance: $2/(\pi)$ H, source frequency: 25 Hz

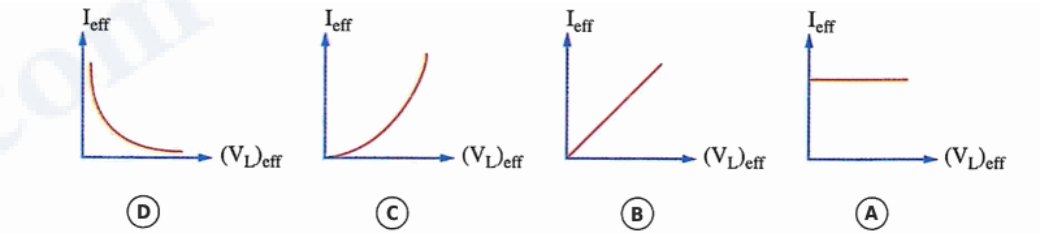
(B) self-inductance: $2/(\pi)$ H, source frequency: 50 Hz

(C) self-inductance: π H, source frequency: 25 Hz

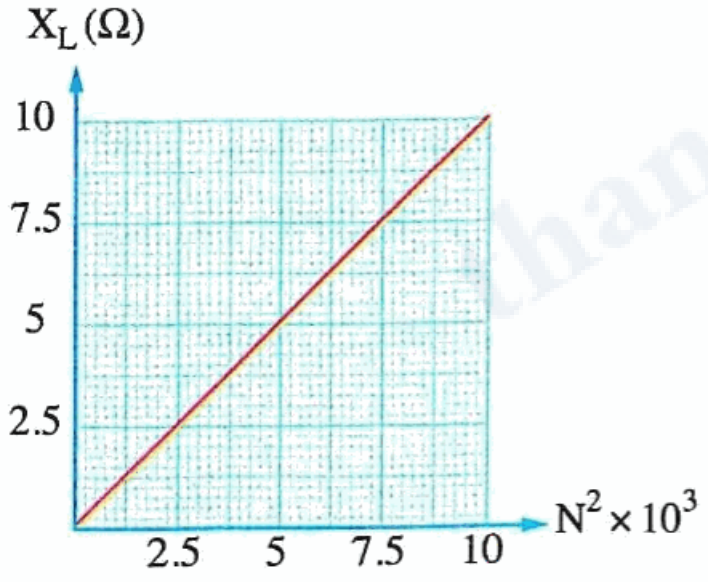
(D) self-inductance: π H, source frequency: 50 Hz

---

46 A circuit consists of an inductor of no ohmic resistance and an AC source of constant frequency whose emf can be changed. The graph that shows the relation between the effective current (I_{eff}) and the effective potential difference $(V_L)_{eff}$ across the coil is .....

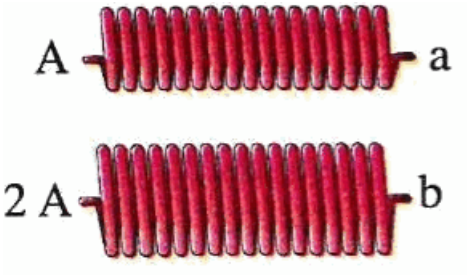


47 Several solenoids with different numbers of turns, each of area (A_0), length 79 cm and core permeability 2×10^{-3} T.m/A, carry an alternating current of frequency 50 Hz. The opposite graph shows the relation between the inductive reactance (X_L) of each coil and the square of its number of turns (N^2). The area of any of the coils (A_0) equals .....



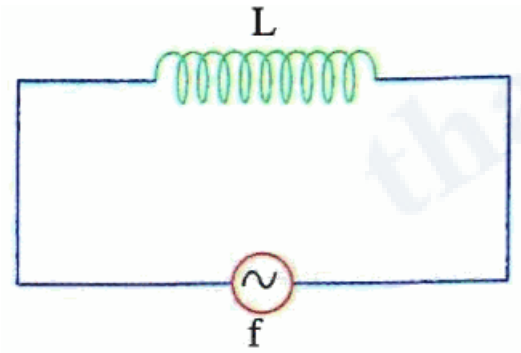
(A) 6.28 cm² (B) 12.6 cm² (C) 25.1 cm² (D) 62.8 cm²

48 The opposite figure shows two solenoids a and b with the same length and the same number of turns. The cross-sectional area of coil b is twice that of coil a. The ratio of their inductive reactances $((X_L)_a/(X_L)_b)$ when connected to the same AC source equals .....



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

49 In the opposite figure, an inductor of self-inductance L is connected to an AC source of frequency f, and the inductive reactance of the coil is X_L. If the coil is cut into three identical parts and one part is connected to the same source, the self-inductance and the inductive reactance of the coil become, respectively, ...



(A) $L/3$, $X_L/3$ (B) 3 L, $X_L/3$ (C) $L/3$, 3 X_L (D) 3 L, 3 X_L

50 An air-core inductor of self-inductance L is connected to an AC source of frequency f, and its inductive reactance is X_L. If a soft iron rod is inserted into the coil, then .....

(A) self-inductance: increases, inductive reactance: decreases

(B) self-inductance: decreases, inductive reactance: increases

(C) self-inductance: increases, inductive reactance: increases

(D) self-inductance: decreases, inductive reactance: decreases

51 A coil of self-inductance 0.7 H and negligible resistance is connected to an AC source of emf 120 V and frequency 50 Hz, then:

(1) The inductive reactance of the coil is .....

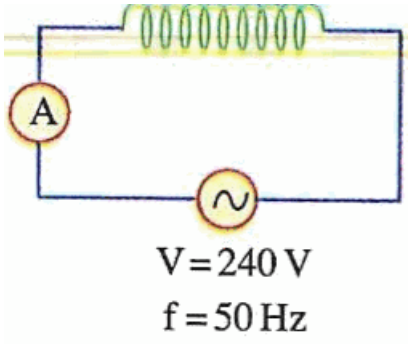
(A) 110 Ω (B) 200 Ω (C) 220 Ω (D) 300 Ω

52 A coil of self-inductance 0.7 H and negligible resistance is connected to an AC source of emf 120 V and frequency 50 Hz, then:

(2) The effective current in the circuit is .....

(A) 0.4 A (B) 0.55 A (C) 0.6 A (D) 1.09 A

53 In the circuit shown, if the reading of the hot-wire ammeter is 4 A, the self-inductance of the coil equals ..... (given that the ohmic resistance of the coil and the ammeter is negligible)



(A) 0.191 H (B) 0.21 H (C) 0.251 H (D) 0.3 H

54 An AC source of maximum voltage 100 V has its terminals connected to an inductor of negligible ohmic resistance with 132 turns, each of area 10^{-3} m², and a core permeability of 2×10^{-3} T.m/A. The maximum current in it is 4 A and it lags behind the maximum voltage by 6.25 ms. The length of the coil equals .....

(A) 17.5 cm (B) 35 cm (C) 70 cm (D) 100 cm

55 An inductor of negligible ohmic resistance has an inductive reactance of 15 Ω when an alternating current of frequency f_1 passes through it. If the frequency increases by 20 Hz to become f_2, its inductive reactance becomes 25 Ω. The frequency of the current in the second case (f_2) equals .....

(A) 30 Hz (B) 40 Hz (C) 50 Hz (D) 60 Hz

56 An inductor of negligible ohmic resistance has an inductive reactance of 12 Ω when an alternating current of frequency f passes through it. If the frequency of the current increases by 20 Hz, its inductive reactance becomes 18 Ω, then:

(1) The ratio of the frequency of the current in the first case to that in the second case is .....

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

57 An inductor of negligible ohmic resistance has an inductive reactance of 12 Ω when an alternating current of frequency f passes through it. If the frequency of the current increases by 20 Hz, its inductive reactance becomes 18 Ω, then:

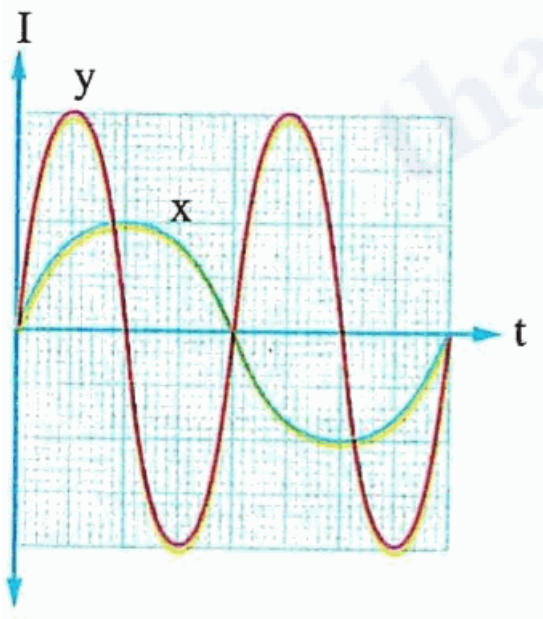
(2) The self-inductance of the coil is .....

(A) 0.021 H (B) 0.031 H (C) 0.048 H (D) 0.071 H

58 A single-layer coil of 300 turns, radius 2.1 cm and length 15 cm is wound around a cylindrical iron rod of permeability 0.002 Wb/A.m and connected to a source of frequency 50 Hz. The inductive reactance of the coil equals .....

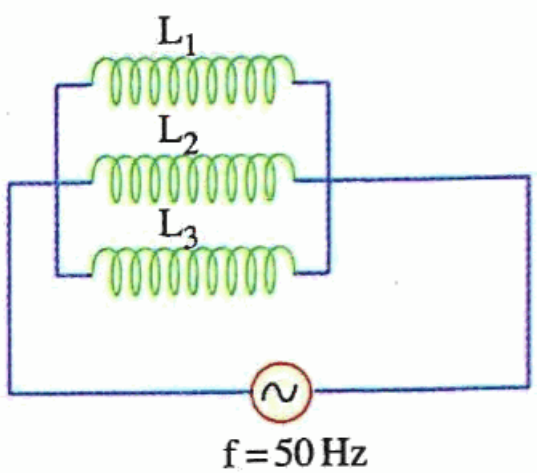
(A) 225.3 Ω (B) 341.4 Ω (C) 425.3 Ω (D) 522.7 Ω

59 Two AC sources (1) and (2) have the same effective voltage. Source (1) is connected to an inductor (x) of negligible ohmic resistance, and source (2) to an inductor (y) of negligible ohmic resistance. The opposite graph shows how the current (I) in the two coils changes with time (t). The ratio between the self-inductances of the two coils (L_x/L_y) equals .....



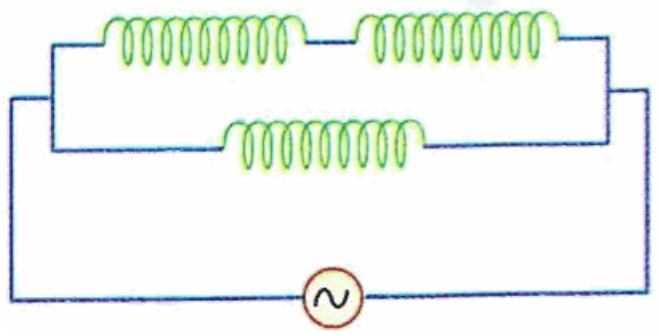
(A) *1/4* (B) *1/2* (C) 2 (D) 4

60 In the circuit shown, three coils L_1, L_2, L_3, far apart and of no ohmic resistance, are connected together in parallel. Their self-inductances are 0.6 H, 0.2 H and 0.3 H, respectively. The inductive reactance of the group is .....



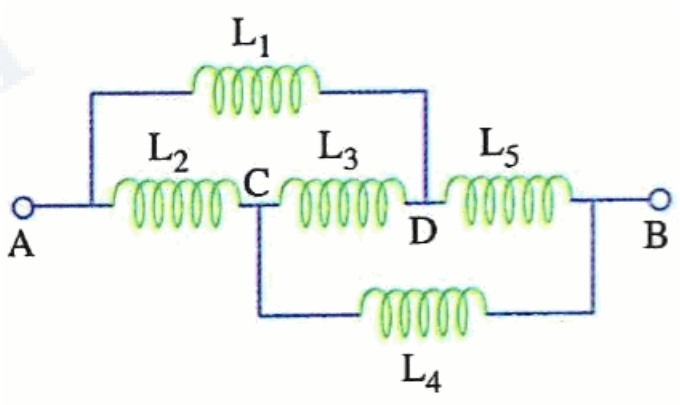
(A) 0.1 Ω (B) 6.28 Ω (C) 31.4 Ω (D) 100 Ω

61 In the circuit shown, the coils are identical with negligible ohmic resistance, and the self-inductance of each is 0.3 H. If their total inductive reactance is 12.56 Ω, and mutual induction between them is neglected, the frequency of the current in the circuit equals ..... (given that $\pi = 3.14$)



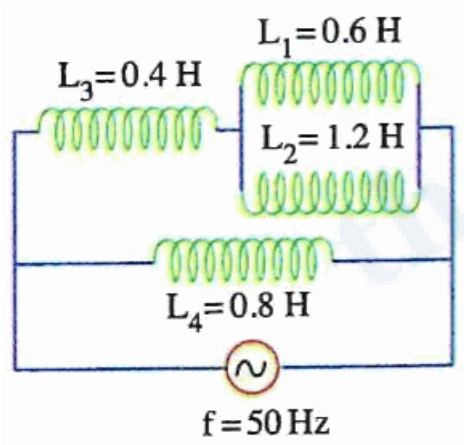
(A) 50 Hz (B) 60 Hz (C) 20 Hz (D) 10 Hz

62 The circuit in front of you has five inductors. If the self-inductance of each is 50 mH, the total self-inductance between points A and B is .....



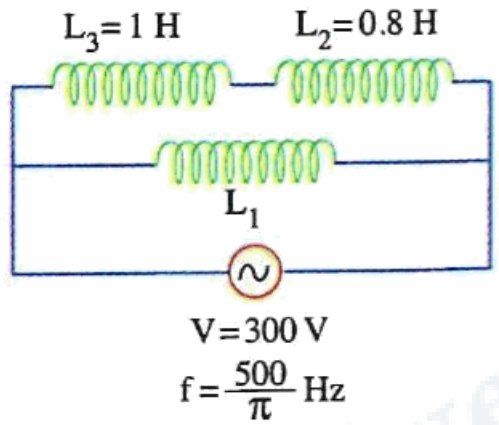
(A) 50 mH (B) 100 mH (C) 150 mH (D) 200 mH

63 In the circuit shown, the total inductive reactance is .....



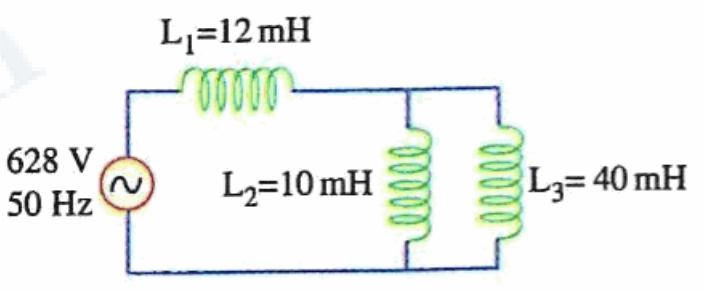
(A) 354.3 Ω (B) 251.4 Ω (C) 125.7 Ω (D) 83.8 Ω

64 In the circuit shown, if the current in the circuit is 0.5 A, then L_1 equals .....



(A) 0.6 H (B) 0.9 H (C) 1.8 H (D) 1.9 H

65 The opposite circuit consists of inductors of no ohmic resistance and an AC source. The currents in the coils L_2 and L_3 are, respectively, ... (given that $\pi = 3.14$)



(A) 20 A, 20 A (B) 80 A, 20 A (C) 80 A, 40 A (D) 80 A, 80 A

66 A group of identical inductors, far apart, is connected in series to an AC source of frequency 50 Hz, and their equivalent inductive reactance is 50 Ω. If the same coils are connected in parallel to the same source, their equivalent inductive reactance is 2 Ω, then:

(1) The number of coils equals .....

(A) 10 (B) 6 (C) 5 (D) 4

67 A group of identical inductors, far apart, is connected in series to an AC source of frequency 50 Hz, and their equivalent inductive reactance is 50 Ω. If the same coils are connected in parallel to the same source, their equivalent inductive reactance is 2 Ω, then:

(2) The inductive reactance of one coil is .....

(A) 5 Ω (B) 8 Ω (C) 10 Ω (D) 12.5 Ω

68 A group of identical inductors, far apart, is connected in series to an AC source of frequency 50 Hz, and their equivalent inductive reactance is 50 Ω. If the same coils are connected in parallel to the same source, their equivalent inductive reactance is 2 Ω, then:

(3) The self-inductance of each coil is about .....

(A) 0.039 H (B) 0.032 H (C) 0.018 H (D) 0.02 H

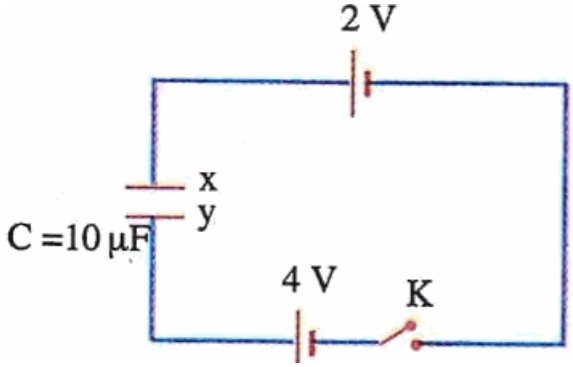
69 If a capacitor of capacitance 1 μF is connected to a DC voltage source, its capacitive reactance equals .....

(A) zero (B) ∞ (C) 1 Ω (D) *1/2* Ω

70 If the capacitance of a capacitor is 3 μF and the potential difference between its plates is 1 V, the charge stored on one of its plates is .....

(A) 3 mC (B) 0.03 mC (C) 0.003 mC (D) 0.333 mC

71 In the circuit shown in the figure, after closing switch K and the capacitor is fully charged, ... (given that $e = 1.6 \times 10^{-19}$ C)



(A) type of charge on plate (y): negative, number of electrons on plate (x): 1.25×10^{14}

(B) type of charge on plate (y): negative, number of electrons on plate (x): 2.5×10^{14}

(C) type of charge on plate (y): positive, number of electrons on plate (x): 1.25×10^{14}

(D) type of charge on plate (y): positive, number of electrons on plate (x): 2.5×10^{14}

---

72 The quantity $\sqrt{(L/C)}$ has the same unit as ..... (where (L) is the self-inductance of the coil and (C) is the capacitance of the capacitor)

(A) resistance

(B) time

(C) frequency

(D) potential difference

---

73 The quantity (CR) is measured in ..... (where (C) is the capacitance of the capacitor and (R) is the ohmic resistance)

(A) ohm

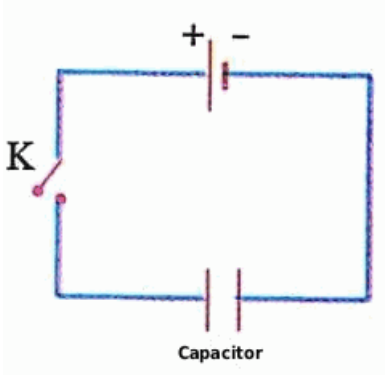
(B) volt

(C) second

(D) hertz

---

74 In the circuit shown, at the moment switch K is closed, the current in the circuit .....



(A) increases with time

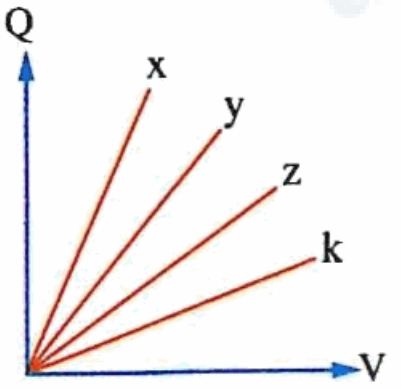
(B) decreases then increases

(C) becomes zero when the capacitor is fully charged

(D) increases and decreases following a sine curve

---

75 Four capacitors x, y, z, k are connected together in parallel to a DC source of adjustable voltage. The opposite graph shows the relation between the charge (Q) on each capacitor and the potential difference (V) between its plates. Which of these capacitors has the largest capacitance?



(A) x (B) y (C) z (D) k

---

76 Figure (1) shows the graph of the electric charge (Q) stored on the plates of each of three capacitors x, y, z against the potential difference (V) between its plates. If the three capacitors are connected as in figure (2), the equivalent capacitance between points a and b equals .....

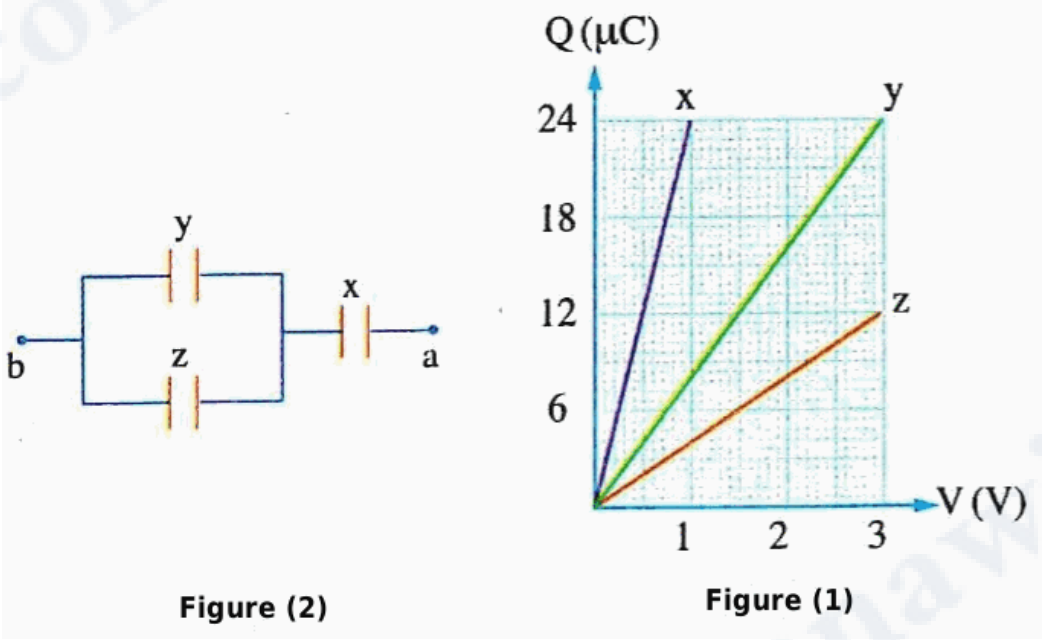


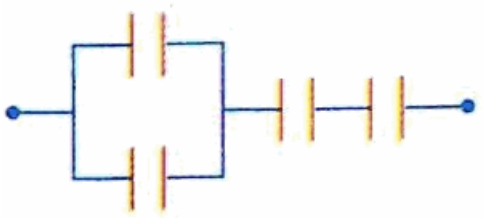
Figure (2) Figure (1)

(A) 6 μF (B) 8 μF (C) 10 μF (D) 12 μF

77 Two capacitors of capacitances C_1 and C_2: when connected in series their total capacitance is 2 μF, and when connected in parallel their total capacitance is 9 μF. The capacitances (C_1) and (C_2) are .....

