Physics · Electric Current and Electromagnetism · AC Circuits

AC Circuits (continued)

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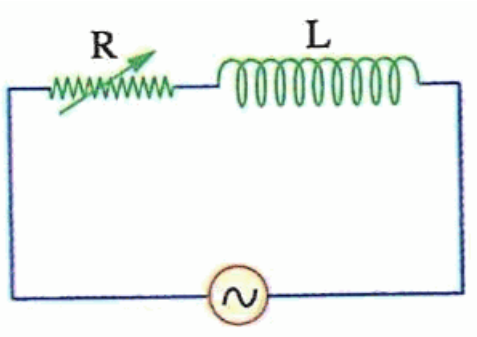
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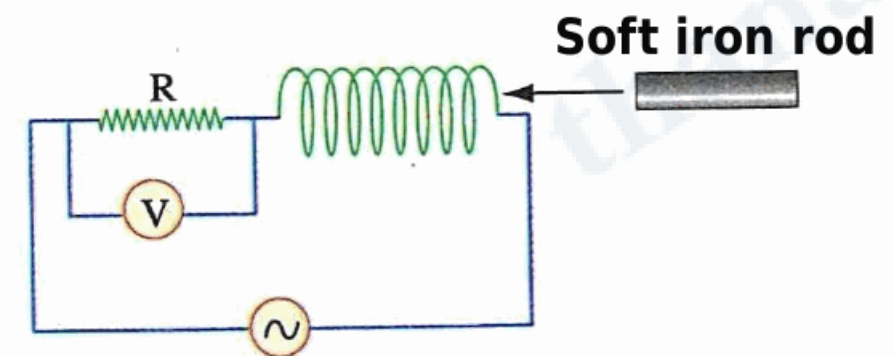
Multiple choice questions — 130 questions

1 In the opposite circuit, the AC source has a constant effective voltage and its frequency can be changed. The effective value of the current in the circuit increases when .....



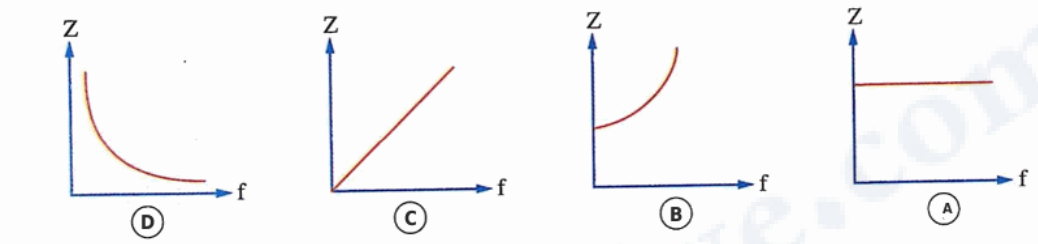
(A) the source frequency is increased
(B) the source frequency is decreased
(C) the resistance R is increased
(D) an iron core is put inside the coil

2 In the opposite circuit, when the iron rod gets inside the coil, the voltmeter reading .....

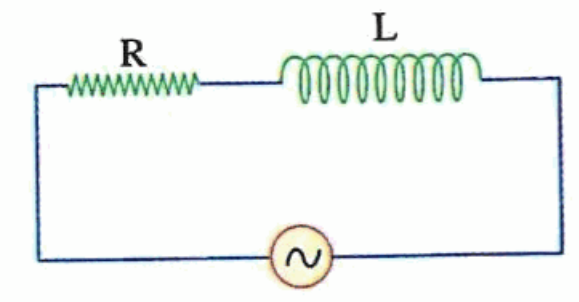


(A) decreases
(B) increases
(C) increases then decreases
(D) stays constant

3 An AC circuit consists of an inductor, an ohmic resistor and an AC source, all connected in series. Which of the following graphs represents the relation between the impedance (Z) of the circuit and the frequency (f) of its current?

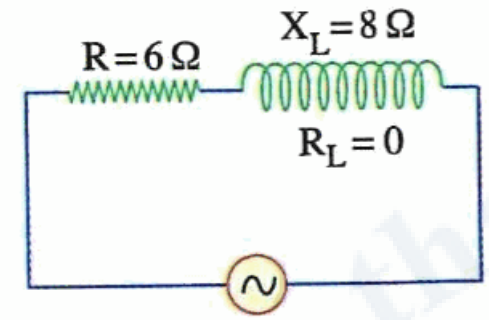


4 In the circuit shown in the figure, if the AC source is replaced by a DC source whose voltage equals the effective voltage of the AC source, the ratio of the effective current in the circuit in the first case to the current in the circuit in the second case is .....