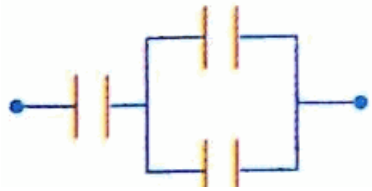
(A) 4 μF, 5 μF (B) 3 μF, 6 μF (C) 4 μF, 4 μF (D) 2 μF, 9 μF

78 In the opposite figure, if the capacitance of each capacitor is 1 pF, the total capacitance is .....



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

79 In the opposite figure, if the capacitance of each capacitor is C, the total capacitance is .....

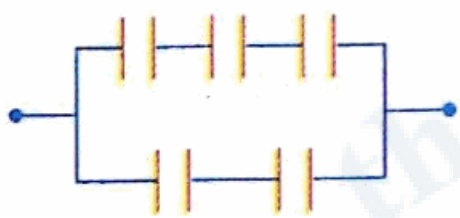


(A) 1.5 C (B) 3 C (C) *2/3* C (D) C

80 Three capacitors C_1, C_2, C_3 are connected together in parallel, and the group is connected across a battery. If $(C_3 > C_2 > C_1)$ and the charges stored on the plates of the capacitors are Q_1, Q_2, Q_3, respectively, then .....

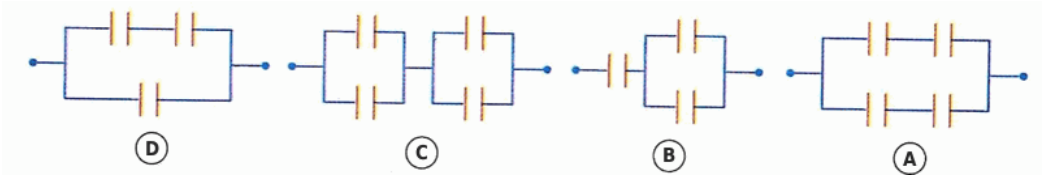
(A) $Q_3 > Q_2 > Q_1$ (B) $Q_1 > Q_3 > Q_2$ (C) $Q_1 > Q_2 > Q_3$ (D) $Q_1 = Q_2 = Q_3$

81 In the opposite figure, several capacitors each of capacitance 24 pF. The total capacitance of the group equals .....



(A) 4.8 pF (B) 16.8 pF (C) 20 pF (D) 24 pF

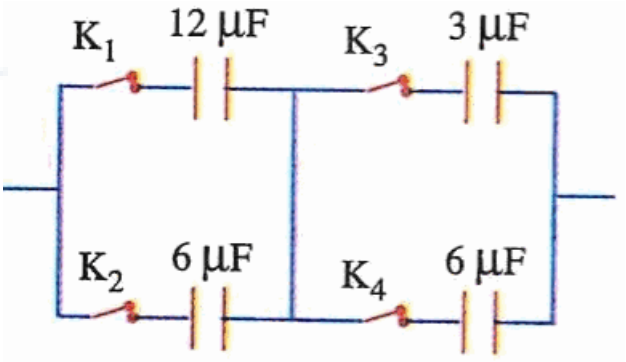
82 You have a group of identical capacitors, each of capacitance 15 μF. The connection that gives an equivalent capacitance of 10 μF is .....



83 A group of capacitors has a total capacitance of 48 μF. It is required to decrease the total capacitance to 30 μF by adding a capacitor to this group. The capacitance of the capacitor to be added and how it is connected are .....

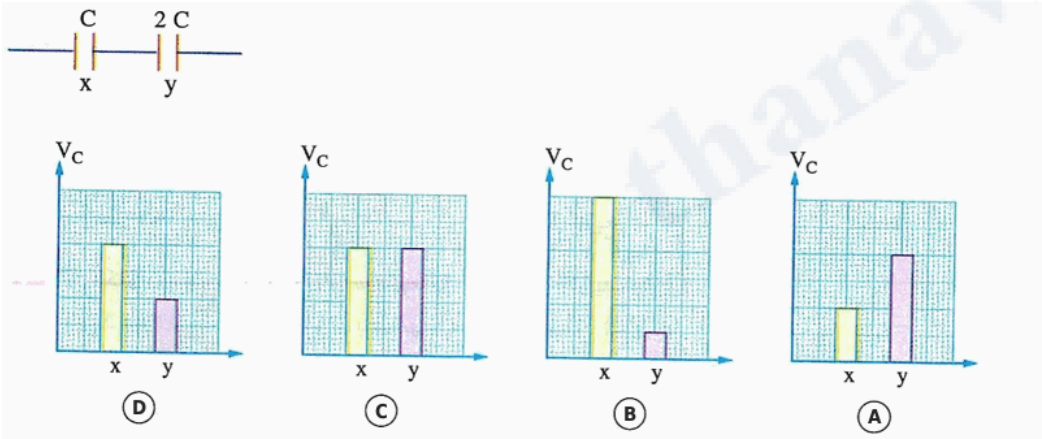
(A) 64 μF, in series (B) 80 μF, in series (C) 64 μF, in parallel (D) 80 μF, in parallel

84 The opposite figure shows four capacitors connected together by four switches. Which of these switches, when opened, decreases the total capacitance by 1.5 μF?

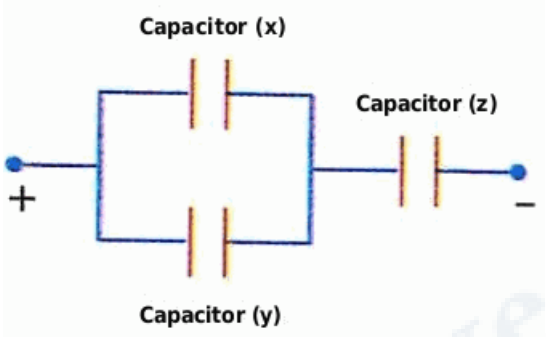


(A) K_1 (B) K_2 (C) K_3 (D) K_4

85 The opposite figure shows two capacitors x and y connected in series. Which of the following graphs shows the ratios of the potential differences across each of them when they are connected to an AC source?



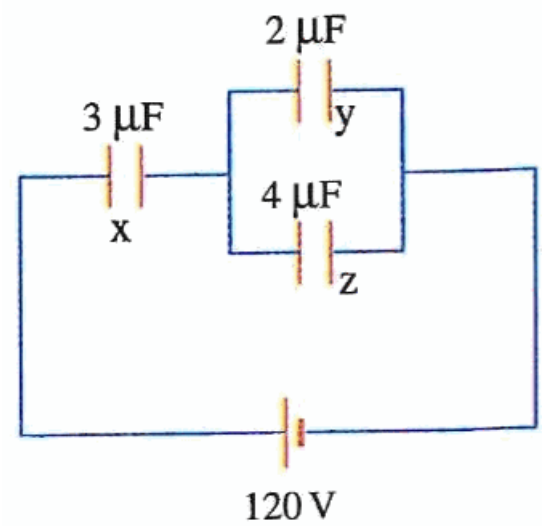
86 Three capacitors (x), (y), (z) of capacitances C, 2 C and *1/2* C, respectively, are connected together and to a DC voltage as in the opposite figure. The correct order of the three capacitors according to the charge on each is .....



(A) $y > x > z$ (B) $z > x > y$ (C) $z = y > x$ (D) $z > y > x$

87 In the circuit shown, a DC source of 120 V is connected to three capacitors x, y, z, then:

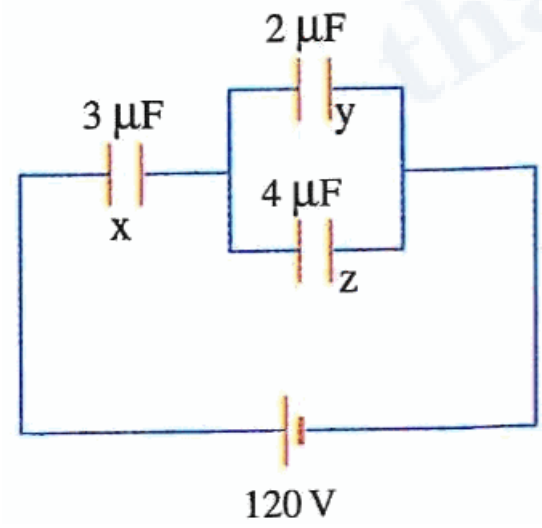
(1) The potential differences across capacitors x and z, respectively, are .....



(A) 120 V, 60 V (B) 40 V, 80 V (C) 80 V, 40 V (D) 60 V, 20 V

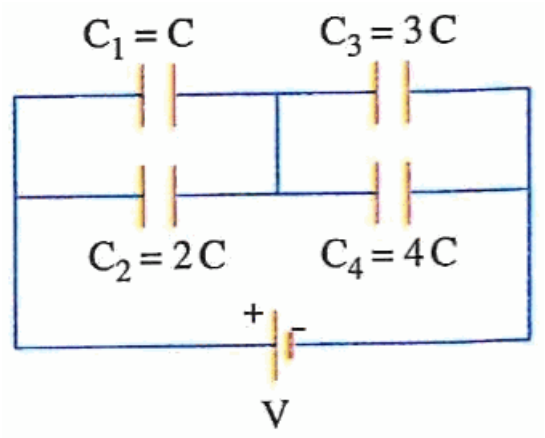
88 In the circuit shown, a DC source of 120 V is connected to three capacitors x, y, z, then:

(2) The charges stored on capacitors x and y, respectively, are .....



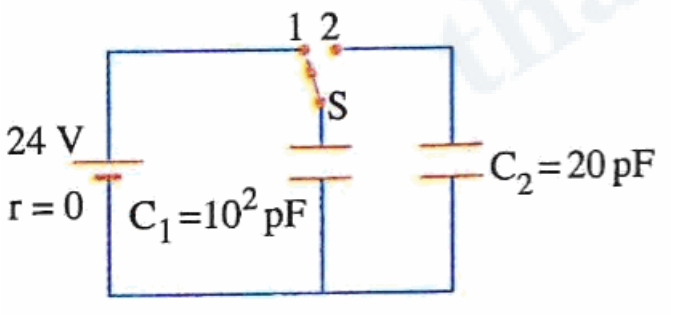
(A) 240 μC, 80 μC (B) 120 μC, 160 μC (C) 80 μC, 120 μC (D) 160 μC, 120 μC

89 A circuit consists of several capacitors of different capacitances connected to a source of negligible internal resistance, as shown in the figure. Which of these capacitors stores the largest charge?



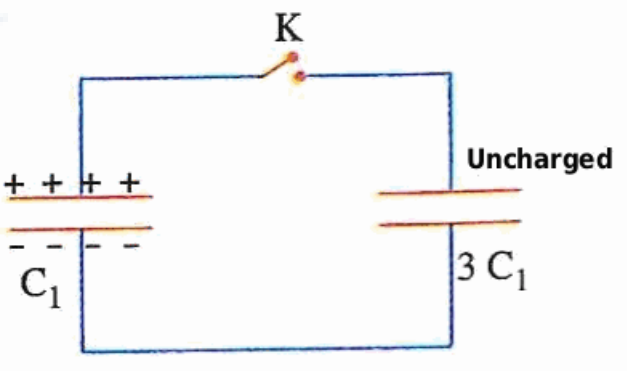
(A) C_1 (B) C_2 (C) C_3 (D) C_4

90 Two uncharged capacitors are connected to a battery of emf 24 V as in the opposite circuit. When switch (S) is put in position (1) until capacitor C_1 is fully charged, then put in position (2), the potential difference across capacitor C_1 becomes .....



(A) 5 V (B) 10 V (C) 20 V (D) 15 V

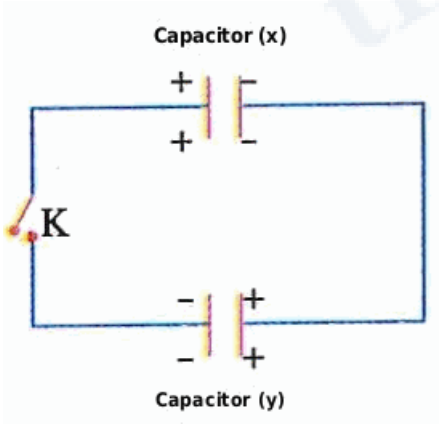
91 A charged capacitor of capacitance C_1 is connected to an uncharged capacitor of capacitance 3 C_1 through a switch K as in the figure. When switch K is closed, the charge of capacitor C_1 .....



(A) doubles
(B) decreases to one half
(C) decreases to one third
(D) decreases to one quarter

---

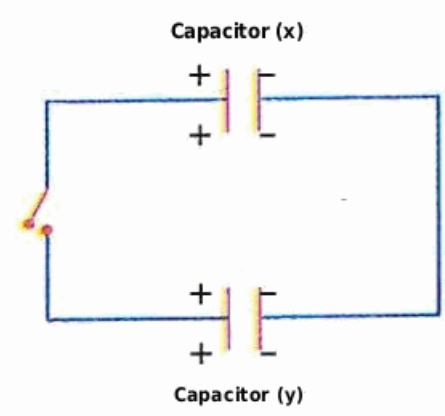
92 Two charged capacitors (x) and (y) of capacitances C and 2 C, respectively, with equal potential differences across them, are connected to each other through a switch (K) as in the opposite figure. What happens to the potential difference across each of capacitors (x) and (y), respectively, after closing switch (K)?



(A) does not change, does not change
(B) decreases, decreases
(C) increases, decreases
(D) decreases, increases

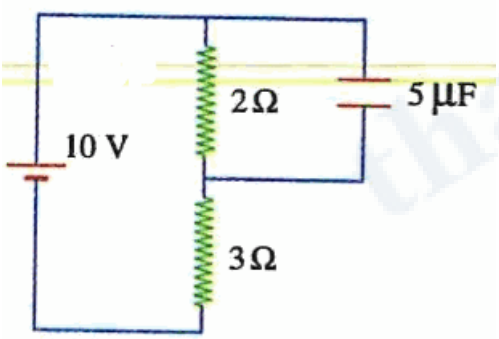
---

93 Two charged capacitors (x) and (y) of capacitances C and 2 C, with potential differences 1 V and 2.5 V, respectively, are connected through a switch as in the opposite figure. After closing the switch, the potential difference across capacitor (x) .....



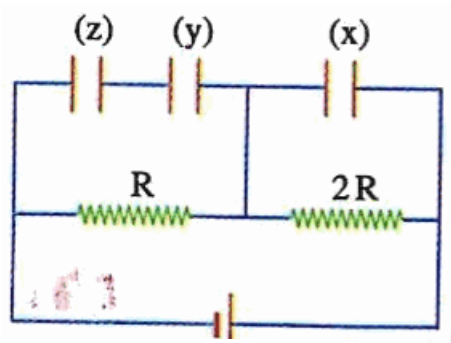
(A) stays 1 V (B) becomes 2 V (C) becomes 3 V (D) becomes 4 V

94 In the circuit shown in the opposite figure, the charge stored on the capacitor is .....



(A) 5 μC (B) 10 μC (C) 15 μC (D) 20 μC

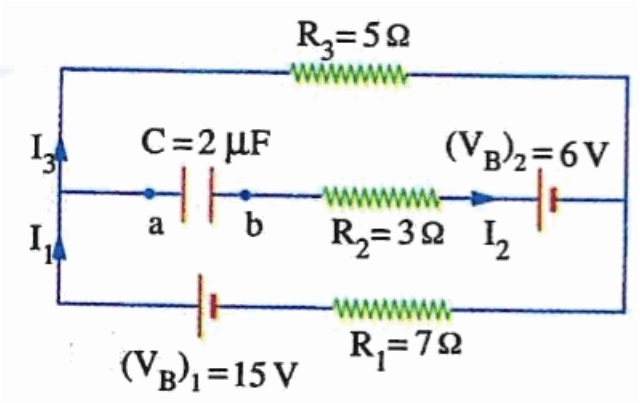
95 Three capacitors (x), (y), (z) of capacitances C, 2 C and 4 C, respectively, are connected in a circuit as in the opposite figure. The correct order of the capacitors according to the potential difference across each is .....



(A) $V_x > V_y > V_z$ (B) $V_x < V_y < V_z$ (C) $V_x = V_y = V_z$ (D) $V_x > V_z > V_y$

96 In the circuit shown in the figure:

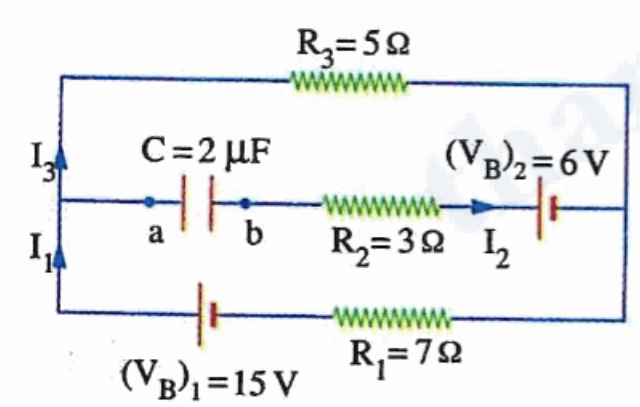
(1) The values of I_1 and I_3, respectively, are .....



(A) 3 A, 2 A (B) 0.75 A, 0.75 A (C) 1.25 A, 0.5 A (D) 1.25 A, 1.25 A

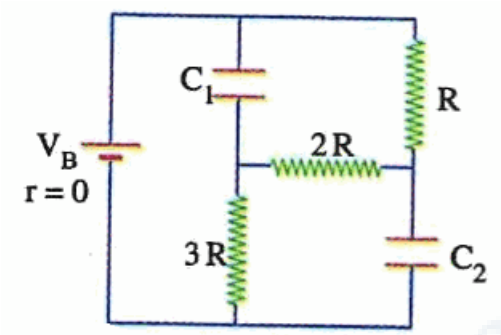
97 In the circuit shown in the figure:

(2) The charge stored on one plate of the capacitor equals .....



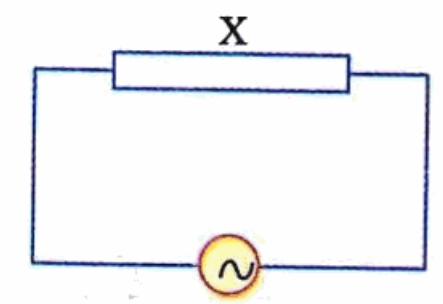
(A) 0.125 μC (B) 0.5 μC (C) 3.2 μC (D) 5.5 μC

98 The opposite circuit contains two charged capacitors C_1 and C_2 of capacitances C and 2 C, respectively. The ratio between the charges on the two capacitors (Q_1/Q_2) equals .....



(A) *1/2* (B) *3/5* (C) *1/1* (D) *3/10*

99 In the circuit shown in the figure, if the voltage lags behind the current in phase, the element (X) is .....



(A) a capacitor

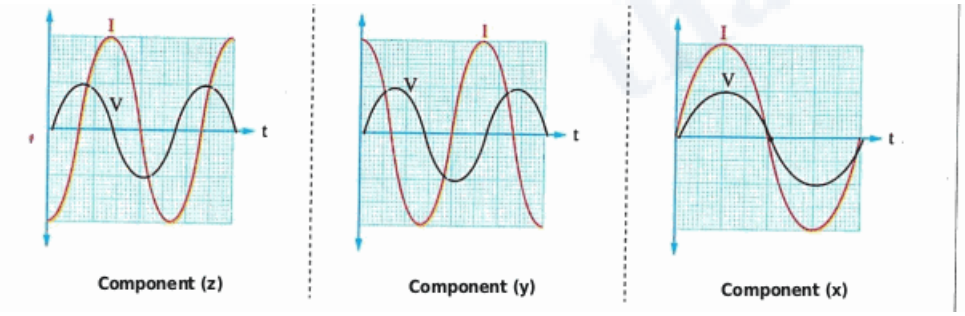
(B) an ohmic resistance

(C) an inductor of negligible ohmic resistance

(D) a hot-wire ammeter

---

100 The terminals of an AC source are connected to three electrical components (x), (y), (z), each on its own. The following graphs show how the potential difference (V) across the source and the current (I) in it change with time (t). The components (x), (y), (z) are .....



(A) (x): non-inductive resistance, (y): capacitor, (z): inductor of no resistance

(B) (x): non-inductive resistance, (y): inductor of no resistance, (z): capacitor

(C) (x): inductor of no resistance, (y): capacitor, (z): non-inductive resistance

(D) (x): inductor of no resistance, (y): non-inductive resistance, (z): capacitor

---

101 A capacitor of fixed capacitance is connected directly to an AC source of frequency f, and its capacitive reactance is X_C. If the frequency of the current is tripled, its capacitive reactance .....

(A) triples

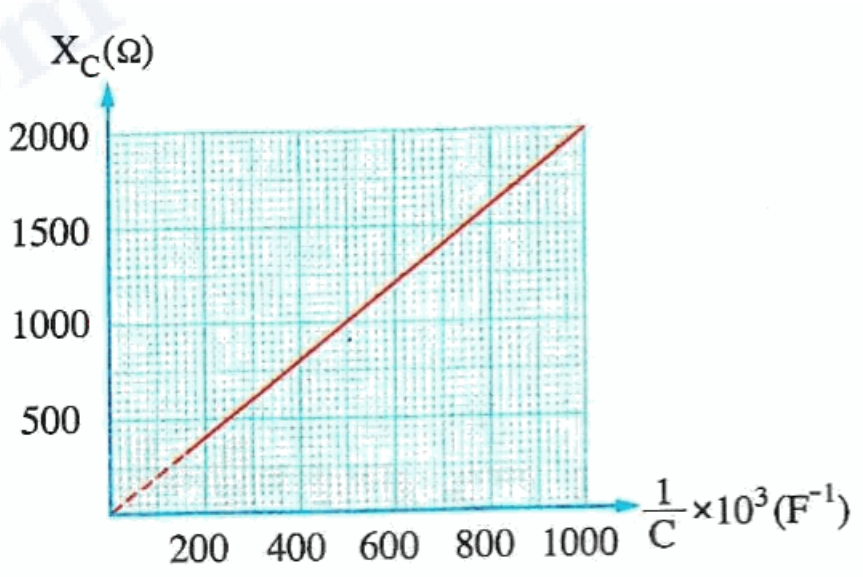
(B) becomes nine times as large

(C) decreases to one third

(D) stays the same

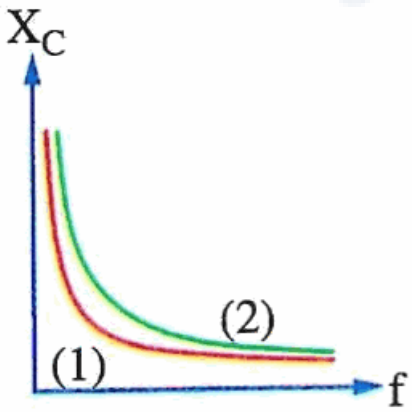
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102 The opposite graph shows the relation between the capacitive reactance (X_C) of a variable capacitor connected to an AC voltage source of frequency f and the reciprocal of the capacitance $(1/C)$. The frequency f of the current equals .....



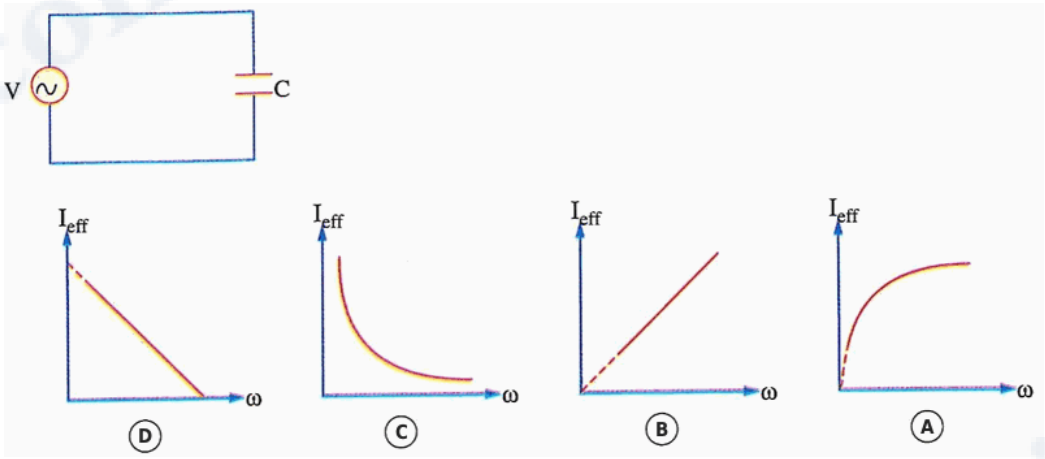
(A) 52.55 Hz (B) 64.54 Hz (C) 79.55 Hz (D) 81.48 Hz

103 The opposite graph shows the relation between the capacitive reactance (X_C) of two capacitors of capacitances C_1 and C_2 and the frequency (f). The relation between them is .....

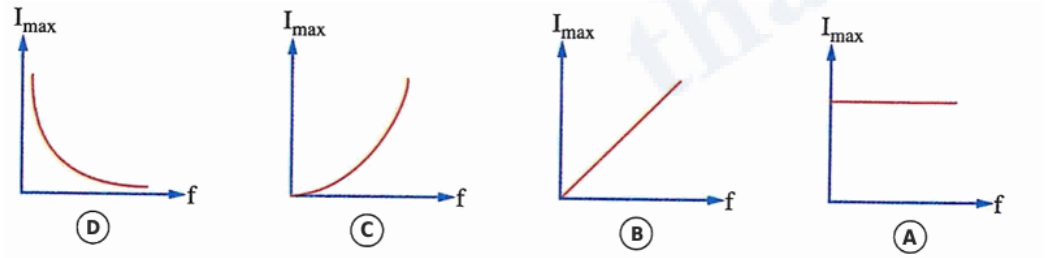


(A) $C_1 = C_2$ (B) $C_1 > C_2$
(C) $C_1 < C_2$ (D) cannot be determined

104 An AC source whose frequency can be changed while its effective voltage stays constant is connected to a capacitor of capacitance C, as shown in the figure. Which of the following graphs shows the relation between the effective current in the circuit (I_{eff}) and the angular frequency (ω) of the source?



105 A circuit consists of an AC dynamo of negligible internal resistance and a capacitor. The graph that shows the relation between the maximum alternating current (I_{max}) in the circuit and the frequency (f) of rotation of the dynamo coil is .....



106 A capacitor of capacitance $7000/11$ μF is connected to an AC source of 20 V and frequency 50 Hz, then:

(1) The capacitive reactance of the capacitor equals .....

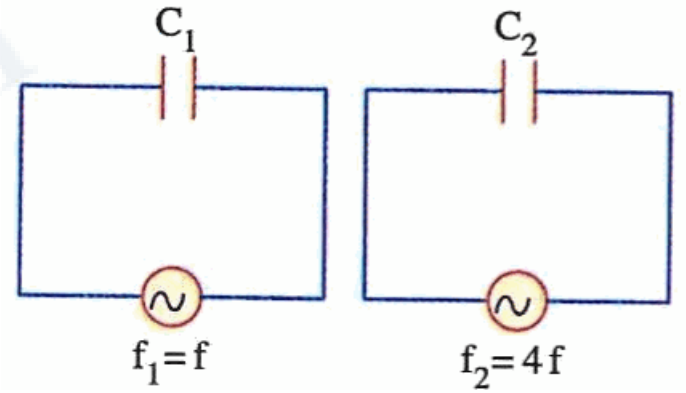
(A) 0.1 Ω (B) 0.2 Ω (C) 5 Ω (D) 10 Ω

107 A capacitor of capacitance $7000/11$ μF is connected to an AC source of 20 V and frequency 50 Hz, then:

(2) The current in the circuit is .....

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

108 The opposite figure shows two circuits, each containing an AC source and a capacitor. If $((X_C)_1)/((X_C)_2) = 2/3$, then .....

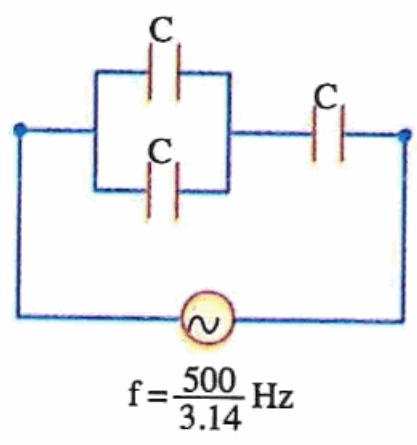


(A) $C_1/C_2 = 3/4$ (B) $C_1/C_2 = 6/1$ (C) $C_1/C_2 = 8/3$ (D) $C_1/C_2 = 1/12$

109 A capacitor of capacitance $700/22$ μF is connected across an AC source whose instantaneous voltage is given by $V = 100 \sin (200 \pi t)$. The instantaneous current in the circuit is given by .....

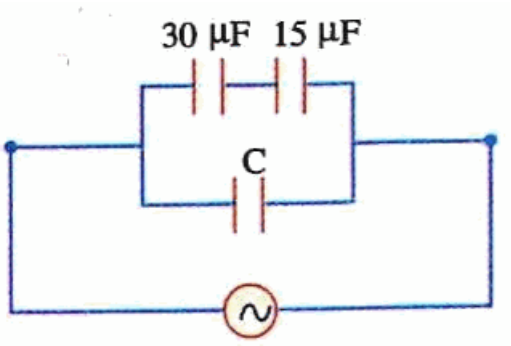
(A) $I = 2 \sin (200 \pi t)$
(B) $I = 0.5 \sin (200 \pi t + (\pi)/2)$
(C) $I = 2 \sin (200 \pi t - (\pi)/2)$
(D) $I = 2 \sin (200 \pi t + (\pi)/2)$

110 In the figure shown, if all capacitors have the same capacitance and the total capacitive reactance is 50 Ω, the capacitance of each capacitor C equals ..... (given that $\pi = 3.14$)



(A) 2 μF (B) 6 μF (C) 12 μF (D) 30 μF

111 An AC source of effective voltage 500 V and frequency $100/(\pi)$ Hz is connected to a group of capacitors as in the opposite figure, and an effective current of 2 A passes in the circuit. The capacitance C equals .....



(A) 15 μF (B) 10 μF (C) 20 μF (D) 50 μF

112 Three capacitors, each of capacitance 14 μF, are connected together in parallel and to a source of frequency 50 Hz. The total capacitive reactance is .....

(A) 681.8 Ω (B) 322.3 Ω (C) 151.5 Ω (D) 75.76 Ω

113 Three capacitors of 10, 20 and 30 microfarad are connected in series to a source of emf 200 volt and frequency 42 hertz, then:

(1) The total capacitive reactance equals .....

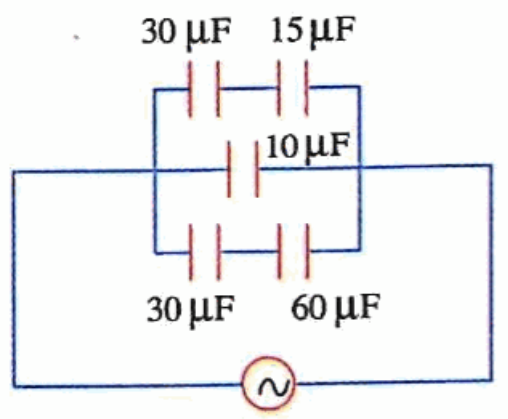
(A) 1388.8 Ω (B) 695.02 Ω (C) 126.26 Ω (D) 63.13 Ω

114 Three capacitors of 10, 20 and 30 microfarad are connected in series to a source of emf 200 volt and frequency 42 hertz, then:

(2) The current in the circuit is .....

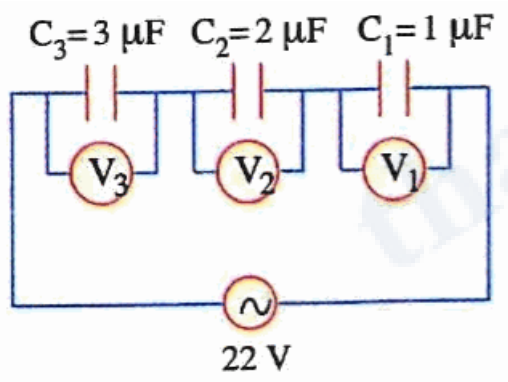
(A) 3.16 A (B) 1.58 A (C) 0.29 A (D) 0.14 A

115 An AC source of 400 V and frequency 50 Hz is connected to a group of capacitors as in the opposite figure. The total current through the source equals .....



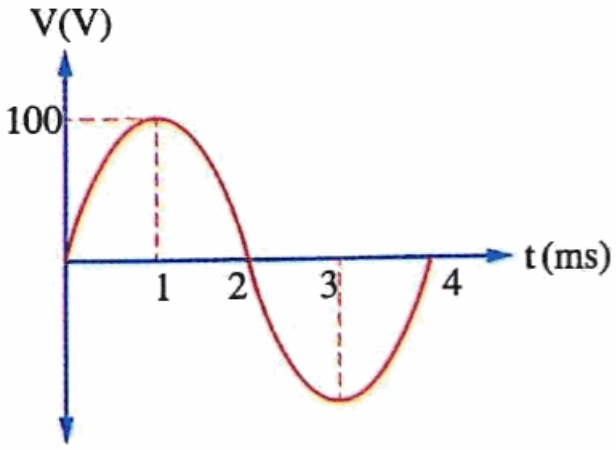
(A) 0.94 A (B) 2.03 A (C) 4.02 A (D) 5.03 A

116 From the opposite figure, ...



(A) V_1: 12 V, V_2: 5 V, V_3: 5 V
(B) V_1: 10 V, V_2: 8 V, V_3: 4 V
(C) V_1: 12 V, V_2: 6 V, V_3: 4 V
(D) V_1: 4 V, V_2: 6 V, V_3: 12 V

117 The opposite graph shows how the emf (V) induced in a dynamo coil changes with time (t). If the terminals of this dynamo are connected to a capacitor of capacitance 2 μF, the effective current through the source is .....

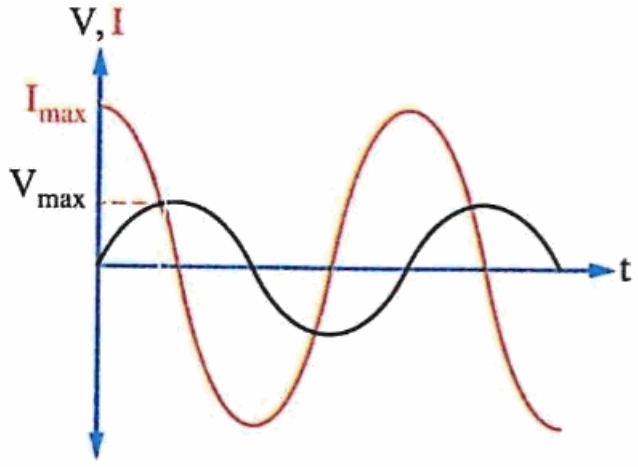


(A) 0.445 A (B) 0.314 A (C) 0.22 A (D) 0.15 A

118 A dynamo coil of 100 turns and area 0.05 m^2 is in a uniform magnetic field of flux density 0.225 T. The terminals of this coil are connected to a capacitor of capacitive reactance 1 kΩ, and an effective current of 0.25 A passes in the circuit. The angular frequency of the dynamo coil is about .....

(A) 157 rad/s (B) 314 rad/s (C) 471 rad/s (D) 628 rad/s

119 An AC source of negligible internal resistance has its terminals connected to a pure element. The opposite graph shows the current (I) in the circuit and the potential difference (V) across the source against time (t). The electric power consumed in the circuit equals .....



(A) $I_{max}\ V_{max}$ (B) $(I_{max}\ V_{max})/2$
(C) $(I_{max}\ V_{max})/(\sqrt{2})$ (D) zero

Essay questions — 23 questions

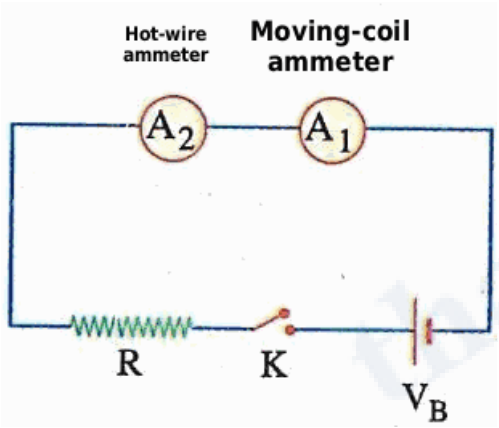
1 Give a reason: measuring the value of an alternating current depends on its heating effect.

2 The opposite figure shows an electric circuit containing two ammeters A_1 and A_2 of two different types. When switch K is closed:

(1) What type of energy is the electrical energy changed into, causing the pointer to deflect, in each of the two instruments?

(2) Which of the two ammeters has its pointer settle first at a definite reading? Why?

(3) In which of the two instruments: (a) does an electric current pass through the spring? (b) does the spring cause the pointer to deflect from zero?



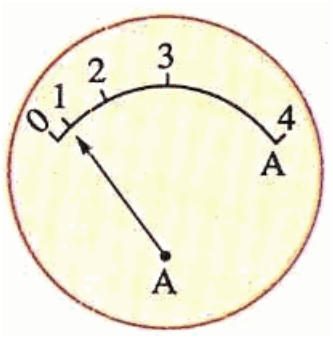
3 When a hot-wire ammeter is used to measure a direct current, does its scale need to be calibrated to be uniform before measuring? Why?

4 A student wanted to use a hot-wire ammeter to measure the current in a circuit, but he noticed that the pointer of the ammeter rests at a reading of 1 A before any current passes through it, as in the opposite figure:

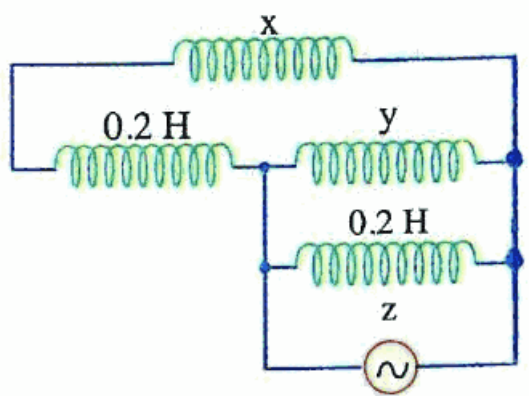
(1) What is the likely reason why the pointer does not rest at zero although no current passes through the ammeter?

(2) The student thought of passing the current in the circuit, recording the reading where the pointer settles, then subtracting 1 A from it to correct the zero error. Is this idea scientifically accurate? Why?

(3) What solutions do you suggest to stop the pointer from resting away from zero before the current passes?



5 In the circuit shown in the figure, all coils have no ohmic resistance. The current in coil z is twice the current in coil x and half the current in coil y. Calculate the self-inductances of coils x and y.

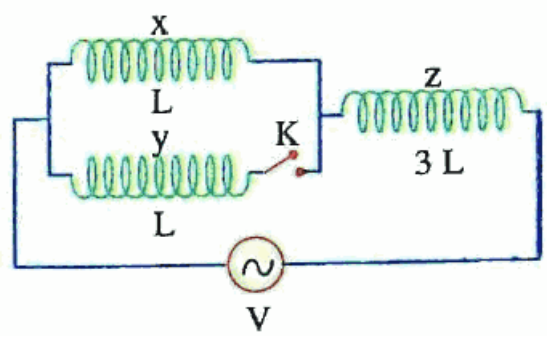


6 An AC circuit consists of three coils of negligible ohmic resistance, an AC source and a switch K, as in the opposite figure. What happens, when switch K is closed, to:

(1) the phase difference between the total voltage and the current in the circuit?

(2) the potential difference across coil z?

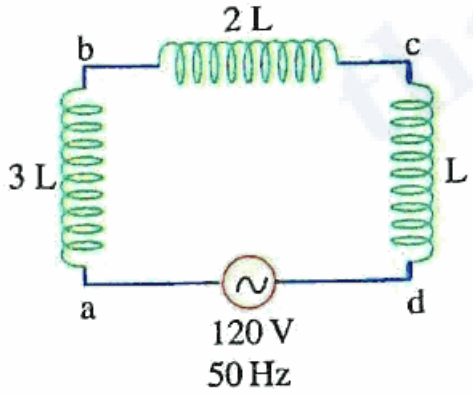
(3) the current in coil x?



7 In the opposite circuit, all coils have no ohmic resistance:

(1) Find the potential difference between points: (a) a and c (b) b and d

(2) If the current in the circuit is 1 A, find the self-inductance L.



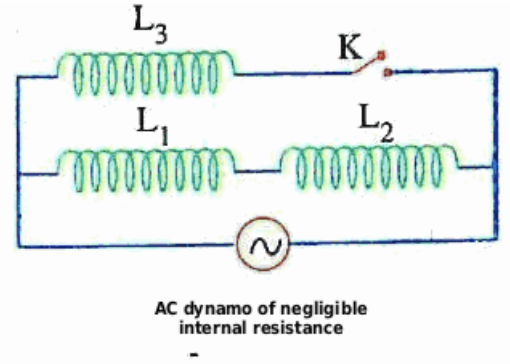
8 What is the result of winding the wires of a solenoid carrying an alternating current as a double (non-inductive) winding, regarding the inductive reactance of the coil?

9 Prove that the quantity L/R has the same unit as time, where (L) is the self-inductance of the coil and (R) is the ohmic resistance.

10 In the opposite circuit, all coils have negligible ohmic resistance. What happens to the maximum current in coil L_1 when:

(1) switch K is closed?

(2) the frequency of the source is increased?



11 The opposite figure shows an AC dynamo whose coil has negligible ohmic resistance and rotates with frequency f. Its terminals are connected to an inductor (L) of negligible ohmic resistance. What happens to the current in the dynamo coil when:

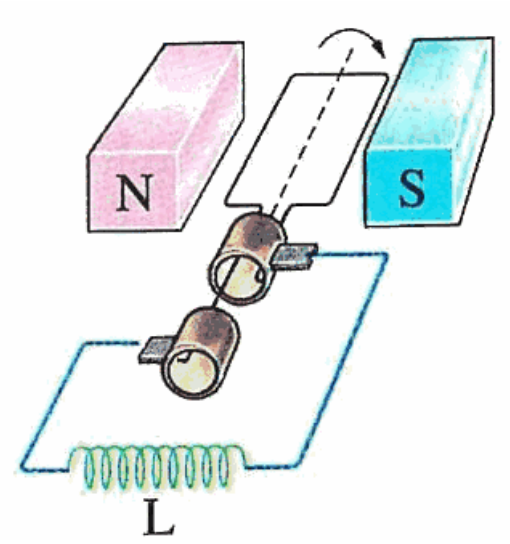
(1) the turns of coil (L) are brought closer to each other uniformly?

(2) another coil (L) is connected in series in the external circuit?

(3) the speed of rotation of the dynamo coil is increased?

(4) an iron core is placed inside the coil?

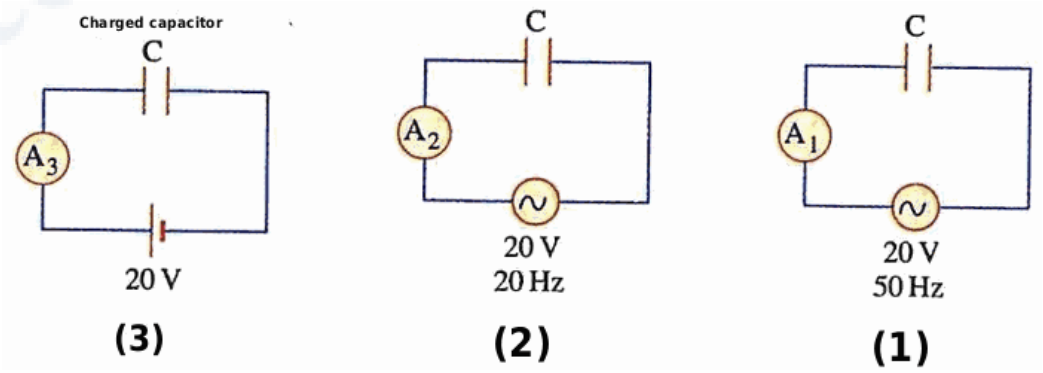
(5) the dynamo coil is replaced by another one with twice the number of turns of the first coil?



12 The following figure shows three electric circuits (1), (2), (3), each with a capacitor of capacitance C, a 20 V source and a hot-wire ammeter. Explain each of the following:

(1) The reading of ammeter A_3 is zero while the readings of ammeters A_1 and A_2 are not zero.

(2) The reading of ammeter A_1 is greater than the reading of ammeter A_2

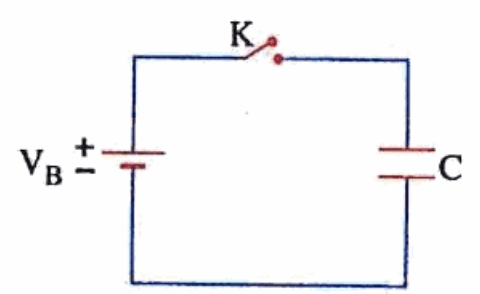


13 In the opposite circuit, a capacitor C, a battery V_B of negligible internal resistance and a switch K are connected together in series. When switch K is closed, capacitor C takes a time t to be fully charged. Describe what happens during the time t to:

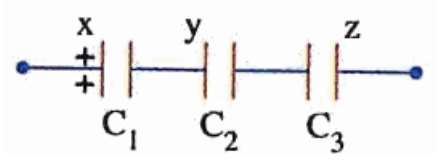
(1) the rate of flow of electric charge from the battery to the capacitor.

(2) the potential difference between the plates of the capacitor.

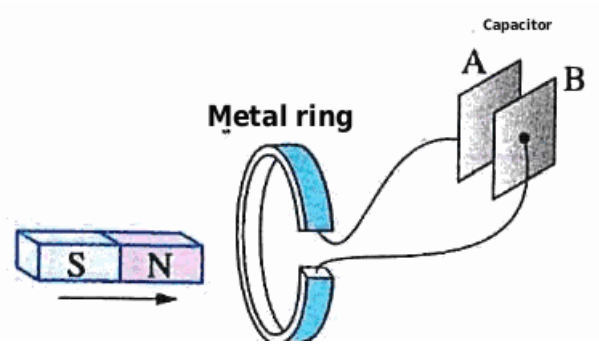
(3) the potential difference between the terminals of the battery.