(A) zero (B) less than one (C) equal to one (D) greater than one

5 In the opposite circuit, the total impedance Z equals .....



(A) 2 Ω (B) 48 Ω (C) 14 Ω (D) 10 Ω

6 An inductor has an ohmic resistance of 12 Ω. When a current of frequency f passes through it, its inductive reactance is 18 Ω, so:

(1) its total impedance in this case is .....

(A) 20.1 Ω (B) 16.3 Ω (C) 21.6 Ω (D) 36.2 Ω

7 An inductor has an ohmic resistance of 12 Ω. When a current of frequency f passes through it, its inductive reactance is 18 Ω, so:

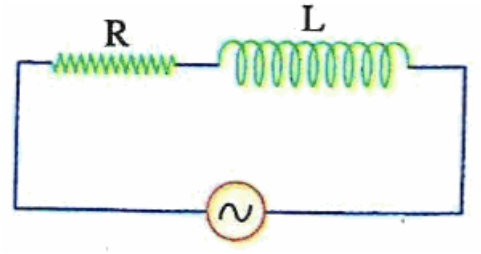
(2) its total impedance when the frequency increases to 2 f is .....

(A) 37.95 Ω (B) 22 Ω (C) 36 Ω (D) 19.99 Ω

8 A circuit contains an AC source and a coil whose inductive reactance is twice its ohmic resistance. The phase angle between the total voltage and the current is .....

(A) 26.56° (B) 60° (C) 30.7° (D) 63.4°

9 In the circuit shown in the figure, when a current of frequency f passes, $(X_L = R)$ and the impedance of the circuit is Z_1. If the frequency increases to 2 f, the impedance of the circuit Z_2 becomes .....

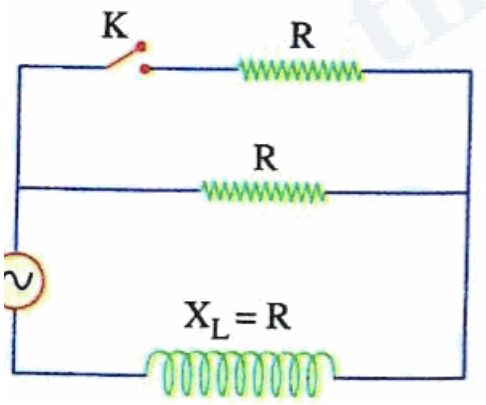


(A) $Z_1/2$ (B) $2\ Z_1$ (C) $1.6\ Z_1$ (D) $2.5\ Z_1$

10 An inductor has an ohmic resistance R and an inductive reactance $\sqrt{(3)}$ R when connected to an AC source of frequency f. The phase angle between the voltage across the coil and its current equals .....

(A) $(\pi)/3$ (B) $(\pi)/2$ (C) $(\pi)/4$ (D) $(\pi)/6$

11 In the electric circuit shown in the opposite figure, if switch K is closed, the phase angle between the total voltage and the current in the circuit .....



(A) decreases by 45° (B) increases by 63.4°
(C) increases by 45° (D) increases by 18.4°

12 An inductor of self-inductance L and ohmic resistance 10 Ω is connected to an AC source of voltage 6.5 V and frequency $30/(\pi)$ Hz. If the power consumed in the circuit is $5/8$ W, the self-inductance (L) of the coil equals .....

(A) 1.1 H (B) 0.3 H (C) 0.4 H (D) 0.6 H

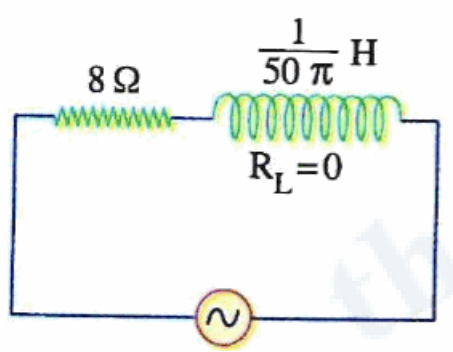
13 An inductor of ohmic resistance 2 Ω is connected to an AC source of effective voltage 6 V. The inductive reactance of the coil is 1 Ω, so the power consumed in the circuit equals .....

(A) 8 W (B) 12 W (C) 14.4 W (D) 18 W

14 An electric lamp of ohmic resistance 44 Ω is connected in series with an inductor of negligible ohmic resistance and an AC source of frequency 42 Hz and effective emf 220 V. An effective current of 4 A passes through the lamp, so the self-inductance of the coil equals .....

(A) 0.163 H (B) 0.125 H (C) 0.14 H (D) 0.1 H

15 The opposite figure shows an AC circuit. When the potential difference across the coil equals the potential difference across the ohmic resistor, the source frequency equals .....



(A) 50 Hz (B) 100 Hz (C) 200 Hz (D) 400 Hz

16 An inductor of self-inductance 0.01 H and ohmic resistance 1 Ω is connected to an AC source of voltage 200 V and frequency 50 Hz. The maximum value of the current .....

(A) lags behind the maximum value of the total voltage by 0.004 s

(B) leads the maximum value of the total voltage by 0.003 s

(C) lags behind the maximum value of the total voltage by 0.002 s

(D) leads the maximum value of the total voltage by 0.001 s

17 An AC generator (dynamo) of negligible internal resistance is connected in series with an ohmic resistor (R) and an inductor (L) of negligible ohmic resistance. When the dynamo frequency is 50 Hz, the maximum value of the total voltage leads the maximum value of the current by a time of 2.5×10^{-3} s. If the dynamo frequency increases to 100 Hz, the maximum value of the total voltage .....

(A) leads the maximum value of the current by 1.76×10^{-3} s

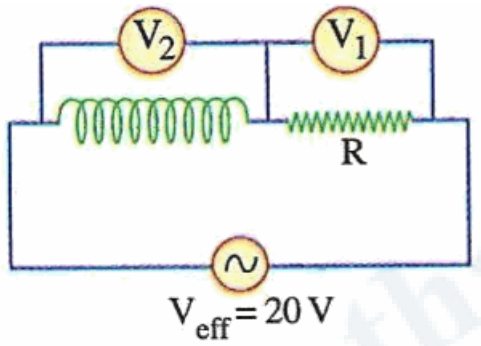
(B) leads the maximum value of the current by 3.52×10^{-3} s

(C) lags behind the maximum value of the current by 1.76×10^{-3} s

(D) lags behind the maximum value of the current by 3.52×10^{-3} s

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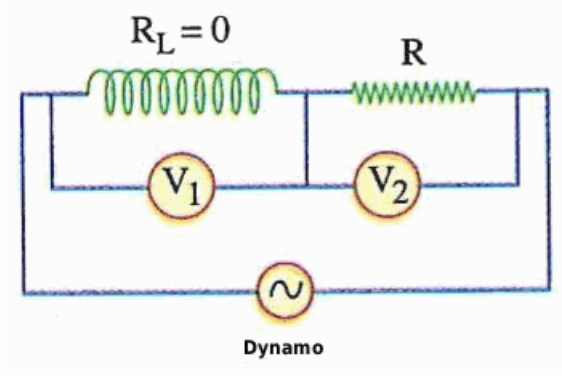
18 In the circuit shown, if the reading of V_1 is 10 V, the reading of V_2 is .....



(A) $10\sqrt{3}$ V (B) 10 V (C) 15 V (D) $10\sqrt{2}$ V

---

19 An AC generator (dynamo) is connected to an ohmic resistor (R) and an inductor (L) of negligible ohmic resistance as shown in the opposite circuit. If the readings of the two voltmeters (V_1) and (V_2) are equal, which of the following relations is correct for the two readings after the rotation frequency of the dynamo coil is doubled?

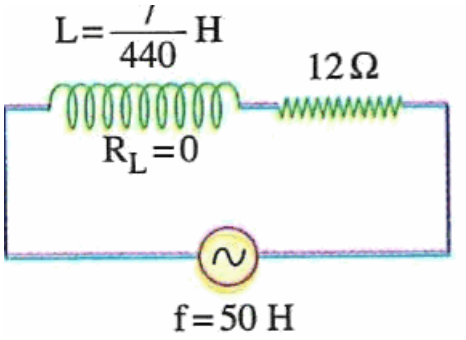


(A) $V_1 = V_2$ (B) $V_1 > V_2$

(C) $V_1 < V_2$ (D) The answer cannot be determined

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20 In the opposite figure, the total impedance of the circuit equals .....