14 Three capacitors C_1, C_2, C_3 are connected in series as in the opposite figure, and plate x of capacitor C_1 carries a positive charge Q. Find the type and amount of charge on plates y and z.

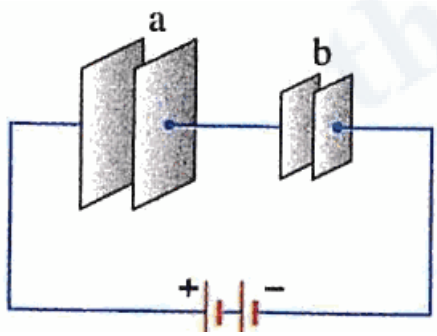


15 In the opposite figure, what type of electric charge forms on plate A of the capacitor while the magnet is moved towards the metal ring? Why?



16 Three capacitors of different capacitances C_1, C_2, C_3 are connected in parallel to a DC source of voltage V. Prove that the charge stored on each capacitor differs from one capacitor to another after they are fully charged.

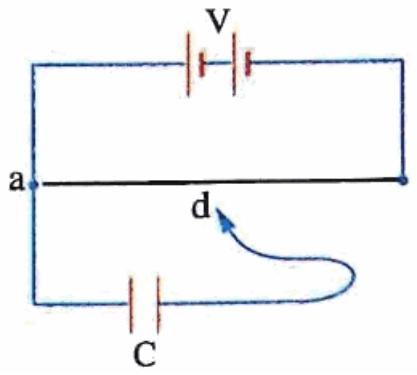
17 Two capacitors a and b of different capacitances, because their plates have different areas, are connected in series with a battery as in the opposite figure. Does the charge stored on the plates of the two capacitors differ? Why?



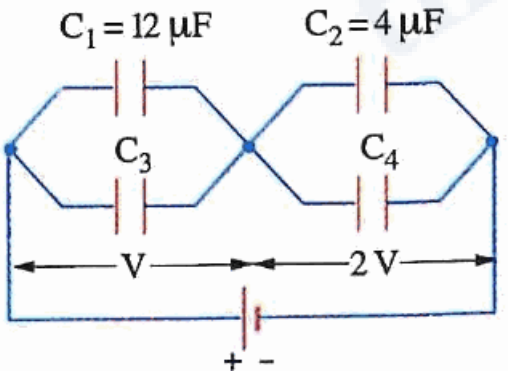
18 The circuit shown in the opposite figure was used to find the capacitance of capacitor (C), where the potential difference applied between the plates of the capacitor changes by moving the slider d along the wire ab:

(1) Draw a graph of the charge (Q) stored on the capacitor on the vertical axis against the potential difference (V) between its plates on the horizontal axis.

(2) How can the capacitance (C) be found from the graph?



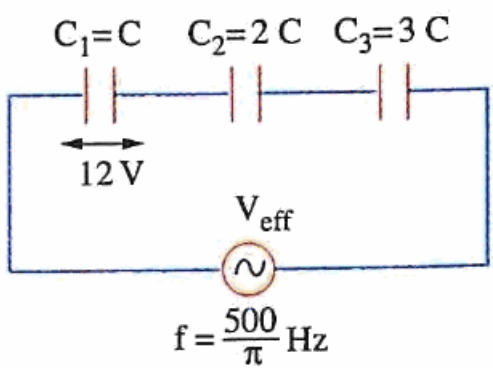
19 A group of four capacitors C_1, C_2, C_3, C_4 is connected to a DC source as in the opposite figure. If the charge of capacitor C_1 equals the charge of capacitor C_3, find the capacitance of capacitor C_4



20 In the opposite circuit, if the effective alternating current in the circuit is 1 A, calculate:

(1) the capacitance of the capacitor (C).

(2) the effective emf of the source (V_eff), neglecting its internal resistance.

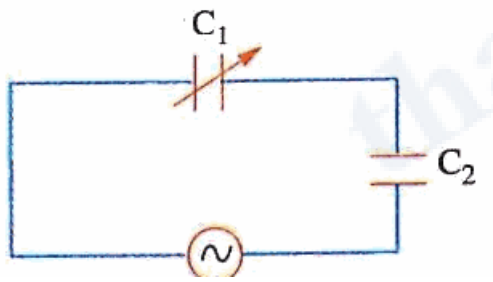


21 In the opposite circuit, when the capacitance of capacitor C_1 is increased, what happens to:

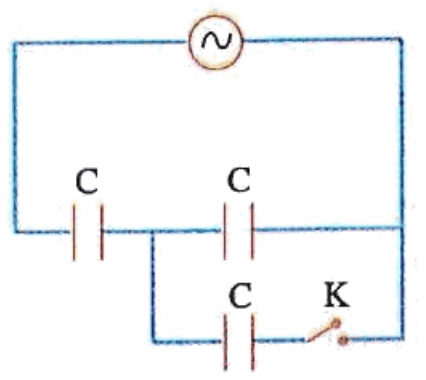
(1) the phase difference between the total voltage and the current in the circuit?

(2) the current through the source?

(3) the potential difference between the plates of capacitor C_2?

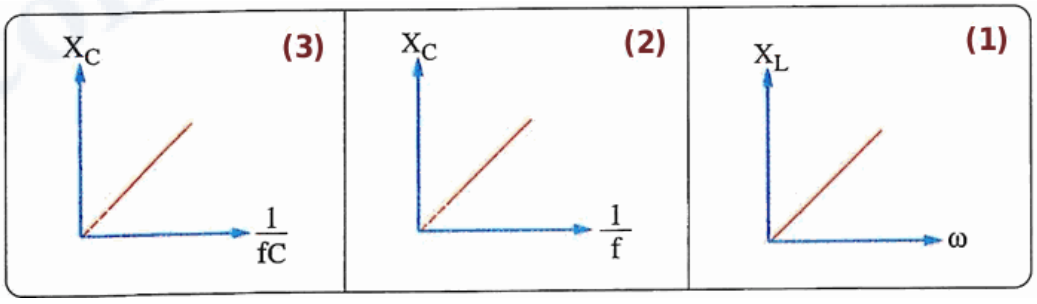


22 In the circuit shown in the figure, neglecting the ohmic resistance in the circuit, calculate the ratio between the currents in the circuit before and after closing the switch (I_1/I_2).



23 Write the mathematical relation shown by each graph, and what the slope of the straight line equals, for each of the following:

where: (X_L) is the inductive reactance of the coil, (ω) the angular velocity, (X_C) the capacitive reactance of a capacitor, (f) the frequency, (C) the capacitance of the capacitor.



Past exam questions — 57 questions

1 The wire of a hot-wire ammeter is fixed on a metal plate with the same thermal expansion coefficient, in order to ..... (Trial exam / May 2021)

(A) return the pointer quickly to zero when the current is cut off

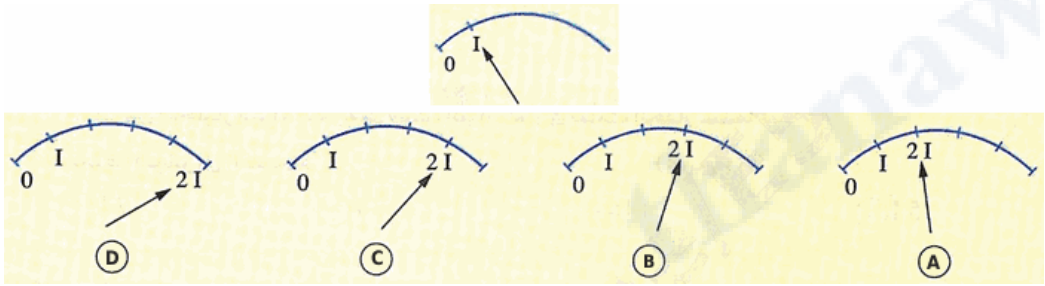
(B) decrease the efficiency of the instrument in measuring

(C) get rid of the zero error

(D) increase the thermal expansion of the wire

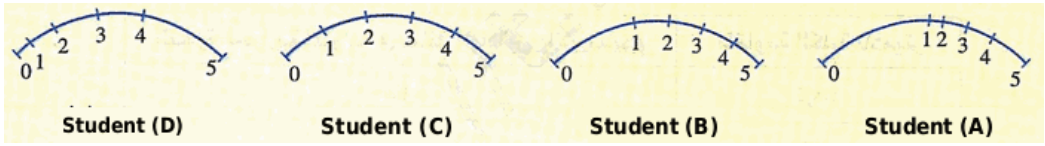
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2 When calibrating the scale of a hot-wire ammeter, its pointer deflected as in the opposite figure when an alternating current of effective value I passed. Which of the following figures correctly shows the position of the pointer when an alternating current of effective value 2I passes through the ammeter? (Trial exam / June 2021)



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3 Some students drew a diagram of a hot-wire ammeter. Which student drew the scale of the hot-wire ammeter correctly? (1st session 2021)



(A) student (A) (B) student (B) (C) student (C) (D) student (D)

---

4 In a hot-wire ammeter, the amount of heat produced in the platinum-iridium wire by an alternating current is directly proportional to ..... (2nd session 2021)

(A) $1/(V_{eff}^2)$ (B) I_{eff} (C) I_{max} (D) V_{eff}^2

---

5 In a hot-wire ammeter, the pointer moves over a scale with unequal divisions because ..... (1st session 2022)

(A) the hot-wire ammeter measures the maximum value of the alternating current

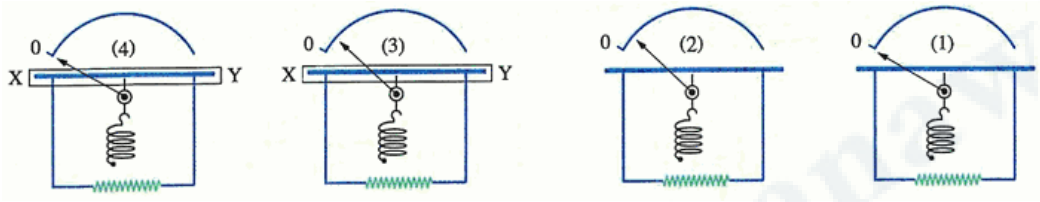
(B) the pointer of the hot-wire ammeter moves slowly when the current starts

(C) the amount of heat produced is directly proportional to the current

(D) the amount of heat produced is directly proportional to the square of the current

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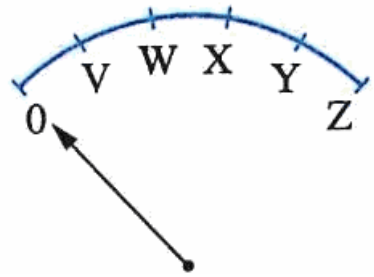
6 In a country with a very hot climate, a student wanted to use the hot-wire ammeter in the school lab, which is not air-conditioned. Which two figures correctly show the position of the pointer of the hot-wire ammeter at the lab temperature? (2nd session 2022)
(given that XY is a strip of a material with the same expansion coefficient as the platinum-iridium wire)



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

---

7 The figure shows the scale of a hot-wire ammeter, and the distances between the divisions in the figure are equal. If a current I passes through the wire of the instrument, the pointer deflects to division V. Which of the following choices is the current in the wire when the pointer deflects to division Y? (Trial exam 2023)



(A) 2I (B) 3I (C) 4I (D) 5I

---

8 In a hot-wire ammeter, when the shunt is decreased while the effective current in the circuit stays constant, ... (1st session 2023)

(A) the heat power produced in the platinum-iridium wire: decreases, the total resistance of the ammeter: increases

(B) the heat power produced in the platinum-iridium wire: decreases, the total resistance of the ammeter: decreases

(C) the heat power produced in the platinum-iridium wire: increases, the total resistance of the ammeter: decreases

(D) the heat power produced in the platinum-iridium wire: increases, the total resistance of the ammeter: increases

---

9 An electric current (I) passes through the wire of a hot-wire ammeter. When the current through the wire is increased to (2I), ... (2nd session 2023)

(A) the expansion of the wire: increases, the heat energy produced in the wire per unit time: doubles

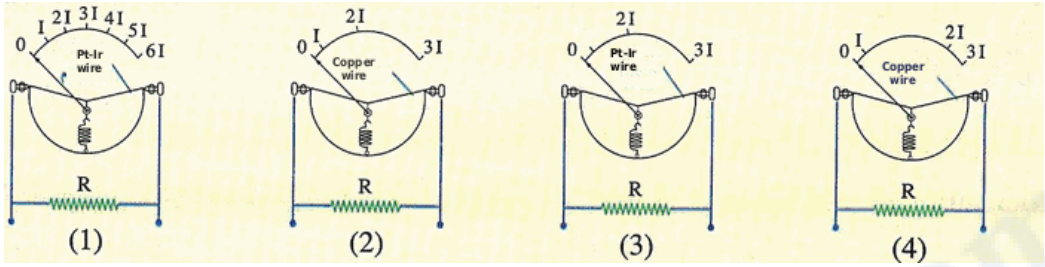
(B) the expansion of the wire: decreases, the heat energy produced in the wire per unit time: decreases to one half

(C) the expansion of the wire: increases, the heat energy produced in the wire per unit time: becomes 4 times as large

(D) the expansion of the wire: decreases, the heat energy produced in the wire per unit time: decreases to one quarter

---

10 The following diagrams show attempts by some students to show the structure of a hot-wire ammeter. Which of these figures shows the correct structure of the hot-wire ammeter? (1st session 2024)



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

---

11 In a hot-wire ammeter, when the shunt is replaced by another of a smaller value while the effective current in the circuit stays constant, ... (2nd session 2024)

(A) the heat power produced in the platinum-iridium wire: increases, the total resistance of the ammeter: increases

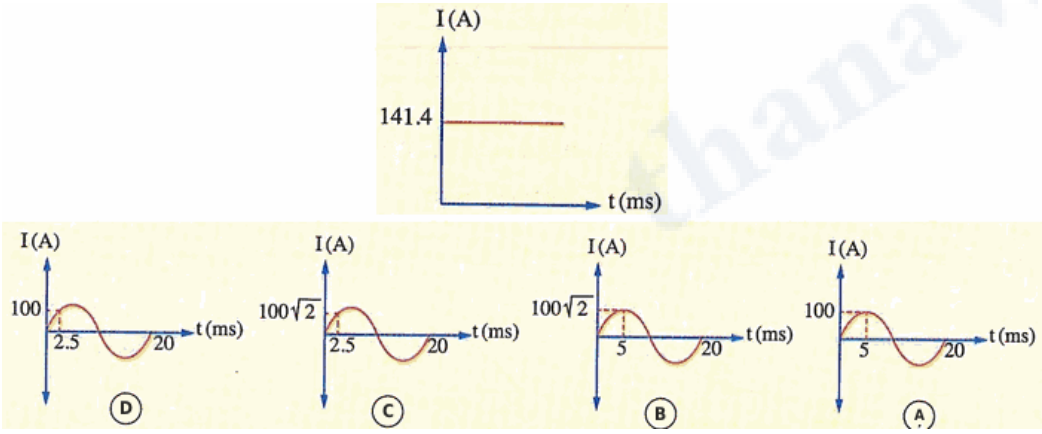
(B) the heat power produced in the platinum-iridium wire: decreases, the total resistance of the ammeter: decreases

(C) the heat power produced in the platinum-iridium wire: increases, the total resistance of the ammeter: decreases

(D) the heat power produced in the platinum-iridium wire: decreases, the total resistance of the ammeter: increases

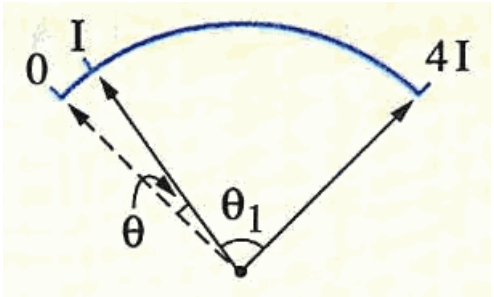
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12 The opposite graph shows the relation between a direct current (I) and time (t). Which of the following graphs shows the alternating current that gives the same heat energy in the same resistance in the same time as the direct current? (2nd session 2024)



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13 The opposite figure shows two deflections of the pointer of a hot-wire ammeter from zero. The value of θ_1 in terms of θ equals ..... (Sample exam 2025)



(A) 5θ (B) 10θ (C) 15θ (D) 20θ

---

14 Alternating current cannot be used directly for ..... (Sample exam 2025)

(A) lighting lamps
(B) running household appliances
(C) charging batteries
(D) operating electric transformers

15 When an alternating current of effective value (I) passes through a hot-wire ammeter, the electric power consumed in the platinum-iridium wire is (P_w). The effective value of the alternating current that makes the power consumed in the same hot-wire ammeter $(2P_w)$ equals ..... (Sample exam 2025)

(A) I (B) $\sqrt{(2)}\ I$ (C) $0.5\ I$ (D) $2I$

16 In a hot-wire ammeter, when the platinum-iridium wire is replaced by another wire of a metal with a smaller thermal expansion coefficient and the same current passes through it, the deflection angle of the pointer ..... (Sample exam 2025)

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

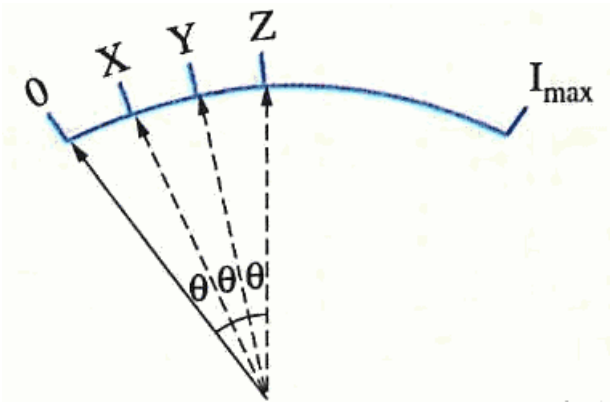
17 The opposite figure shows the scale of a hot-wire ammeter and several values of the current, where:

(ΔI_1) is the change in current from zero to position X

(ΔI_2) is the change in current from position X to position Y

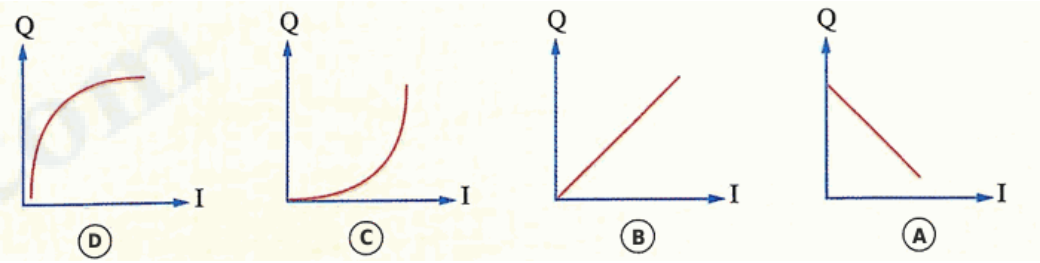
(ΔI_3) is the change in current from position Y to position Z

If the angles shown are equal, the correct order of the changes in current is ..... (Sample exam 2025)



(A) $\Delta I_1 > \Delta I_2 > \Delta I_3$
(B) $\Delta I_1 = \Delta I_2 = \Delta I_3$
(C) $\Delta I_1 < \Delta I_2 < \Delta I_3$
(D) $\Delta I_1 < \Delta I_2 > \Delta I_3$

18 Which of the following graphs shows the relation between the amount of heat (Q) produced in the (platinum-iridium) wire and the current in it (I)? (Sample exam 2025)



19 The reading of a hot-wire ammeter in an AC circuit represents ..... (1st session 2025)

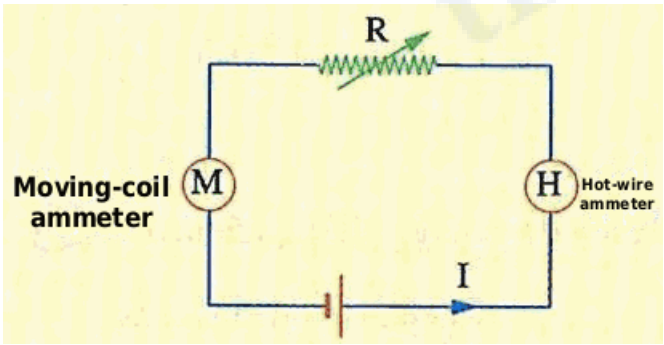
(A) the average value over a complete cycle of the alternating current

(B) the maximum value of the alternating current

(C) the instantaneous value of the alternating current

(D) the effective value of the alternating current

20 The figure shows an electric circuit consisting of a DC source, a variable resistance (R), a hot-wire ammeter (H) and a moving-coil ammeter (M). If the current changes by equal amounts, what happens to the pointer of each ammeter? (2nd session 2025)



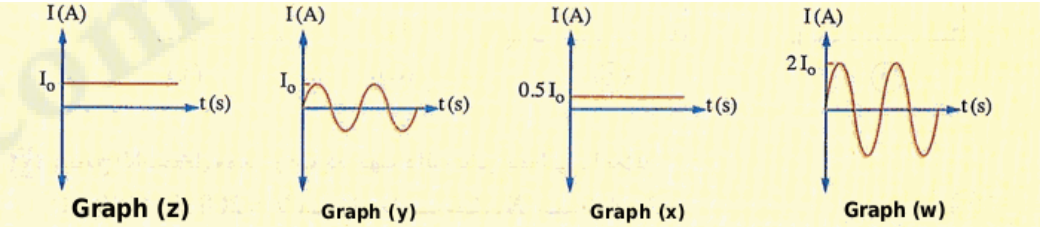
(A) ammeter (H): deflects by equal angles, ammeter (M): deflects by equal angles

(B) ammeter (H): deflects by equal angles, ammeter (M): deflects by unequal angles

(C) ammeter (H): deflects by unequal angles, ammeter (M): deflects by equal angles

(D) ammeter (H): deflects by unequal angles, ammeter (M): deflects by unequal angles

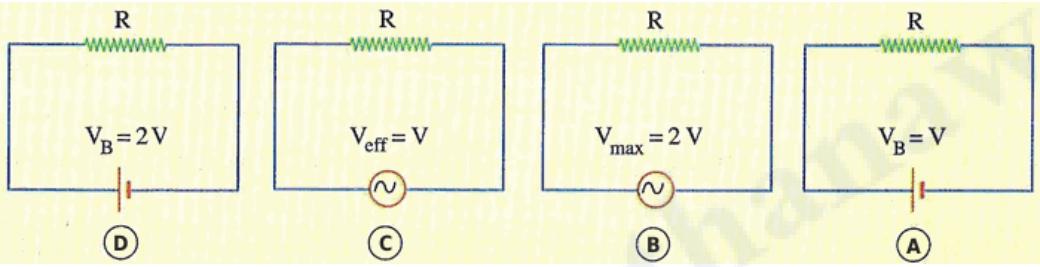
21 Four different electric circuits each contain a hot-wire ammeter. Each of the following graphs w, x, y, z shows the current (I) through the ammeter against time (t). The correct order of the graphs according to the reading of the hot-wire ammeter is ..... (Sample exam 2026)



(A) $z < x < y < w$ (B) $w < z < y < x$ (C) $x < y < z < w$ (D) $x < y = z < w$

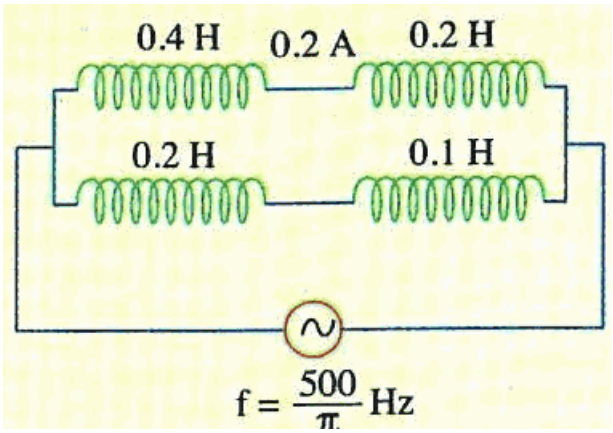
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22 The following figures show four electric circuits, each with a resistance R, and the sources in each have negligible ohmic resistance. The circuit in which the power consumed is the largest is ..... (Sample exam 2025)



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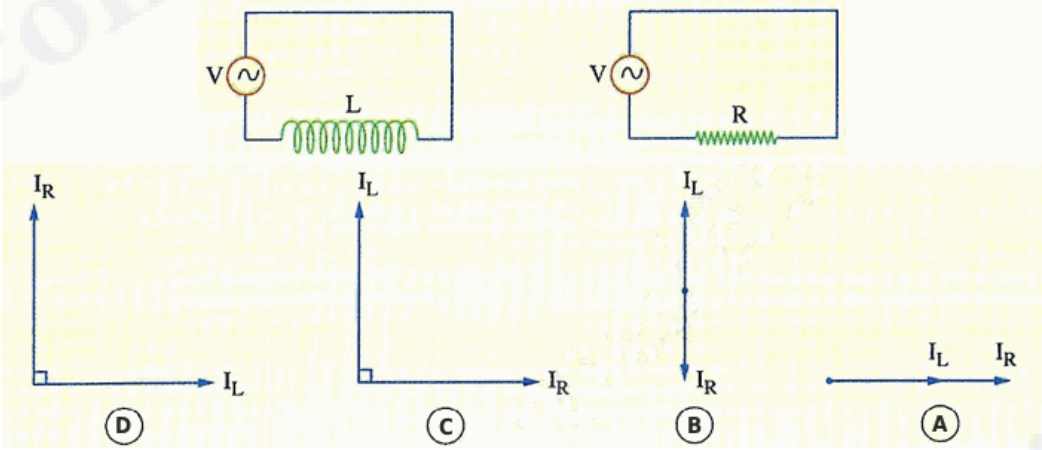
23 The figure shows inductors of no ohmic resistance connected to an AC source. The voltage of the AC source equals ..... (1st session 2023)



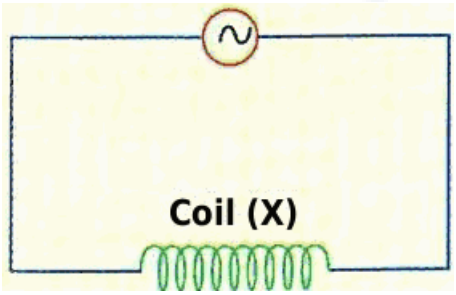
(A) 20 V (B) 40 V (C) 120 V (D) 80 V

---

24 The following figure shows two AC circuits, one containing an ohmic resistance (R) and the other an inductor (L) of no ohmic resistance. If the voltages of the two sources are in phase, the phase difference between the two currents I_L and I_R is shown by figure ..... (Trial exam / May 2021)

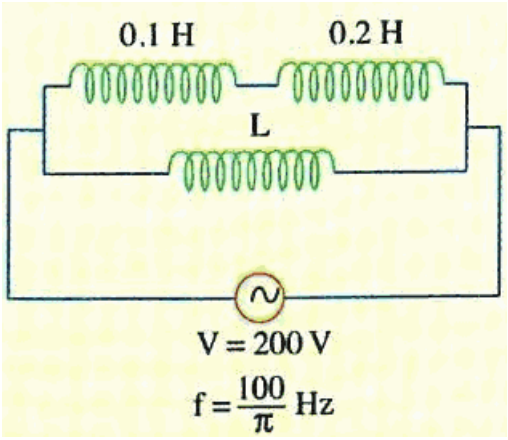


25 The figure shows an AC source whose instantaneous voltage is given by $V = 200\sin(100\pi t)$, connected to an inductor (X) of self-inductance L and no ohmic resistance. If the effective current in the circuit is 2 A, what is the self-inductance of another coil of no ohmic resistance connected with coil (X) so that the effective current in the circuit doubles? And how is it connected with coil (X)? (Trial exam / May 2021, Sample exam 2025)



(A) 0.22 H, in series
(B) 0.22 H, in parallel
(C) 0.11 H, in series
(D) 0.11 H, in parallel

26 Three inductors of negligible ohmic resistance are connected together as in the figure. If the effective current in the circuit is 5 A, and mutual induction between these coils is neglected, then L equals ..... (Trial exam / June 2021)

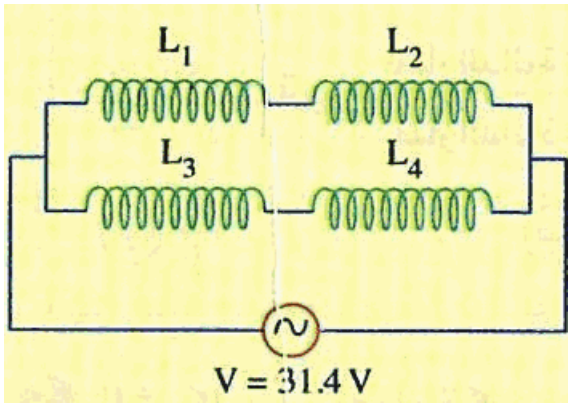


(A) 0.6 H (B) 0.4 H (C) 0.3 H (D) 0.2 H

27 A number of identical inductors of negligible ohmic resistance are connected together in series to an AC source of frequency $50/(\pi)$ Hz, and their total inductive reactance is 40 Ω. When they are connected together in parallel to the same source, their total inductive reactance is 2.5 Ω. Neglecting mutual induction between the coils, the self-inductance of each coil equals ..... (1st session 2021)

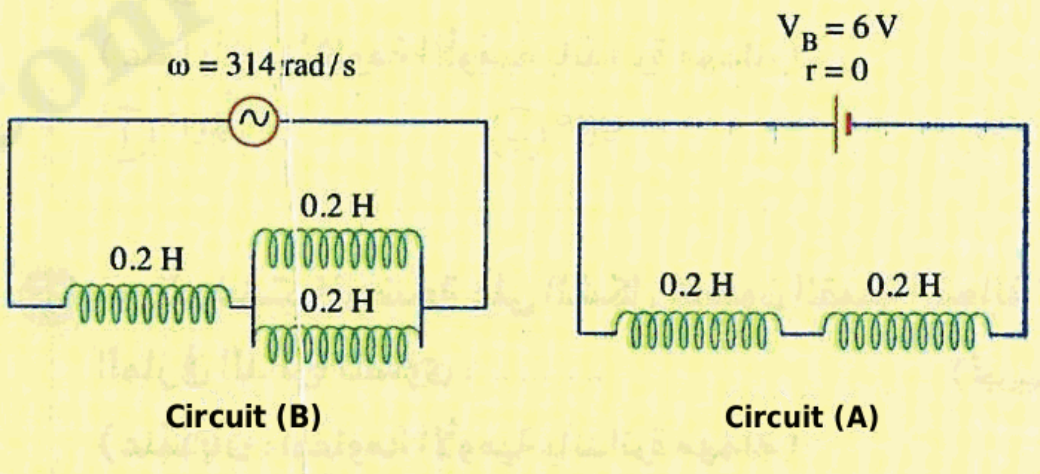
(A) 0.1 H (B) 0.2 H (C) 0.3 H (D) 0.4 H

28 Four inductors of negligible ohmic resistance, each of self-inductance 50 mH, are connected together as in the opposite circuit. If the effective current in the circuit is 10 A, and mutual induction between the coils is neglected, the frequency of this current is about ..... (2nd session 2021)



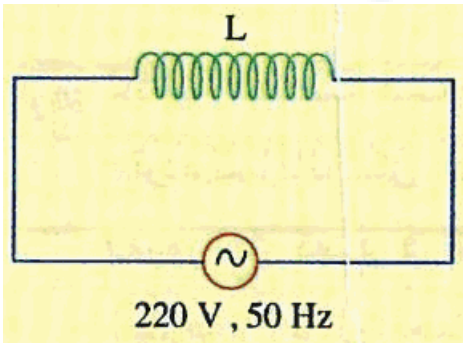
(A) 20 Hz (B) 50 Hz (C) 10 Hz (D) 60 Hz

29 Two electric circuits A and B as in the figure. The total inductive reactance of circuit A equals ..... and the total inductive reactance of circuit B equals ..... ($\pi = 3.14$) (1st session 2022)



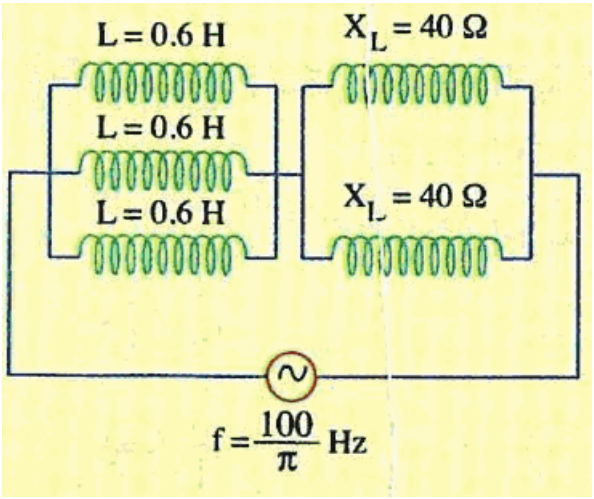
(A) circuit A: zero Ω, circuit B: 94.2 Ω
(B) circuit A: 125.6 Ω, circuit B: 94.2 Ω
(C) circuit A: zero Ω, circuit B: 62.8 Ω
(D) circuit A: 125.6 Ω, circuit B: 62.8 Ω

30 When an AC source (50 Hz, 220 V) is connected to a coil of self-inductance L and negligible ohmic resistance as in the figure, a current of 2 A passes through the coil. The self-inductance L is ..... ($\pi = 3.14$) (1st session 2022)



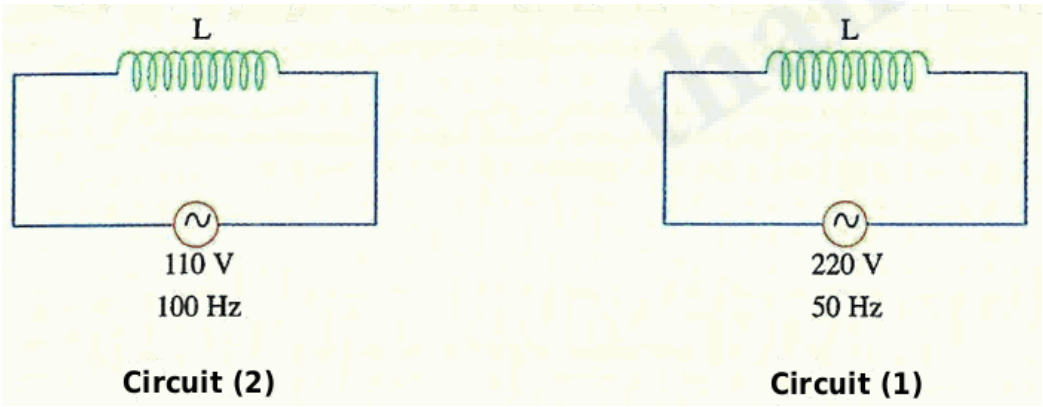
(A) 0.7 H
(B) 0.35 H
(C) 4.4 H
(D) 0.04 H

31 In the opposite circuit, the total inductive reactance equals ..... (2nd session 2022)



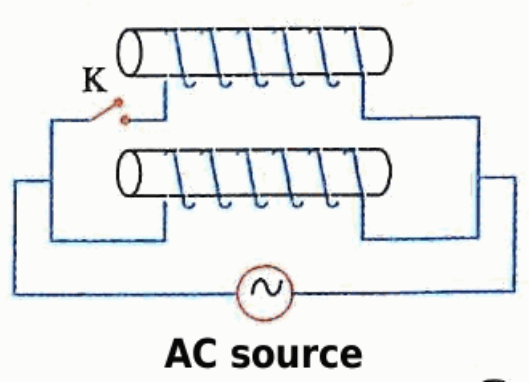
(A) 40 Ω (B) 60 Ω (C) 20 Ω (D) 80 Ω

32 A coil of self-inductance (L) and negligible ohmic resistance is put in two AC circuits as shown in the figure. The ratio of the current of circuit (1) to the current of circuit (2) = ... (2nd session 2022)



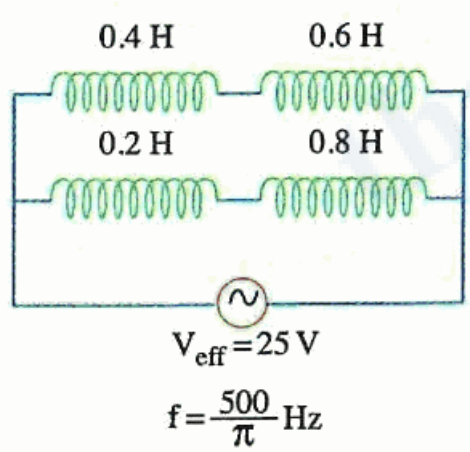
(A) *1/1* (B) *2/1* (C) *4/1* (D) *1/2*

33 The figure shows an electric circuit containing two inductors connected to an AC source. The phase angle between the total voltage and the source current after closing switch K equals ..... (given that the ohmic resistance in the circuit is negligible) (Trial exam 2023)



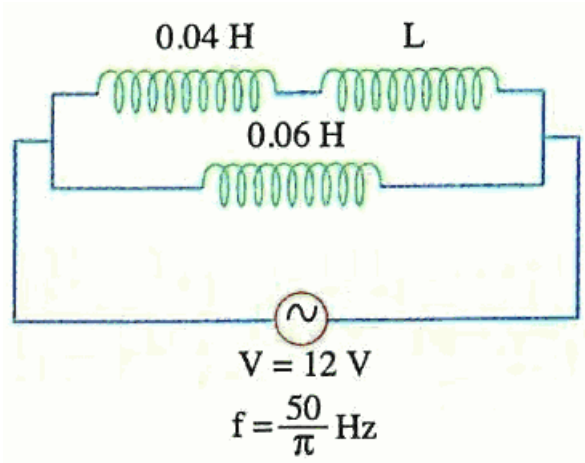
(A) 180° (B) 90° (C) 45° (D) zero

34 From the data shown in the figure, the effective current in the circuit equals ..... (given that the ohmic resistance in the circuit is negligible) (Trial exam 2023)



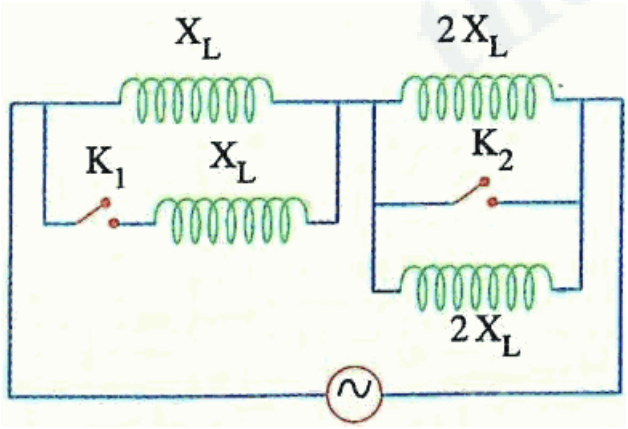
(A) 0.05 mA (B) 0.5 mA (C) 5 mA (D) 50 mA

35 Three inductors of negligible ohmic resistance are connected to an AC source as in the figure. The self-inductance of coil (L) that lets a current of 3 A pass in the circuit is ..... (neglecting mutual induction between the coils) (2nd session 2023)



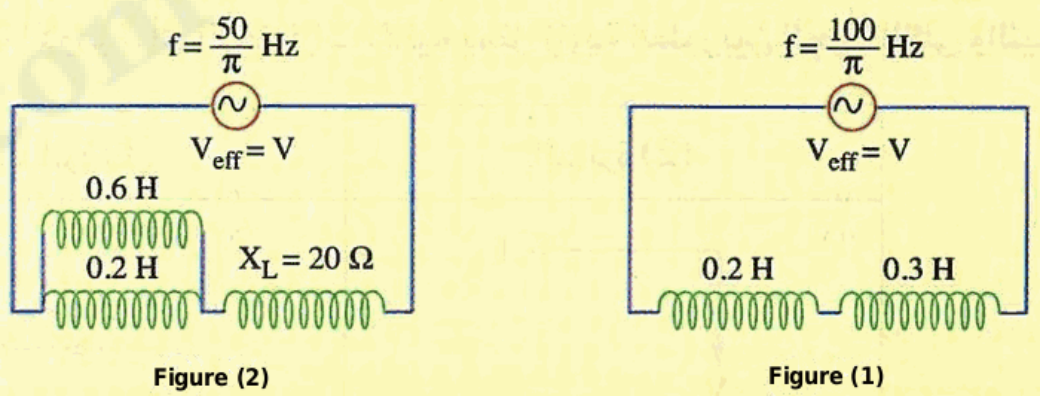
(A) 0.08 mH (B) 80 mH (C) 40 mH (D) 120 mH

36 The opposite figure shows an electric circuit with several inductors connected together. The ratio of (the total inductive reactance when K_1 is closed and K_2 is open) to (the total inductive reactance when K_2 is closed and K_1 is open) = ... (1st session 2024)



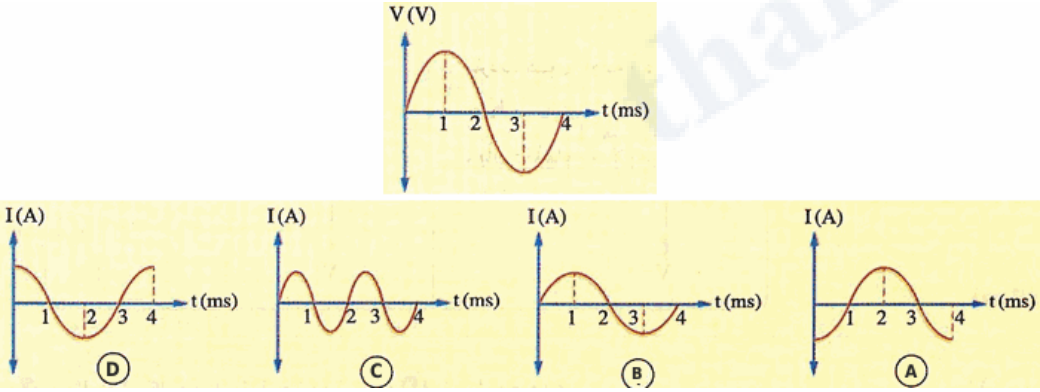
(A) *1/3* (B) *2/3* (C) *3/1* (D) *3/2*

37 In the following two figures, neglecting the ohmic resistance of the coils and the mutual induction between them, the ratio between the currents through the two sources (I_2/I_1) = ... (2nd session 2024)



(A) 20/7 (B) 7/20 (C) 20/3 (D) 3/20

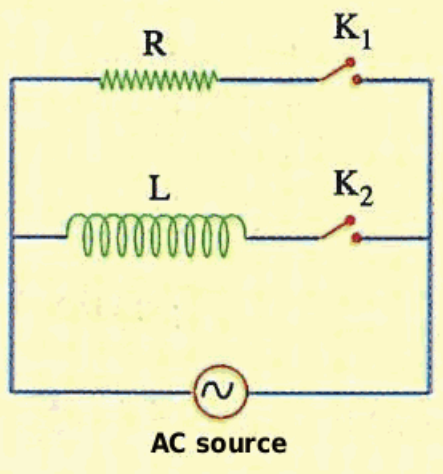
38 If the potential difference (V) across an inductor of no ohmic resistance connected to an AC source changes with time (t) as in the opposite graph, the graph that shows how the current (I) in the coil changes with time (t) during the same period is ..... (Sample exam 2025)



39 If the inductive reactance of a coil = (440 L) ohm, where (L) is the self-inductance of the coil, the angular velocity is ..... (Sample exam 2025)

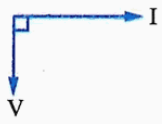
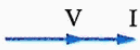
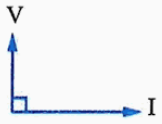
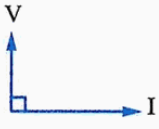
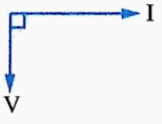
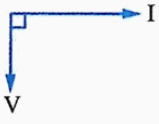
(A) 440 rad/s (B) 140 rad/s (C) 70 rad/s (D) 80 rad/s

40 The figure shows an AC circuit consisting of an AC source, an ohmic resistance (R) and an inductor (L) of negligible ohmic resistance. What is the phase angle between the voltage across the source and the current in the circuit in the following two cases? (1st session 2025)

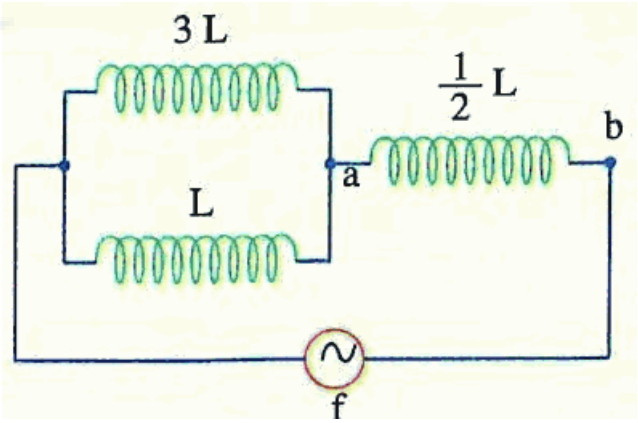


(A) only K_1 closed: 90°, only K_2 closed: 90°
(B) only K_1 closed: 0°, only K_2 closed: 90°
(C) only K_1 closed: 90°, only K_2 closed: 0°
(D) only K_1 closed: 0°, only K_2 closed: 0°

41 Two AC circuits: circuit (1) consists of an AC source and an ohmic resistance, and circuit (2) consists of an AC source and an inductor of negligible ohmic resistance. Which of the following choices shows the phase angle between the total voltage and the current in each circuit? (2nd session 2025)

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

42 The figure shows an AC source of frequency (f) connected to several inductors of no ohmic resistance. If the current in coil (3L) is (I), the potential difference between points a and b equals ..... (Sample exam 2026)