(A) 17 Ω (B) 13 Ω (C) 12.2 Ω (D) 7 Ω

21 An inductor has a self-inductance of *7/44* H and an inductive reactance of 50 Ω. If its ohmic resistance is 30 Ω, then:

(1) the frequency of the current in the coil equals .....

(A) 100 Hz (B) 75 Hz (C) 50 Hz (D) 25 Hz

22 An inductor has a self-inductance of *7/44* H and an inductive reactance of 50 Ω. If its ohmic resistance is 30 Ω, then:

(2) the impedance of the coil equals .....

(A) 80 Ω (B) 58.31 Ω (C) 50 Ω (D) 18.75 Ω

23 The operating coil of a circuit regulator has an inductive reactance of 40 Ω and an ohmic resistance of 30 Ω, and it is connected to an AC source of voltage 5 V, so:

(1) the total impedance of the coil is .....

(A) 70 Ω (B) 60 Ω (C) 50 Ω (D) 10 Ω

24 The operating coil of a circuit regulator has an inductive reactance of 40 Ω and an ohmic resistance of 30 Ω, and it is connected to an AC source of voltage 5 V, so:

(2) the current through the coil is .....

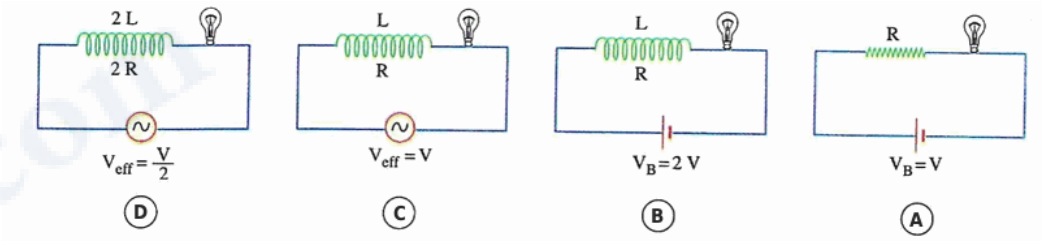
(A) 0.07 A (B) 0.09 A (C) 0.1 A (D) 0.2 A

25 The operating coil of a circuit regulator has an inductive reactance of 40 Ω and an ohmic resistance of 30 Ω, and it is connected to an AC source of voltage 5 V, so:

(3) the phase angle between the total voltage and the current equals .....

(A) 36.87° (B) 51.34° (C) 53.13° (D) 59.03°

26 An electric lamp of resistance R is connected in different circuits with sources of negligible internal resistance. In which of the following circuits is the lamp brightest?



27 An AC source of emf 100 V and frequency 50 Hz works in a circuit containing an ohmic resistor of 30 Ω and an inductor of no resistance with a self-inductance of *7/35* H, connected in series, so:

(1) the current equals .....

(A) 1.44 A (B) 1.37 A (C) 1.07 A (D) 0.5 A

28 An AC source of emf 100 V and frequency 50 Hz works in a circuit containing an ohmic resistor of 30 Ω and an inductor of no resistance with a self-inductance of *7/35* H, connected in series, so:

(2) the phase angle between the total voltage and the current equals .....

(A) 72.1° (B) 64.49° (C) 59.2° (D) 51.42°

29 An AC source of emf 100 V and frequency 50 Hz works in a circuit containing an ohmic resistor of 30 Ω and an inductor of no resistance with a self-inductance of *7/35* H, connected in series, so:

(3) the potential differences across the resistor and across the coil are, respectively, ...

(A) 50 V, 50 V (B) 20 V, 80 V (C) 43.2 V, 56.8 V (D) 43.2 V, 90.52 V

30 An ohmic resistor of 15 Ω is connected in series with an inductor of no ohmic resistance and an AC source of emf 60 V and negligible internal resistance. If the potential difference across the resistor is 45 V, then:

(1) the inductive reactance of the coil equals .....

(A) 11.25 Ω (B) 13.23 Ω (C) 15 Ω (D) 30 Ω

31 An ohmic resistor of 15 Ω is connected in series with an inductor of no ohmic resistance and an AC source of emf 60 V and negligible internal resistance. If the potential difference across the resistor is 45 V, then:

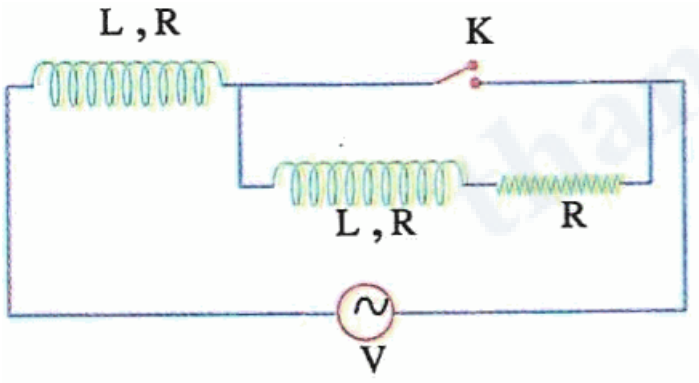
(2) the potential difference across the coil equals .....

(A) 15 V (B) 24.28 V (C) 39.69 V (D) 41.3 V

32 An AC circuit consists of an ohmic resistance X and an inductor of inductive reactance X connected in series. The phase angle between the total voltage and the current equals .....

(A) 30° (B) 45° (C) 0° (D) 90°

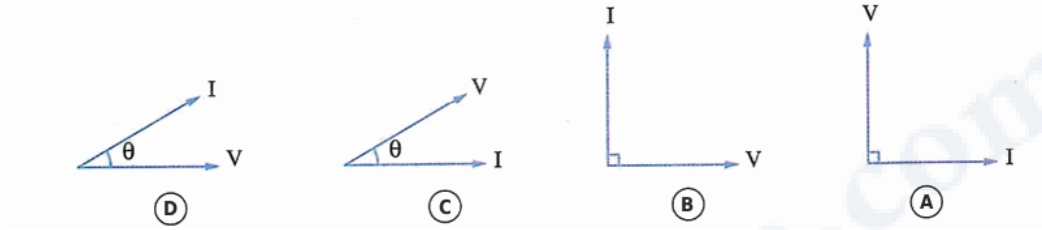
33 Two identical coils, each of self-inductance L and ohmic resistance R, are connected together with an AC source of voltage V, a switch K and an ohmic resistor R as in the opposite figure. When switch K is closed, the effective current and the phase angle between the total voltage and the current, respectively, ...



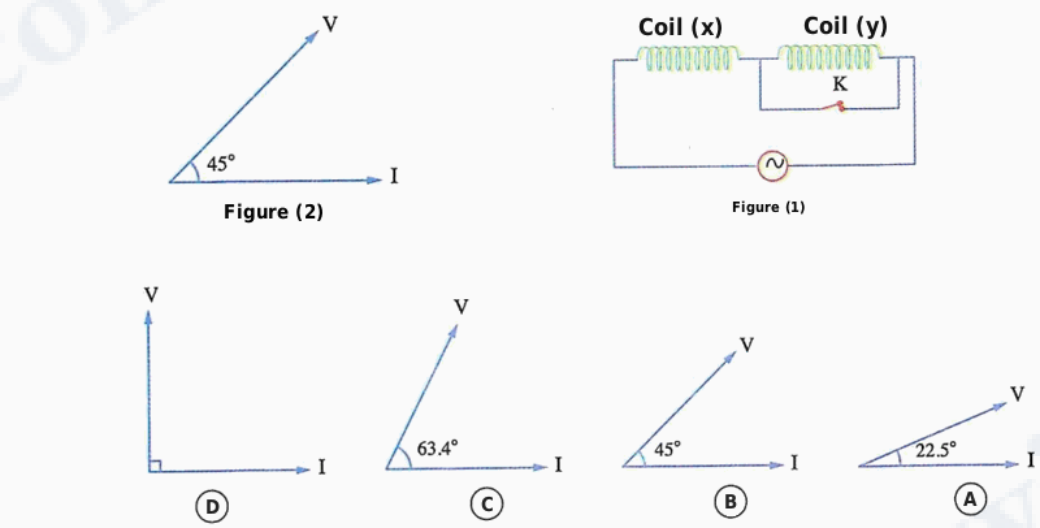
(A) increases, increases (B) increases, decreases

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

34 An electric circuit consists of an AC source and an inductor of ohmic resistance R. The figure that represents the phase difference between the vectors of the potential difference (V) across the coil and the current (I) through it is .....



35 Two identical inductors (x) and (y) are connected in an electric circuit as in figure (1). Figure (2) represents the phase difference between the vectors of the total voltage (V) and the current (I) in this circuit. Which of the following figures represents the phase difference between the total voltage (V) and the current (I) after switch (K) is opened?