(A) $4I\pi\ Lf$ (B) $2I\pi\ Lf$ (C) $1/2I\pi\ Lf$ (D) $1/4I\pi\ Lf$

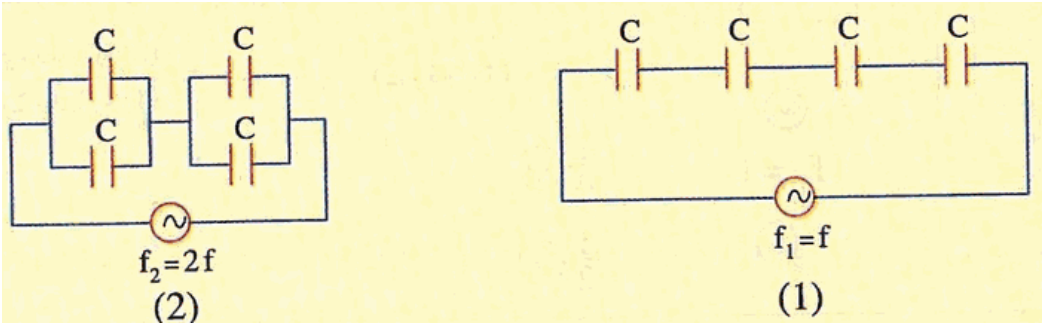
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43 A capacitor of capacitance 10 μF is connected to an oscillator of frequency 1000 Hz with a maximum emf of 5 V. The maximum current in the capacitor circuit is about ..... (Trial exam / May 2021)

(A) 0.6 A (B) 1.2 A (C) 0.8 A (D) 0.3 A

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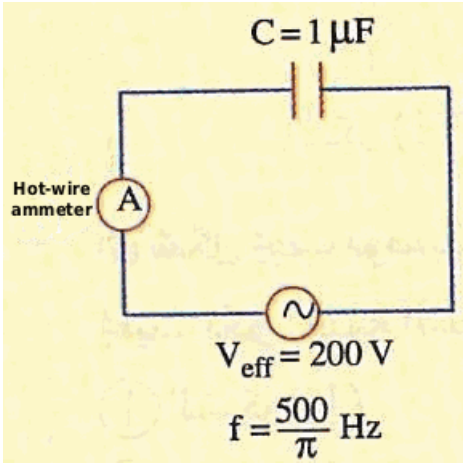
44 In the two circuits shown, if the capacitance of each capacitor is (C), the ratio of (the equivalent capacitive reactance in circuit (1)) to (the equivalent capacitive reactance in circuit (2)) equals ..... (Trial exam / June 2021)



(A) $1/2$ (B) $2/1$ (C) $8/1$ (D) $1/8$

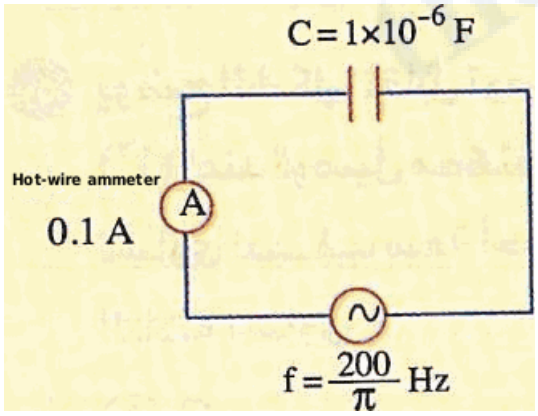
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45 The figure shows a circuit containing an AC voltage source, a hot-wire ammeter of negligible ohmic resistance and a capacitor. The reading of the hot-wire ammeter is ..... (Trial exam / June 2021)



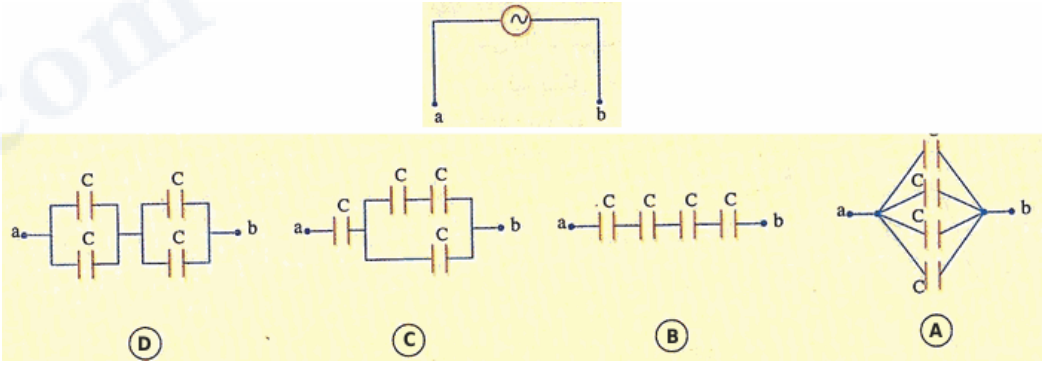
(A) 0.02 A (B) 0.2 A (C) 2 A (D) 20 A

46 The opposite figure shows an electric circuit containing a hot-wire ammeter of negligible ohmic resistance, a capacitor and an AC source. The effective voltage of the source is ..... (1st session 2021)

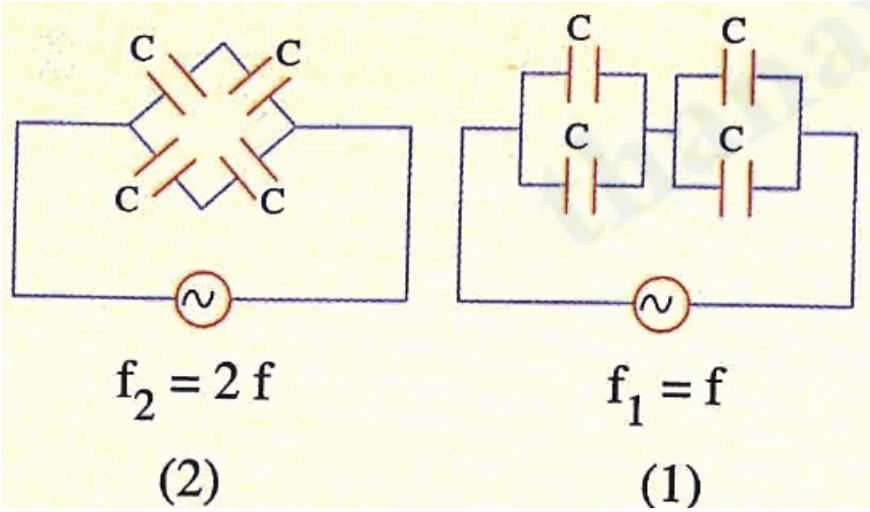


(A) 2.5 V (B) 250 V (C) 25 V (D) 2500 V

47 The following figures show four equal capacitors, each of capacitance (C). Which figure should be connected between points a and b to close the circuit shown so that the current is as large as possible? (1st session 2021)

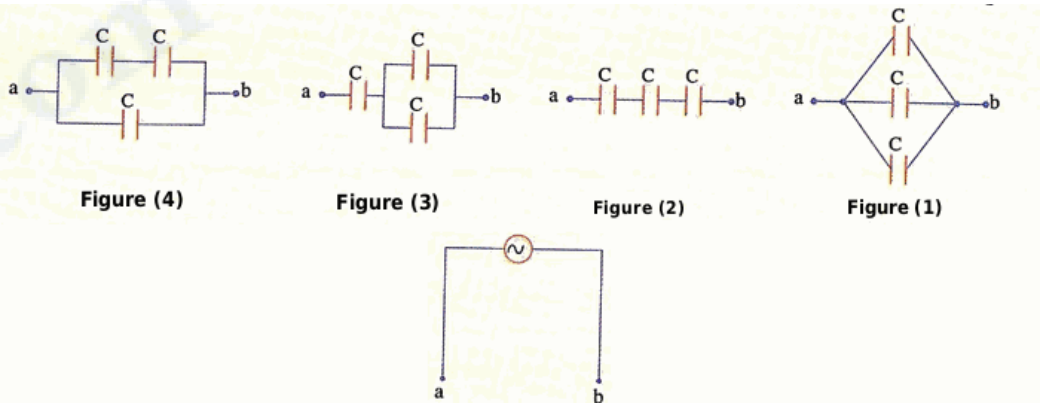


48 In the two circuits shown, if the capacitance of each capacitor is (C), the ratio of (the capacitive reactance in circuit (2)) to (the capacitive reactance in circuit (1)) = ... (2nd session 2021)



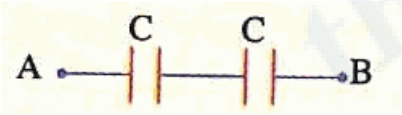
(A) *2/1* (B) *1/4* (C) *4/1* (D) *1/2*

49 The following figures show four different ways of connecting three capacitors, each of capacitance (C). Which figure should be connected between points a and b to close the circuit shown so that the current is as small as possible? (1st session 2022)



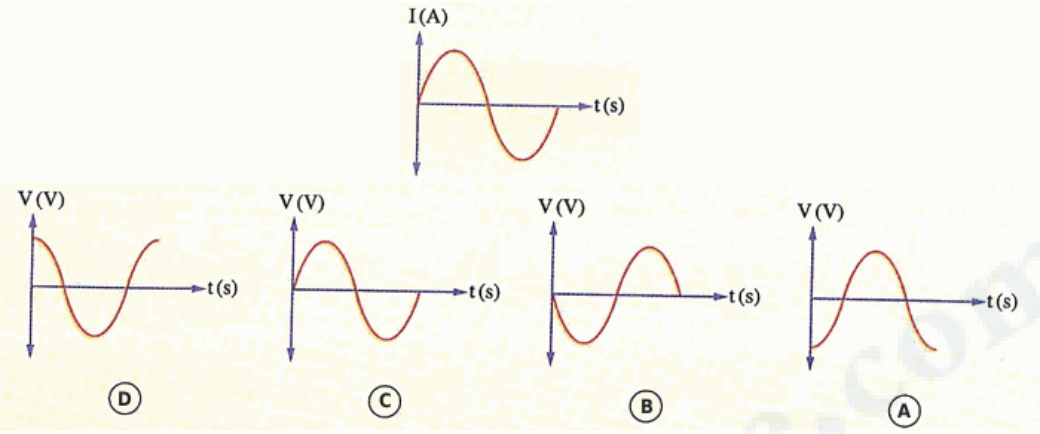
(A) figure (1) (B) figure (2) (C) figure (3) (D) figure (4)

50 The opposite figure shows two capacitors connected in series, each of capacitance (C). When another capacitor, whose capacitance is half that of one of the two capacitors, is connected in parallel between points A and B, the total capacitance of the three capacitors equals ..... (2nd session 2022)

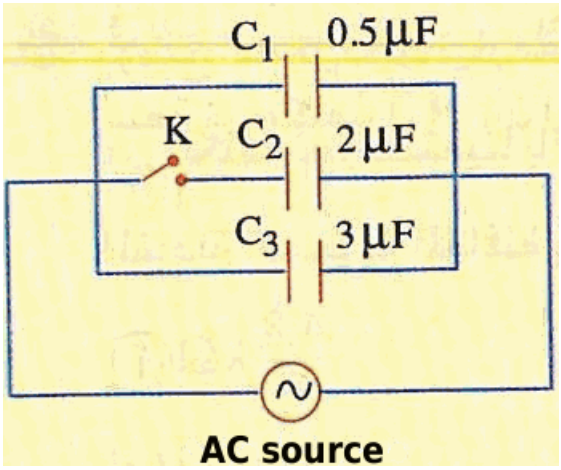


(A) C (B) 2C (C) *C/2* (D) *3/2C*

51 The graph shows the alternating current (I) in a circuit containing a capacitor against time (t). Which of the following graphs shows the potential difference (V) across the plates of the capacitor against time (t) during the same period? (Trial exam 2023)

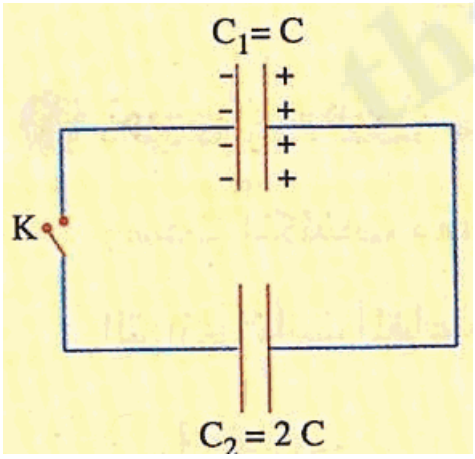


52 In the circuit shown in the figure, the ratio between the capacitances of the group of capacitors before and after closing switch (K), respectively, is ..... (Trial exam 2023)



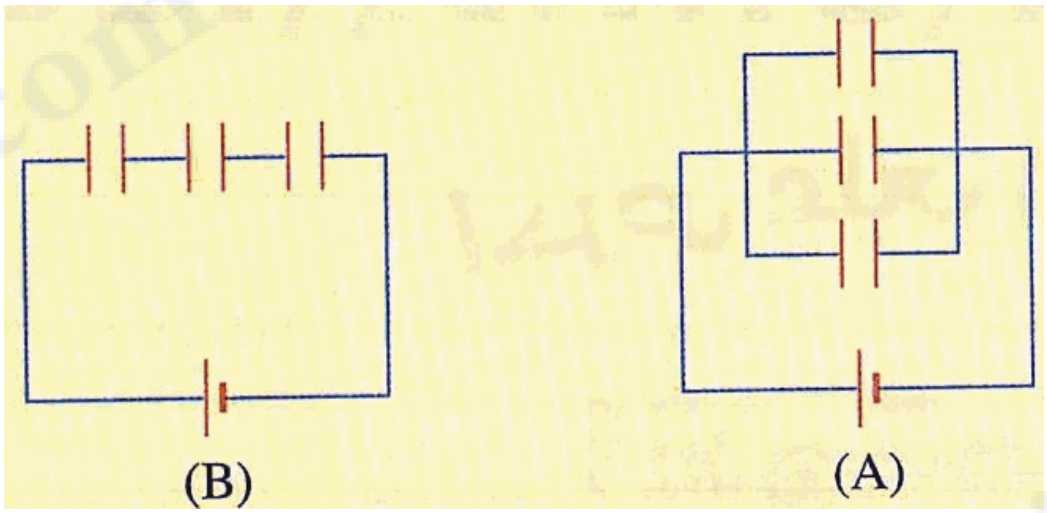
(A) 7/11 (B) 11/7 (C) 6/1 (D) 1/6

53 The figure shows two capacitors (1) and (2). Capacitor (1) is charged with 60 µC and capacitor (2) is uncharged. Which of the following choices gives the final charge on each capacitor after closing switch (K)? (1st session 2023)



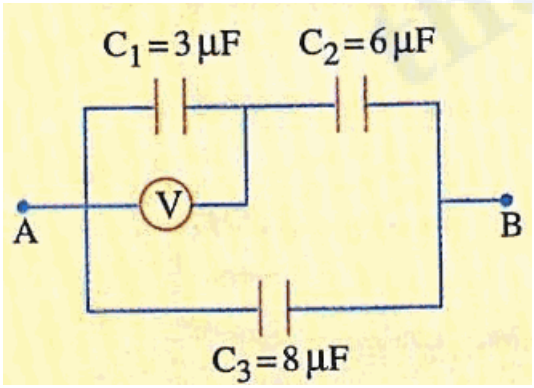
(A) $Q_1 = 40\ \mu C$, $Q_2 = 20\ \mu C$
(B) $Q_1 = 20\ \mu C$, $Q_2 = 40\ \mu C$
(C) $Q_1 = 30\ \mu C$, $Q_2 = 30\ \mu C$
(D) $Q_1 = 0$, $Q_2 = 60\ \mu C$

54 Three capacitors, each of $(12\ \mu F)$, are connected to a 20 V DC source in two different ways, as in figures (A, B). The ratio of the charge on each capacitor in circuit (A) to the charge on each capacitor in circuit (B) (Q_A/Q_B) is ..... (2nd session 2023)



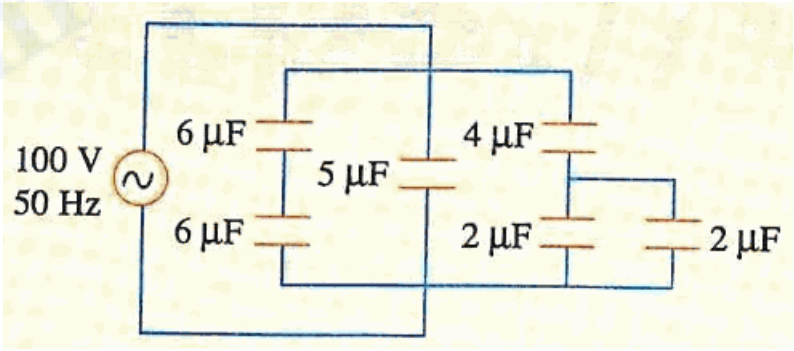
(A) *9/1* (B) *1/9* (C) *3/1* (D) *1/3*

55 The opposite figure shows part of an electric circuit. If the charge on one plate of capacitor (C_3) is 2.4 mC, the voltmeter (V) reads ..... (Sample exam 2025)



(A) 10 V (B) 20 V (C) 100 V (D) 200 V

56 The figure shows an AC circuit consisting of an AC source and a group of capacitors. Using the data on the figure, the equivalent capacitive reactance of the circuit equals ..... (1st session 2025)



(A) $4.8/(\pi)\ k\Omega$ (B) $1/(\pi)\ k\Omega$ (C) $2\pi\ k\Omega$ (D) $\pi\ k\Omega$

57 An electric circuit consists of an AC source of frequency $100/(\pi)$ Hz and a group of identical capacitors, each of capacitance C. When the capacitors were connected together in series, the capacitive reactance of the circuit was 200 Ω, and when they were connected together in parallel, it was 12.5 Ω. The number of capacitors is ..... (2nd session 2025)

(A) 4 capacitors (B) 8 capacitors (C) 12 capacitors (D) 16 capacitors

Answer key and solutions

Multiple choice questions

1 C	2 C	3 B	4 C	5 D	6 D	7 B	8 A	9 D	10 A
11 D	12 C	13 C	14 A	15 C	16 B	17 B	18 A	19 B	20 B
21 B	22 A	23 C	24 B	25 A	26 A	27 D	28 D	29 B	30 C
31 B	32 B	33 A	34 C	35 D	36 A	37 A	38 C	39 D	40 B
41 C	42 B	43 D	44 D	45 A	46 B	47 B	48 A	49 A	50 C
51 C	52 B	53 A	54 B	55 C	56 B	57 C	58 D	59 D	60 C
61 D	62 A	63 C	64 B	65 B	66 C	67 C	68 B	69 B	70 C
71 C	72 A	73 C	74 C	75 A	76 B	77 B	78 D	79 C	80 A
81 C	82 B	83 B	84 C	85 D	86 D	87 C	88 A	89 B	90 C
91 D	92 B	93 B	94 D	95 A	96 D	97 B	98 D	99 A	100 A
101 C	102 C	103 B	104 B	105 C	106 C	107 D	108 B	109 D	110 D
111 B	112 D	113 B	114 C	115 D	116 C	117 C	118 B	119 D	

1 **Answer (C)**

The hot-wire ammeter works by the heating effect of the current: the current heats the platinum-iridium wire, so it expands and the pointer moves.

It does not depend on the direction of the current, so it measures both AC and DC.

2 **Answer (C)**

The resistance R is connected in parallel with the wire, so it is a shunt.

It carries the larger part of the current, so the current range of the instrument increases.

3 **Answer (B)**

The platinum-iridium wire is the wire the current passes through; it heats up and expands.
It is component (2).

4 **Answer (C)**

Component (3) is the spring.
It always keeps the silk thread taut, to take up the expansion of the wire and to pull it back when it cools.

5 **Answer (D)**

The current in the instrument divides between wire (2) and the resistance R connected in parallel with it.
No current passes through the thread, the spring or the pointer.

6 **Answer (D)**

The heat energy produced in the wire is $H = I^2Rt$
so it is proportional to the square of the effective value of the current $I_{rms}{}^2$

7 **Answer (B)**

The effective value of the alternating current gives the same heat power as a direct current.
$I_{rms} = (I_{max})/(\sqrt{(2)}) = 14/1.414 \approx 10\ A$

8 **Answer (A)**

Increasing the shunt resistance decreases the current in it, so a larger current passes in the wire for the same total current.
$H = I^2Rt$, so the heat power in the wire increases.

9 **Answer (D)**

10 **Answer (A)**

When the shunt is decreased, the current in the wire decreases, so it heats less and expands less.
The spring stays more stretched, so the tension in it increases.

11 **Answer (D)**

The deflection is proportional to the heat power $H \propto I^2$
so the scale is not uniform: the divisions are narrow at the start of the scale and get wider towards the end,
i.e. the deflection at $2I$ is four times that at I, which is figure (D).

12 **Answer (C)**

The deflection $\propto I^2$, so at $2I$ the deflection becomes 4 times the deflection at I

If I is at the first division, $2I$ is at the fourth division, which is figure (C).

13 **Answer (C)**

The deflection is proportional to I^2, so $(I_2{}^2)/(I_1{}^2) = 9 \Rightarrow I_2 = 3I_1$

$I = V/R_t$, so the total resistance becomes one third: $R + 5R = 3\,(R + R_x)$

$R_x = R$

14 **Answer (A)**

$\theta \propto I^2 \Rightarrow I \propto \sqrt{(\theta)}$ and the parts are equal

The current at the end of each part: $\sqrt{(1)}$, $\sqrt{(2)}$, $\sqrt{(3)}$, $\sqrt{(4)}$, i.e. 1 , 1.41 , 1.73 , 2

The change in the first part is 1, the largest, then 0.41, then 0.32, then 0.27

So part OA has the largest change.

15 **Answer (C)**

The deflection is proportional to I^2, so we find it at each division: $I = 1 \rightarrow 10^\circ$

$I = 2 \rightarrow 4 \times 10^\circ = 40^\circ$, $I = 3 \rightarrow 9 \times 10^\circ = 90^\circ$

$\theta_1 = 40^\circ - 10^\circ = 30^\circ$, $\theta_2 = 90^\circ - 40^\circ = 50^\circ$

16 **Answer (B)**

The hot-wire ammeter reads the effective value $I_{rms} = (I_{max})/(\sqrt{(2)}) = 0.707\, I_{max}$

$I = I_{max} sin((2\pi)/Tt)$ and the periodic time is $T = 8\ ms$

$sin((2\pi)/Tt) = 0.707 \Rightarrow (2\pi)/Tt = 45^\circ \Rightarrow t = T/8 = 1\ ms$

17 **Answer (B)**

The two ammeters are in series, so the same current passes through them.

The moving-coil deflection is proportional to I and the hot-wire deflection is proportional to I^2

At $1\ A$ the two deflections are equal (θ_0), and at $2\ A$ the deflection of x becomes $2\theta_0 = \theta$

and the deflection of y is $4\theta_0 = 2\theta$, which is greater than θ

18 **Answer (A)**

In a hot-wire ammeter the deflection is proportional to the power consumed in the wire $H \propto P$

so the relation is a straight line through the origin, which is curve (a).

19 **Answer (B)**

The deflection is proportional to I^2, so the relation between θ and I is a second-degree curve starting from zero
which is curve (b).

20 **Answer (B)**

The moving-coil pointer is at zero, so no current passes in the wire.
The deflection of the hot-wire ammeter is caused by a rise in the surrounding temperature, so the wire expanded more than the plate it is fixed on.
So the expansion coefficient of the plate is less than that of the wire.

21 **Answer (B)**

The moving-coil pointer moves as soon as the current passes, so it settles at its reading quickly.
The hot-wire ammeter needs time for the wire to heat and expand before it settles.

22 **Answer (A)**

Instrument (1) has its zero in the middle and a uniform scale, so it is a moving-coil instrument that measures direct current only.
Instrument (3) has a non-uniform scale $(\theta \propto I^2)$, so it is a hot-wire ammeter that measures DC and AC.
Instrument (2) has its zero on the right and ∞ on the left, so it is an ohmmeter.

23 **Answer (C)**

Instrument (3) has a non-uniform scale, so it is a hot-wire ammeter, which measures the effective value of an alternating current.

24 **Answer (B)**

Instrument (2) has its zero on the right and ∞ on the left, so it is an ohmmeter that measures the unknown resistance.

25 **Answer (A)**

Instrument (1) has its zero in the middle, so the pointer deflects to the right or to the left according to the direction of the current.

26 **Answer (A)**

A non-inductive resistance does not affect the phase, so the voltage across it is in phase with the current.

27 **Answer (D)**

$V_{max} = 424.27\ V \Rightarrow V_{rms} = 424.27/(\sqrt{2}) = 300\ V$

$P = (V_{rms}^2)/R = (300^2)/100 = 900\ W$

28 **Answer (D)**

The two resistances are in series, so the same current passes through them.

The voltage across each resistance is in phase with the current, so the two voltages have the same phase.

29 **Answer (B)**

The maximum emf of the dynamo is $V_{max} = NBA\ 2\pi f$, so it is directly proportional to the frequency

$I_{max} = (V_{max})/R$, so the relation between I_{max} and f is a straight line through the origin

30 **Answer (C)**

Lamp y is lit by a DC voltage of $60\ V$, so the equivalent effective value needed is $60\ V$

The effective voltage of lamp x is $(V_{max})/(\sqrt{2})$, which is less than $60\ V$; we need $V_{max} = 60\sqrt{2}\ V$

$V_{max} = NBA\ 2\pi f$ is proportional to f, so the frequency must be increased from 50 to $50\sqrt{2}\ Hz$

31 **Answer (B)**

Branch cd: $V_{rms} = 300\ V$ and $I_{rms} = 1\ A$, so its resistance $6R = 300\ \Omega \Rightarrow R = 50\ \Omega$

Branch ab: $3R = 150\ \Omega \Rightarrow I_{rms} = 300/150 = 2\ A$

Total current $I_{rms} = 2 + 1 = 3\ A$, so $I_{max} = 3\sqrt{2}\ A$

The circuit has resistances only, so the current is in phase with the voltage: $I = 3\sqrt{2}\sin(100\pi t)$

32 **Answer (B)**

Branch cd of resistance $6R$ carries $1\ A$ and its effective voltage is $(300\sqrt{2})/(\sqrt{2}) = 300\ V$

$6R = 300/1 = 300\ \Omega \Rightarrow R = 50\ \Omega$

33 **Answer (A)**

The current in an inductor lags behind the voltage by $90°$, i.e. a quarter of a cycle

The periodic time is $4\ ms$, so the lag is $1\ ms$: the voltage peaks at $1\ ms$, so the current peaks at $2\ ms$

So the current starts from its negative minimum at $t = 0$, which is figure (A).

34 **Answer (C)**

$X_L = \omega L = 2\pi f L = 440 L \Rightarrow 2\pi f = 440$

$f = 440/(2\pi) \approx 70\ Hz$

35 **Answer (D)**

$X_L = 2\pi f L$ and both are doubled, so X_L becomes four times as large

$X_L' = 4 \times 1000 = 4000\ \Omega$

36 **Answer (A)**

$X_L = 2\pi f L = 2\pi \times 50 \times 0.1 = 31.4\ \Omega$

$V = I X_L = 0.1 \times 31.4 = 3.14\ V$

37 **Answer (A)**

$X_L = 2\pi f L$, so the inductive reactance is directly proportional to the frequency and the relation is a straight line through the origin.

38 **Answer (C)**

The maximum emf of the dynamo is proportional to the frequency: $V_{max} = NBA\ 2\pi f$

$I = V/X_L = (NBA\ 2\pi f)/(2\pi f L) = NBA/L$

so the current is constant and does not change with frequency.

39 **Answer (D)**

An inductor with no resistance consumes no power: $P_w = V_{rms} I_{rms} \cos 90^\circ = 0$

so the relation is a line on the frequency axis at zero.

40 **Answer (B)**

The slope of the line $= X_L/L = 300/0.3 = 1000 = 2\pi f$

$f = 1000/(2\pi) = 159.1\ Hz$

41 **Answer (C)**

$X_L = 2\pi f L \Rightarrow L = 8/(2\pi \times 400)$

$L = 1/(100\pi)\ H$

42 **Answer (B)**

$X_L = 2\pi f L$, so the slope of the line is proportional to L

The slope of L_1 is greater than the slope of L_2, so $L_1 > L_2$

43 **Answer (D)**

$X_L = \omega L$, so the slope of the line $= L = \tan\theta$

Line A makes an angle of 45°, so $L_A = \tan 45^\circ = 1$

Line B makes an angle of $45^\circ + 15^\circ = 60^\circ$, so $L_B = \tan 60^\circ = \sqrt{3}$

$L_A/L_B = 1/(\sqrt{3}) = (\sqrt{3})/3$

44 **Answer (D)**

$X_L = (V_{max})/(I_{max}) = 66/2 = 33\ \Omega$

$L = X_L/(\omega) = 33/(116\pi) = 0.09\ H$

45 **Answer (A)**

$\omega = 50\pi \Rightarrow f = (\omega)/(2\pi) = 25\ Hz$

$X_L = 200/2 = 100\ \Omega \Rightarrow L = X_L/(\omega) = 100/(50\pi) = 2/(\pi)\ H$

The current lags $(\pi)/2$ behind the voltage, as in an inductor.

46 **Answer (B)**

The frequency is constant, so the reactance X_L is constant

$I_{eff} = ((V_L)_{eff})/X_L$, so the relation is a straight line through the origin

47 **Answer (B)**

$X_L = 2\pi f L$ and $L = (\mu N^2 A_0)/(\ell)$, so $X_L = (2\pi f\mu A_0)/(\ell)N^2$

The slope of the line $k = X_L/(N^2) = 10/(10^4) = 10^{-3}$

$A_0 = (k\ \ell)/(2\pi f\mu) = (10^{-3}\times 0.79)/(2\pi\times 50\times 2\times 10^{-3}) = 1.26\times 10^{-3}\ m^2 = 12.6\ cm^2$

48 **Answer (A)**

$L = (\mu N^2 A)/(\ell)$, so the inductance is proportional to the area: $L_b = 2L_a$

$X_L \propto L$ for the same frequency, so $((X_L)_a)/((X_L)_b) = 1/2$

49 **Answer (A)**

Each part has $N/3$ turns and a length of $(\ell)/3$

$L' = (\mu(N/3)^2A)/((\ell)/3) = 1/3\cdot(\mu N^2A)/(\ell) = L/3$

$X_L' = 2\pi fL' = X_L/3$

50 **Answer (C)**

Inserting soft iron increases the magnetic permeability of the core.

$L = (\mu N^2A)/(\ell)$, so L increases and so does $X_L = 2\pi fL$

51 **Answer (C)**

$X_L = 2\pi fL = 2\pi \times 50 \times 0.7 = 220\ \Omega$

52 **Answer (B)**

$I = V/X_L = 120/220 = 0.55\ A$

53 **Answer (A)**

$X_L = V/I = 240/4 = 60\ \Omega$

$L = X_L/(2\pi f) = 60/(2\pi \times 50) = 0.191\ H$

54 **Answer (B)**

$X_L = (V_{max})/(I_{max}) = 100/4 = 25\ \Omega$

The current lags a quarter of a cycle: $T/4 = 6.25\ ms \Rightarrow T = 25\ ms \Rightarrow f = 40\ Hz$

$L = X_L/(2\pi f) = 25/(2\pi \times 40) = 0.0995\ H$

$\ell = (\mu N^2 A)/L = (2 \times 10^{-3} \times 132^2 \times 10^{-3})/0.0995 = 0.35\ m = 35\ cm$

55 **Answer (C)**

$X_L \propto f$, so $15/f_1 = 25/(f_1 + 20)$

$15f_1 + 300 = 25f_1 \Rightarrow f_1 = 30\ Hz$

$f_2 = 30 + 20 = 50\ Hz$

56 **Answer (B)**

$12/f = 18/(f + 20) \Rightarrow 12f + 240 = 18f \Rightarrow f = 40\ Hz$

$f_2 = 60\ Hz$

$f_1/f_2 = 40/60 = 2/3$

57 **Answer (C)**

$f = 40\ Hz$, so $L = X_L/(2\pi f) = 12/(2\pi \times 40) = 0.048\ H$

58 **Answer (D)**

$A = \pi r^2 = \pi(0.021)^2 = 1.385 \times 10^{-3}\ m^2$

$L = (\mu N^2 A)/(\ell) = (0.002 \times 300^2 \times 1.385 \times 10^{-3})/0.15 = 1.66\ H$

$X_L = 2\pi fL = 2\pi \times 50 \times 1.66 \approx 522.7\ \Omega$

59 **Answer (D)**

$X_L = 2\pi fL = V/I$ and the effective voltage is the same for both sources, so $L = V/(2\pi f I)$

From the graph: the frequency of y is twice that of x (two cycles against one), and its maximum current is twice that of x

$L_x/L_y = f_y/f_x times I_y/I_x = 2 \times 2 = 4$

60 **Answer (C)**

The coils are in parallel: $1/L_t = 1/0.6 + 1/0.2 + 1/0.3 = 10 \Rightarrow L_t = 0.1\ H$

$X_L = 2\pi fL_t = 2\pi \times 50 \times 0.1 = 31.4\ \Omega$

61 **Answer (D)**

The two coils in the upper branch are in series: $0.3 + 0.3 = 0.6\ H$, and this is in parallel with the third coil

$L_t = (0.6 \times 0.3)/(0.6 + 0.3) = 0.2\ H$

$f = X_L/(2\pi L_t) = 12.56/(2 \times 3.14 \times 0.2) = 10\ Hz$

62 **Answer (A)**

The network is a bridge: branch $L_2 \rightarrow L_4$, branch $L_1 \rightarrow L_5$, and coil L_3 between C and D

The coils are equal, so $L_2/L_4 = L_1/L_5$; the bridge is balanced, no current passes in L_3 and it is ignored

$L_2 + L_4 = 100\ mH$ in parallel with $L_1 + L_5 = 100\ mH$

$L_t = 100/2 = 50\ mH$

63 **Answer (C)**

L_1 and L_2 in parallel: $(0.6 \times 1.2)/(0.6 + 1.2) = 0.4\ H$, in series with L_3: $0.4 + 0.4 = 0.8\ H$

This branch is in parallel with $L_4 = 0.8\ H$, so the result is $0.4\ H$

$X_L = 2\pi fL = 2\pi \times 50 \times 0.4 = 125.7\ \Omega$

64 **Answer (B)**

$\omega = 2\pi f = 2\pi \times 500/(\pi) = 1000\ rad/s$

$X_L = V/I = 300/0.5 = 600\ \Omega \Rightarrow L_t = 600/1000 = 0.6\ H$

L_3 and L_2 are in series: $1.8\ H$, in parallel with L_1

$(1.8\ L_1)/(1.8 + L_1) = 0.6 \Rightarrow 1.2\ L_1 = 1.08 \Rightarrow L_1 = 0.9\ H$

65 **Answer (B)**

L_2 and L_3 in parallel: $(10\times40)/(10+40) = 8\ mH$, in series with L_1: $L_t = 20\ mH$

$X_L = 2\pi\times50\times0.02 = 6.28\ \Omega \Rightarrow I = 628/6.28 = 100\ A$

The voltage across the parallel pair $V = I\,X_{L_{23}} = 100\times(2\pi\times50\times0.008) = 251.2\ V$

$I_3 = 251.2/(2\pi\times50\times0.04) = 20\ A$, $I_2 = 251.2/(2\pi\times50\times0.01) = 80\ A$

66 **Answer (C)**

In series: $nX = 50$, and in parallel: $X/n = 2$

Multiplying: $X^2 = 100 \Rightarrow X = 10\ \Omega$

$n = 50/10 = 5$ coils

67 **Answer (C)**

In series: $nX = 50$, and in parallel: $X/n = 2$

Multiplying: $X^2 = 100 \Rightarrow X = 10\ \Omega$

68 **Answer (B)**

$X_L = 10\ \Omega$ for each coil (from the previous part)

$L = X_L/(2\pi f) = 10/(2\pi\times50) = 0.032\ H$

69 **Answer (B)**

$X_C = 1/(2\pi fC)$ and direct current has frequency $f = 0$

So the capacitive reactance $X_C = \infty$, i.e. the capacitor blocks direct current

70 **Answer (C)**

$Q = CV = 3\times10^{-6}\times1 = 3\times10^{-6}\ C = 0.003\ mC$

71 **Answer (C)**

The two batteries oppose each other, so the net voltage on the capacitor is $V = 4 - 2 = 2\ V$

The higher potential (the $4\ V$ battery) is at plate y, so plate y is positive and plate x is negative

$Q = CV = 10\times10^{-6}\times2 = 2\times10^{-5}\ C$

Number of electrons on x: $N = Q/e = (2\times10^{-5})/(1.6\times10^{-19}) = 1.25\times10^{14}$

72 **Answer (A)**

$X_L = \omega L$ and $X_C = 1/(\omega C)$ are both measured in ohm

$X_LX_C = L/C$, so $\sqrt{(L/C)} = \sqrt{(X_LX_C)}$ is measured in ohm

73 **Answer (C)**

The time constant $\tau = RC$ is measured in seconds.

74 **Answer (C)**

At the moment of closing, the largest current passes and the capacitor is empty.

Then the current decreases as the capacitor charges, until it becomes zero when it is fully charged (the capacitor voltage equals the battery voltage).

75 **Answer (A)**

$Q = CV$, so the slope of the line $= C$

Line x has the largest slope, so its capacitance is the largest.

76 **Answer (B)**

$C = Q/V$ from the slope: $C_x = 24/1 = 24\ \mu F$, $C_y = 24/3 = 8\ \mu F$, $C_z = 12/3 = 4\ \mu F$

y and z in parallel: $8 + 4 = 12\ \mu F$, in series with x

$C_t = (12 \times 24)/(12 + 24) = 8\ \mu F$

77 **Answer (B)**

In parallel: $C_1 + C_2 = 9$, and in series: $C_1C_2/(C_1 + C_2) = 2$

$C_1C_2 = 18$

C_1 and C_2 are $3\ \mu F$ and $6\ \mu F$

78 **Answer (D)**

The two capacitors in parallel: $1 + 1 = 2\ pF$

then in series with two capacitors: $1/C_t = 1/2 + 1/1 + 1/1 = 5/2$

$C_t = 2/5\ pF$

79 **Answer (C)**

The two capacitors in parallel: $C + C = 2C$, in series with the first capacitor

$C_t = (C \times 2C)/(C + 2C) = 2/3C$

80 **Answer (A)**

In parallel, the potential difference across the capacitors is the same.

$Q = CV$, so the charge is proportional to the capacitance: $Q_3 > Q_2 > Q_1$

81 **Answer (C)**

The upper branch has three capacitors in series: $24/3 = 8\ pF$

The lower branch has two capacitors in series: $24/2 = 12\ pF$

The two branches in parallel: $8 + 12 = 20\ pF$

82 **Answer (B)**

We need $10\ \mu F = 2/3 \times 15$

Two capacitors in parallel give $30\ \mu F$, in series with a third capacitor of $15\ \mu F$

$C_t = (30 \times 15)/(30 + 15) = 10\ \mu F$, which is figure (B).

83 **Answer (B)**

To decrease the capacitance we add a capacitor in series.

$1/30 = 1/48 + 1/C \Rightarrow 1/C = (8 - 5)/240 = 1/80$

$C = 80\ \mu F$

84 **Answer (C)**

With all switches closed: $C_1 = 12 + 6 = 18\ \mu F$ and $C_2 = 3 + 6 = 9\ \mu F$ in series:

$(18 \times 9)/27 = 6\ \mu F$

The capacitance must become $6 - 1.5 = 4.5\ \mu F$

When K_3 is opened: $C_2 = 6\ \mu F$, so $C_t = (18 \times 6)/(18 + 6) = 4.5\ \mu F$

85 **Answer (D)**

The two capacitors are in series, so the charge Q is the same

$V = Q/C$, so the voltage of capacitor x (capacitance C) is twice that of y (capacitance $2C$) which is figure (D).

86 **Answer (D)**

x and y in parallel: $C + 2C = 3C$, in series with z

The charge of z equals the total charge Q, which is the largest charge

The charge divides between x and y in the ratio of their capacitances $1 : 2$, so $Q_y = 2/3Q > Q_x = 1/3Q$

So the order is $z > y > x$

87 **Answer (C)**

y and z in parallel: $2 + 4 = 6\ \mu F$, in series with x

$C_t = (3 \times 6)/(3 + 6) = 2\ \mu F \Rightarrow Q = C_t V = 2 \times 120 = 240\ \mu C$

$V_x = Q/C_x = 240/3 = 80\ V$

$V_z = V_y = 120 - 80 = 40\ V$

88 **Answer (A)**

From the previous part the total charge is $Q = 240\ \mu C$, which is the charge of x because it is in series with the group

$V_y = 40\ V \Rightarrow Q_y = C_y V_y = 2 \times 40 = 80\ \mu C$

89 **Answer (B)**

C_1 and C_2 in parallel: $3C$, and C_3 and C_4 in parallel: $7C$, and the two are in series

$C_t = (3C \times 7C)/10C = 2.1\ C \Rightarrow Q = 2.1\ CV$

$V_{12} = Q/3C = 0.7\ V$ and $V_{34} = Q/7C = 0.3\ V$

$Q_1 = 0.7\ CV$, $Q_2 = 1.4\ CV$, $Q_3 = 0.9\ CV$, $Q_4 = 1.2\ CV$

So the largest charge is on C_2

90 **Answer (C)**

In position (1), C_1 is charged to the battery voltage: $Q = C_1 V = 100 \times 24 = 2400\ pC$

In position (2), the charge is shared between C_1 and C_2 in parallel, and the total charge does not change

$V' = Q/(C_1 + C_2) = 2400/120 = 20\ V$

91 **Answer (D)**

The charge is shared between the two capacitors in parallel in the ratio of their capacitances $(C_1 : 3C_1 = 1 : 3)$

So the charge of C_1 becomes one quarter of the total charge, i.e. it decreases to one quarter

92 **Answer (B)**

The two plates connected through the switch have opposite charges, so the two charges partly cancel each other.

$Q_x = CV$ and $Q_y = 2CV$, so the remaining charge $2CV$ - $CV = CV$ is shared by the two capacitances in parallel

$V' = CV/(C + 2C) = V/3$, so the potential difference across each of them decreases

93 **Answer (B)**

The connected plates have the same sign of charge, so the two charges add up.

$Q_x = C \times 1 = C$ and $Q_y = 2C \times 2.5 = 5C$

$V' = (Q_x + Q_y)/(C + 2C) = 6C/3C = 2\ V$

94 **Answer (D)**

After the capacitor is fully charged, no current passes through it, so the current passes through the two resistances in series.

$I = V/R = 10/(2 + 3) = 2\ A$

The capacitor is in parallel with the $2\ \Omega$ resistance, so its voltage is $V_C = 2 \times 2 = 4\ V$

$Q = CV_C = 5 \times 4 = 20\ \mu C$

95 **Answer (A)**

With direct current no current passes through the capacitors, so the resistances R and $2R$ stay in series with the battery

$I = V/3R$, so the voltage of R is $V/3$ and the voltage of $2R$ is $2V/3$

Capacitor x is in parallel with $2R$, so $V_x = 2V/3$; capacitors z and y in series are across R, so together they have $V/3$

In series the voltage is inversely proportional to the capacitance: $V_y = 4/6 times V/3 = 2V/9$ and $V_z = 2/6 times V/3 = V/9$

So the order is $V_x > V_y > V_z$

96 **Answer (D)**

In the steady state no current passes in the branch with the capacitor: $I_2 = 0$

So the same current passes through R_1 and R_3: $I_1 = I_3 = 15/(7 + 5) = 1.25\ A$

97 **Answer (B)**

From the previous part $I_3 = 1.25\ A$, so the voltage across R_3 is $V = 1.25 \times 5 = 6.25\ V$

No current passes in R_2, so there is no voltage drop on it, and the capacitor voltage is the difference between $6.25\ V$ and the battery voltage $6\ V$

$V_C = 6.25 - 6 = 0.25\ V$, so $Q = CV_C = 2 \times 0.25 = 0.5\ \mu C$

98 **Answer (D)**

In the steady state no current passes in the capacitors, so the resistances R, $2R$ and $3R$ are in series with the battery: $I = V_B/6R$

C_1 is across the resistances R and $2R$: $V_1 = I \times 3R = V_B/2$

C_2 is across the resistances $2R$ and $3R$: $V_2 = I \times 5R = 5V_B/6$

$Q_1/Q_2 = (C \times 1/2)/(2C \times 5/6) = 3/10$

99 **Answer (A)**

The voltage lags behind the current, i.e. the current leads the voltage by $90°$

This is a property of the capacitor.

100 **Answer (A)**

Component (x): the voltage and the current are in phase, so it is a non-inductive resistance

Component (y): the current leads the voltage by a quarter of a cycle, so it is a capacitor

Component (z): the current lags behind the voltage by a quarter of a cycle, so it is an inductor of no resistance

101 **Answer (C)**

$X_C = 1/(2\pi fC)$, so the capacitive reactance is inversely proportional to the frequency

When the frequency is tripled, the reactance decreases to one third.

102 **Answer (C)**

$X_C = 1/(2\pi f) \times 1/C$, so the slope of the line $= 1/(2\pi f)$

Slope $= 2000/(1000 \times 10^3) = 2 \times 10^{-3}$

$f = 1/(2\pi \times 2 \times 10^{-3}) = 79.55\ Hz$

103 **Answer (B)**

$X_C = 1/(2\pi fC)$, so at the same frequency the reactance is inversely proportional to the capacitance

Curve (1) has a smaller reactance than (2), so its capacitance is larger: $C_1 > C_2$

104 **Answer (B)**

$I_{eff} = V/X_C = V\,\omega\,C$ and the voltage is constant

So the current is directly proportional to ω: a straight line through the origin

105 **Answer (C)**

The maximum emf of the dynamo is proportional to the frequency: $V_{max} \propto f$

$X_C \propto 1/f$, so $I_{max} = (V_{max})/X_C \propto f^2$

So the relation is a second-degree curve starting from the origin.

106 **Answer (C)**

$X_C = 1/(2\pi fC) = 1/(2 \times 22/7 \times 50 \times 7000/11 \times 10^{-6}) = 1/0.2 = 5\ \Omega$

107 **Answer (D)**

$I = V/X_C = 20/5 = 4\ A$

108 **Answer (B)**

$X_C \propto 1/fC$, so $((X_C)_1)/((X_C)_2) = f_2C_2/f_1C_1 = 4fC_2/fC_1 = 2/3$

$C_1/C_2 = (4 \times 3)/2 = 6$

109 **Answer (D)**

$\omega = 200\pi$, so $X_C = 1/(\omega C) = 1/(200\pi \times 700/22 \times 10^{-6}) = 50\ \Omega$

$I_{max} = (V_{max})/X_C = 100/50 = 2\ A$

The current in a capacitor leads the voltage by $(\pi)/2$, so $I = 2\sin(200\pi t + (\pi)/2)$

110 **Answer (D)**

$\omega = 2\pi f = 2 \times 3.14 \times 500/3.14 = 1000\ rad/s$

$C_t = 1/(\omega X_C) = 1/(1000 \times 50) = 20\ \mu F$

The circuit is two capacitors in parallel $(2C)$ in series with one capacitor: $C_t = (2C \times C)/3C = 2/3C$

$C = 3/2 \times 20 = 30\ \mu F$

111 **Answer (B)**

$\omega = 2\pi f = 2\pi \times 100/(\pi) = 200\ rad/s$

$X_C = V/I = 500/2 = 250\ \Omega \Rightarrow C_t = 1/(\omega X_C) = 1/(200 \times 250) = 20\ \mu F$

30 and 15 in series: $(30 \times 15)/45 = 10\ \mu F$, in parallel with C

$10 + C = 20 \Rightarrow C = 10\ \mu F$

112 **Answer (D)**

In parallel: $C_t = 3 \times 14 = 42\ \mu F$

$X_C = 1/(2\pi f C_t) = 1/(2\pi \times 50 \times 42 \times 10^{-6}) = 75.76\ \Omega$

113 **Answer (B)**

In series: $1/C_t = 1/10 + 1/20 + 1/30 = 11/60 \Rightarrow C_t = 5.45\ \mu F$

$X_C = 1/(2\pi f C_t) = 1/(2\pi \times 42 \times 5.45 \times 10^{-6}) = 695\ \Omega$

114 **Answer (C)**

$X_C = 695\ \Omega$ from the previous part

$I = V/X_C = 200/695 = 0.29\ A$

115 **Answer (D)**

Upper branch: 30 and 15 in series $= 10\ \mu F$

Lower branch: 30 and 60 in series $= (30 \times 60)/90 = 20\ \mu F$

The three branches in parallel: $C_t = 10 + 10 + 20 = 40\ \mu F$

$X_C = 1/(2\pi \times 50 \times 40 \times 10^{-6}) = 79.6\ \Omega \Rightarrow I = 400/79.6 = 5.03\ A$

116 **Answer (C)**

The capacitors are in series, so the current is the same and the voltage of each capacitor is inversely proportional to its capacitance.

$V_1 : V_2 : V_3 = 1/1 : 1/2 : 1/3 = 6 : 3 : 2$

The sum of the ratios 11 corresponds to $22\ V$, so each unit is $2\ V$

$V_1 = 12\ V\ ,\ V_2 = 6\ V\ ,\ V_3 = 4\ V$

117 **Answer (C)**

From the graph: $V_{max} = 100\ V$ and the periodic time $T = 4\ ms \Rightarrow f = 1/T = 250\ Hz$

$X_C = 1/(2\pi fC) = 1/(2\pi \times 250 \times 2 \times 10^{-6}) = 318.3\ \Omega$

$I_{rms} = (V_{rms})/X_C = (100/\sqrt{(2)})/318.3 = 0.22\ A$

118 **Answer (B)**

$I_{max} = \sqrt{(2)} \times 0.25$ and the effective voltage $V_{rms} = I\,X_C = 0.25 \times 1000 = 250\ V$

$V_{max} = \sqrt{(2)} \times 250 = 353.6\ V$

$V_{max} = NBA\omega \Rightarrow \omega = 353.6/(100 \times 0.225 \times 0.05) = 314\ rad/s$

119 **Answer (D)**

In the graph the current and the voltage differ in phase by 90° (a pure element: a capacitor or a coil)

$P = V_{rms} I_{rms} \cos 90^\circ = 0$

Essay questions

1 **Model answer**

Because the heating effect of the electric current does not depend on the direction of its flow in the wire, but on its effective value.

2 **Model answer**

(1) The moving-coil ammeter (A_1): magnetic energy. The hot-wire ammeter (A_2): heat energy.

(2) The pointer of the moving-coil ammeter (A_1) settles first at a definite reading, when the restoring torque equals the magnetic torque acting on the coil.

In the hot-wire ammeter (A_2), thermal equilibrium in the platinum-iridium wire takes a longer time.

(3) (a) The moving-coil ammeter (A_1). (b) The hot-wire ammeter (A_2).

3 **Model answer**

No, because the scale of the hot-wire ammeter depends on the heating effect of the electric current, and the electric power changed into heat is directly proportional to the square of the current according to the relation $(P_w = I^2R)$, so the scale is not uniform whatever the type of current in its wire.

4 **Model answer**

(1) A rise in the air temperature, which makes the platinum-iridium wire of the hot-wire ammeter expand; this is known as the zero error.

(2) Not accurate, because the scale of the hot-wire ammeter is not uniform, so subtracting 1 A from the reading after the pointer settles does not work.

(3) Stretching the platinum-iridium wire on a plate made of a material with the same coefficient of linear expansion as the wire, while insulating it from the plate.

5 **Model answer**

Coils y and z are connected in parallel: $V_y = V_z$

$I_y L_y = I_z L_z = I_y/2 \times 0.2 \Rightarrow L_y = 0.1\ H$

Coil x and the 0.2 H coil are in series, and their branch is in parallel with coil z:

$I_x (0.2 + L_x) = I_z L_z = 2I_x \times 0.2 \Rightarrow L_x = 0.2\ H$

6 **Model answer**

(1) It does not change, because in an AC circuit that contains inductors only, the total voltage leads the current by a phase angle of $90°$

(2) The potential difference across it increases, because when the switch is closed the total self-inductance of the coils in the circuit decreases, so the total inductive reactance decreases and the current in the circuit increases, i.e. the current in coil z increases, so the potential difference across it increases.

(3) The current in coil x decreases, because the increase of the potential difference across coil z, while the total potential difference stays constant, decreases the potential difference across each of coils x and y.

7 **Model answer**

(1) When inductors are connected in series with a voltage source, the potential difference is divided between them in the ratio of their self-inductances:

$V_{ab} : V_{bc} : V_{cd} = 3 : 2 : 1$

$V_{ab} = 60\ V\ ,\ V_{bc} = 40\ V\ ,\ V_{cd} = 20\ V$

(a) $V_{ac} = 60 + 40 = 100\ V$ (b) $V_{bd} = 40 + 20 = 60\ V$

(2) $X_L = V/I = 120/1 = 120\ \Omega$

$120 = 2 \times 22/7 \times 50 \times 6L \Rightarrow L = 0.06\ H$

8 **Model answer**

The inductive reactance of the coil becomes zero, because its self-inductance becomes zero.

9 **Model answer**

The unit of L/R is: $H/(\Omega) = (\Omega \cdot s)/(\Omega) = s$

10 **Model answer**

(1) It does not change, because the branch containing coil L_1 is connected directly to the terminals of the dynamo, so the potential difference across this branch is not affected by any change in the total current of the circuit.

(2) It does not change, since: $(emf)_{max} = NBA\omega$, $X_L = \omega L$

$I_{max} = (NBA\omega)/(\omega L) = NBA/L$ and N, B, A, L are all constant.

11 **Model answer**

(1) The self-inductance of the coil increases $(L = (\mu A N^2)/(\ell))$, so the inductive reactance increases $(X_L = 2\pi f L)$, and the current in the dynamo coil decreases.

(2) The self-inductance becomes 2L, so the inductive reactance in the circuit increases and the current in the dynamo coil decreases.

(3) The induced emf increases $(emf = NBA\omega \sin\theta)$ and the inductive reactance increases by the same ratio, so the current in the dynamo coil stays unchanged.

(4) The self-inductance increases, so the inductive reactance increases and the current in the dynamo coil decreases.

(5) The induced emf in the dynamo coil increases, so the current in the dynamo coil increases.

12 **Model answer**

(1) Because in circuit (3) the DC source is connected to a charged capacitor that blocks the current, while in circuits (1) and (2) the capacitor is connected to an AC source, so it keeps charging and discharging through the circuit and an alternating current passes in both circuits.

(2) The frequency of the source in circuit (1) is greater, so the capacitive reactance of its capacitor is smaller $(X_C = 1/(2\pi f C))$, and the current in it is greater $(I = V/X_C)$.

13 **Model answer**

(1) The rate of flow of charge from the battery to the capacitor decreases until it becomes zero when the potential difference between the capacitor plates equals the potential difference between the battery terminals.

(2) The potential difference between the capacitor plates increases until it equals the potential difference between the battery terminals.

(3) It is not affected, since $V = V_B$ always because the internal resistance of the battery is negligible.

14 **Model answer**

The capacitors are connected in series, so the charge on each plate of any of the three capacitors = Q

The charge on plate y is positive and the charge on plate z is negative.

15 **Model answer**

The charge on plate A is negative, because as the magnet approaches the ring an induced current is produced in the ring that opposes the change in flux; on the face opposite the magnet its direction is anticlockwise, so plate B is charged positively and plate A is charged negatively.

16 **Model answer**

The capacitors are connected in parallel: $V_1 = V_2 = V_3$

$V = Q/C \Rightarrow Q_1/C_1 = Q_2/C_2 = Q_3/C_3$

Since $C_1 \neq C_2 \neq C_3$, then $Q_1 \neq Q_2 \neq Q_3$

17 **Model answer**

The charge stored on the plates of the two capacitors does not differ, although their capacitances differ, because they are connected in series.

18 **Model answer**

(1) A straight line through the origin (Q on the vertical axis and V on the horizontal axis).

(2) $slope = (\Delta Q)/(\Delta V)$ and $C = Q/V$, so $C = slope$

i.e. the capacitance can be found by calculating the slope of the line.

19 **Model answer**

Capacitors C_1 and C_3 are connected in parallel: $V_1 = V_3$ and $Q_1 = Q_3$, so $C_1 = C_3 = 12\ \mu F$

The equivalent of C_1 and C_3 is in series with the equivalent of C_2 and C_4: $Q_{1,3} = Q_{2,4}$

$C_{1,3}\ V = C_{2,4} \times 2V \Rightarrow C_{2,4} = 1/2 \times 24 = 12\ \mu F$

$C_4 = 12 - 4 = 8\ \mu F$

20 **Model answer**

(1) $V_C = I X_C = I/(2\pi f C)$

$12 = 1/(2\pi \times 500/(\pi) C) \Rightarrow C = 8.33 \times 10^{-5}\ F$

(2) The capacitors are in series: $V \propto 1/C$

$V_1 : V_2 : V_3 = 6 : 3 : 2$, so $V_2 = 6\ V$, $V_3 = 4\ V$

$V_{eff} = 12 + 6 + 4 = 22\ V$

21 **Model answer**

(1) It does not change, because the elements in the circuit are capacitors only, and in a capacitor the total voltage lags behind the current by $90°$ whatever its capacitance.

(2) It increases, because increasing C_1 increases the total capacitance of the circuit, so the total capacitive reactance decreases and the current through the source increases.

(3) It increases, because when the capacitance of C_1 is increased the current in the circuit increases, so the potential difference between the plates of C_2 increases $(V_2 = I X_{C_2})$.

22 **Model answer**

$I = V/X_C = 2\pi f C V$ and both V and f are constant.

$I_1/I_2 = C_1/C_2 = (C/2)/(2C/3) = 3/4$

23 **Model answer**

(1) Relation: $X_L = \omega L$, slope: $slope = (\Delta X_L)/(\Delta \omega) = L$

(2) Relation: $X_C = 1/(2\pi f C)$, slope: $slope = (\Delta X_C)/(\Delta(1/f)) = 1/(2\pi C)$

(3) Relation: $X_C = 1/(2\pi f C)$, slope: $slope = (\Delta X_C)/(\Delta(1/(fC))) = 1/(2\pi)$

Past exam questions

1	2	3	4	5	6	7	8	9	10
C	C	D	D	D	A	A	B	C	C
11	12	13	14	15	16	17	18	19	20
B	C	C	C	B	B	A	C	D	C
21	22	23	24	25	26	27	28	29	30
C	D	C	D	B	A	A	C	A	B
31	32	33	34	35	36	37	38	39	40
B	C	B	D	B	D	A	A	A	B
41	42	43	44	45	46	47	48	49	50
B	A	D	C	B	B	A	D	B	A

51	52	53	54	55	56	57
A	A	B	C	D	B	A

1 **Answer (C)**

The plate expands with the wire by the same amount when the air temperature changes, so the pointer does not move, and we get rid of the zero error.

2 **Answer (C)**

The heat produced is proportional to the square of the current, so the deflection at 2I is about 4 times the deflection at I.

3 **Answer (D)**

The deflection is proportional to I^2, so the divisions are close together at the start and far apart at the end.

4 **Answer (D)**

$Q = I_{eff}^2 \, R \, t = (V_{eff}^2)/Rt$

So the heat is directly proportional to V_{eff}^2

5 **Answer (D)**

$Q \propto I^2$, so the scale is not uniform.

6 **Answer (A)**

Without strip XY, the wire expands with the air temperature, so the pointer deflects away from zero as in figure (2).

With strip XY, it expands as much as the wire, so the pointer stays at zero as in figure (4).

7 **Answer (A)**

The deflection is proportional to I^2

Y is 4 divisions and V is one division:

$(I_Y^2)/(I^2) = 4 \Rightarrow I_Y = 2I$

8 **Answer (B)**

Decreasing the shunt resistance increases the current in it, so the current in the wire decreases and the heat power in it decreases.

The shunt is connected in parallel with the wire, so the total resistance decreases.

9 **Answer (C)**

$P = I^2 R$

When the current is doubled, the heat energy becomes 4 times as large, so the expansion of the wire increases.

10 **Answer (C)**

The hot-wire ammeter has a platinum-iridium wire and a non-uniform scale (divisions close together at the start and far apart at the end): figure (3).

11 **Answer (B)**

The shunt resistance decreases, so the current in it increases and the current in the platinum-iridium wire decreases, so the heat power decreases.

The total resistance decreases because the shunt is connected in parallel.

12 **Answer (C)**

The effective value of the alternating current must be 141.4 A

$I_{max} = \sqrt{(2)} \times 141.4 = 200\ A$

In (C) the periodic time is 20 ms, so at 2.5 ms the angle is 45°

$I = 200 \sin 45^\circ = 100\sqrt{(2)}\ A$, which is what the figure shows.

13 **Answer (C)**

The deflection is proportional to I^2, so the deflection of 4I is 16 times the deflection of I

$\theta_1 = 16\theta - \theta = 15\theta$

14 **Answer (C)**

Charging batteries needs a direct current in one direction.

15 **Answer (B)**

$P_w = I^2 R$

$2P_w = I'^2 R \Rightarrow I' = \sqrt{(2)}\ I$

16 **Answer (B)**

The expansion coefficient is smaller, so the wire expands less and the deflection angle of the pointer decreases.

17 **Answer (A)**

The angle is proportional to I^2, so equal angle divisions correspond to current changes that get smaller as the current increases.

$\Delta I_1 > \Delta I_2 > \Delta I_3$

18 **Answer (C)**

$Q \propto I^2$, so the relation is a curve whose slope increases (a parabola).

19 **Answer (D)**

The hot-wire ammeter measures the effective value of the alternating current.

20 **Answer (C)**

The hot-wire ammeter has a non-uniform scale $(\theta \propto I^2)$, so it deflects by unequal angles.
The moving-coil ammeter has a uniform scale, so it deflects by equal angles.

21 **Answer (C)**

The reading = the effective value:
w : $2I_0/(\sqrt{(2)}) = 1.41\ I_0$, x : $0.5\ I_0$
y : $I_0/(\sqrt{(2)}) = 0.71\ I_0$, z : I_0
$x < y < z < w$

22 **Answer (D)**

$P = (V_{eff}^2)/R$
(A) $(V^2)/R$, (B) $V_{eff} = \sqrt{(2)}V$, so $(2V^2)/R$
(C) $(V^2)/R$, (D) $(4V^2)/R$

23 **Answer (C)**

$\omega = 2\pi f = 1000\ rad/s$
Upper branch: $L = 0.4 + 0.2 = 0.6\ H$ and it carries 0.2 A
$V = I\omega L = 0.2 \times 1000 \times 0.6 = 120\ V$

24 **Answer (D)**

In the resistance I_R is in phase with the voltage, and in the coil I_L lags behind the voltage by 90°
So I_L lags behind I_R by 90°

25 **Answer (B)**

$V_{eff} = 200/(\sqrt{(2)}) = 141.4\ V$

$X_L = 141.4/2 = 70.7\ \Omega$

$L = X_L/(\omega) = 70.7/(100\pi) = 0.225\ H$

To double the current the reactance must be halved, so an identical coil of 0.22 H is connected in parallel.

26 **Answer (A)**

$\omega = 2\pi f = 200\ rad/s$

$X_L = 200/5 = 40\ \Omega \Rightarrow L_{eq} = 0.2\ H$

Upper branch $0.1 + 0.2 = 0.3\ H$, in parallel with L

$(0.3\ L)/(0.3 + L) = 0.2 \Rightarrow L = 0.6\ H$

27 **Answer (A)**

$nX = 40\ ,\ X/n = 2.5$

$X^2 = 100 \Rightarrow X = 10\ \Omega$

$L = X/(\omega) = 10/100 = 0.1\ H$

28 **Answer (C)**

Each branch has two coils in series, $0.1\ H$, and the two branches are in parallel: $L = 0.05\ H$

$X_L = 31.4/10 = 3.14\ \Omega$

$f = X_L/(2\pi\ L) = 3.14/(2 \times 3.14 \times 0.05) = 10\ Hz$

29 **Answer (A)**

Circuit A has a DC source, so there is no inductive reactance: zero

Circuit B: $L = 0.2 + 0.1 = 0.3\ H$

$X_L = 314 \times 0.3 = 94.2\ \Omega$

30 **Answer (B)**

$X_L = 220/2 = 110\ \Omega$

$L = 110/(2 \times 3.14 \times 50) = 0.35\ H$

31 **Answer (B)**

$\omega = 200\ rad/s$

Three 0.6 H coils in parallel: $0.2\ H$, so $X = 40\ \Omega$

Two reactances of 40 Ω in parallel: $20\ \Omega$

$X_{total} = 40 + 20 = 60\ \Omega$

32 **Answer (C)**

$I = V/(2\pi f L)$

$I_1/I_2 = (220/50)/(110/100) = 4/1$

33 **Answer (B)**

The circuit contains inductors only, so the voltage leads the current by 90°

34 **Answer (D)**

$\omega = 1000\ rad/s$

Each branch is $1\ H$ and the two branches are in parallel: $L = 0.5\ H$

$X_L = 500\ \Omega$

$I = 25/500 = 0.05\ A = 50\ mA$

35 **Answer (B)**

$\omega = 100\ rad/s$, $X_L = 12/3 = 4\ \Omega \Rightarrow L_{eq} = 0.04\ H$

$((0.04 + L) \times 0.06)/(0.1 + L) = 0.04$

$L = 0.08\ H = 80\ mH$

36 **Answer (D)**

When only K_1 is closed: $X_L/2 + X_L = 1.5\ X_L$

When only K_2 is closed: K_2 short-circuits the right group and X_L remains

The ratio $= (1.5\ X_L)/X_L = 3/2$

37 **Answer (A)**

(1): $\omega = 200$, $L = 0.5\ H$, so $X_1 = 100\ \Omega$

(2): $\omega = 100$, $0.6 \parallel 0.2 = 0.15\ H$, so $15\ \Omega$ and $X_2 = 15 + 20 = 35\ \Omega$

$I_2/I_1 = X_1/X_2 = 100/35 = 20/7$

38 **Answer (A)**

In a coil the current lags behind the voltage by 90° (a quarter of a cycle = 1 ms).

So the current starts from its negative maximum, reaches zero at 1 ms and its maximum at 2 ms

39 **Answer (A)**

$X_L = \omega L = 440L \Rightarrow \omega = 440\ rad/s$

40 **Answer (B)**

Closing K_1: an ohmic resistance only, so the current and the voltage are in phase, 0°

Closing K_2: an inductor only, so the voltage leads by 90°

41 **Answer (B)**

(1) Resistance: V and I are in phase.

(2) Coil: V leads I by 90°

42 **Answer (A)**

$3L \parallel L = 3L/4$

The current of coil (3L) is I, so the current of coil L is 3I and the total current is 4I

$V_{ab} = 4I \times \omega L/2 = 2I\omega L = 4\pi I L f$

43 **Answer (D)**

$X_C = 1/(2\pi f C) = 1/(2\pi \times 1000 \times 10 \times 10^{-6}) = 15.9\ \Omega$

$I_{max} = 5/15.9 = 0.3\ A$

44 **Answer (C)**

(1): 4 capacitors in series give $C/4$, so $X_1 = 4/(2\pi f C)$

(2): two groups in series, each 2C, give C, and $X_2 = 1/(2\pi (2f) C)$

$X_1/X_2 = 8$

45 **Answer (B)**

$X_C = 1/(2\pi \times 500/(\pi) \times 10^{-6}) = 1000\ \Omega$

$I = 200/1000 = 0.2\ A$

46 **Answer (B)**

$X_C = 1/(2\pi \times 200/(\pi) \times 10^{-6}) = 2500\ \Omega$

$V = 0.1 \times 2500 = 250\ V$

47 **Answer (A)**

The largest current means the smallest reactance, i.e. the largest capacitance: the four capacitors in parallel, $4C$

48 **Answer (D)**

(1): two groups in series, each 2C, so the capacitance is C

(2): two branches in parallel, each two capacitors in series, so the capacitance is C

$X_2/X_1 = f_1/f_2 = 1/2$

49 **Answer (B)**

The smallest current means the largest reactance, i.e. the smallest capacitance: the three in series, $C/3$, figure (2).

50 **Answer (A)**

The two capacitors in series give $C/2$, and in parallel with them $C/2$

$C_{\text{total}} = C/2 + C/2 = C$

51 **Answer (A)**

In a capacitor the voltage lags behind the current by 90°

52 **Answer (A)**

Before closing K: $C_1 \parallel C_3 = 0.5 + 3 = 3.5\ \mu F$

After closing K: the three in parallel, $5.5\ \mu F$

$3.5/5.5 = 7/11$

53 **Answer (B)**

After closing K the voltages become equal, so the charge is shared in the ratio of the capacitances.

$Q_1 = 60 \times 1/3 = 20\ \mu C$, $Q_2 = 40\ \mu C$

54 **Answer (C)**

(A) in parallel: $Q_A = 12 \times 20 = 240\ \mu C$

(B) in series: $V = 20/3$ and $Q_B = 80\ \mu C$

$Q_A/Q_B = 3/1$

55 **Answer (D)**

$V_{AB} = Q_3/C_3 = (2.4 \times 10^{-3})/(8 \times 10^{-6}) = 300\ V$

C_1 , C_2 in series: $C = 2\ \mu F$ and $Q = 600\ \mu C$

The voltmeter is across C_1: $V = 600/3 = 200\ V$

56 **Answer (B)**

The equivalent capacitance of the group is $10\ \mu F$

$X_C = 1/(2\pi \times 50 \times 10^{-5}) = 1000/(\pi)\ \Omega = 1/(\pi)\ k\Omega$

57 **Answer (A)**

$nX = 200$, $X/n = 12.5$

$n^2 = 16 \Rightarrow n = 4$