36 An inductor of no resistance is connected in series with an AC source of emf 260 V and a hot-wire ammeter. The ammeter reads 2 A. If the ratio of the potential difference across the ammeter to the potential difference across the coil is *5/12*, then:

(1) the ratio of the ammeter resistance to the inductive reactance of the coil is .....

(A) *5/12* (B) *12/5* (C) *1/2* (D) *2/1*

37 An inductor of no resistance is connected in series with an AC source of emf 260 V and a hot-wire ammeter. The ammeter reads 2 A. If the ratio of the potential difference across the ammeter to the potential difference across the coil is *5/12*, then:

(2) the impedance of the circuit equals .....

(A) 138 Ω (B) 130 Ω (C) 10 Ω (D) 24 Ω

38 An inductor of no resistance is connected in series with an AC source of emf 260 V and a hot-wire ammeter. The ammeter reads 2 A. If the ratio of the potential difference across the ammeter to the potential difference across the coil is *5/12*, then:

(3) the resistance of the hot-wire ammeter equals .....

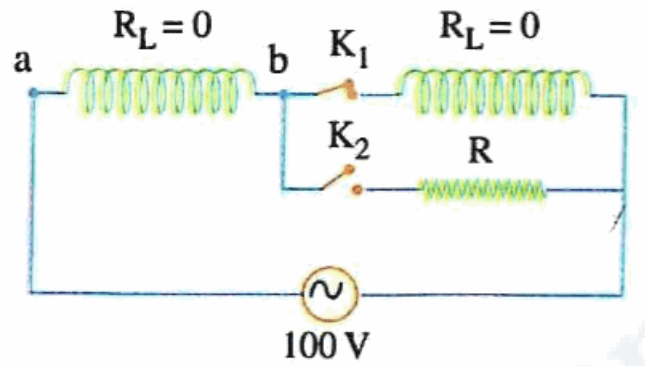
(A) 130 Ω (B) 120 Ω (C) 100 Ω (D) 50 Ω

39 An inductor of no resistance is connected in series with an AC source of emf 260 V and a hot-wire ammeter. The ammeter reads 2 A. If the ratio of the potential difference across the ammeter to the potential difference across the coil is *5/12*, then:

(4) the inductive reactance of the coil equals .....

(A) 130 Ω (B) 120 Ω (C) 100 Ω (D) 50 Ω

40 In the opposite circuit, the current in the circuit is 1 A and the potential difference between points a and b is 80 V. After switch (K_1) is opened and switch (K_2) is closed, the potential difference between a and b stays 80 V. The ohmic resistance (R) equals .....



(A) 40 Ω (B) 50 Ω (C) 60 Ω (D) 80 Ω

41 When a coil is connected to a DC source of emf 11 V, the current in it is 2.2 A. When the coil is connected to an AC source of frequency 50 Hz and emf 13 V, the current in the coil is 1 A. The self-inductance of the coil is .....

(A) 0.01 H (B) 0.025 H (C) 0.03 H (D) 0.038 H

42 An inductor of self-inductance *7/275* H and ohmic resistance 6 Ω is connected to a source of emf 6 V and negligible internal resistance. The current in the coil, if the source voltage is:

(1) alternating with frequency 50 Hz, equals .....

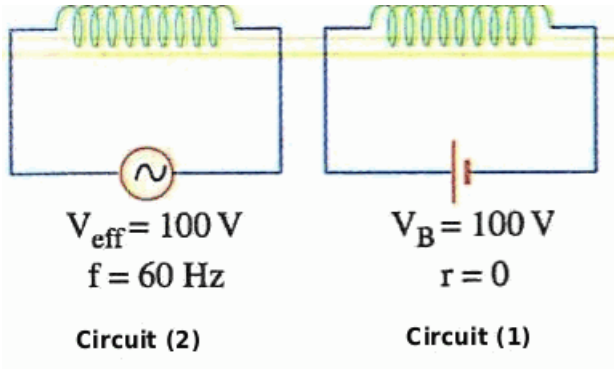
(A) 0.2 A (B) 0.42 A (C) 0.6 A (D) 1 A

43 An inductor of self-inductance *7/275* H and ohmic resistance 6 Ω is connected to a source of emf 6 V and negligible internal resistance. The current in the coil, if the source voltage is:

(2) direct, equals .....

(A) 0 (B) 0.42 A (C) 0.6 A (D) 1 A

44 An inductor of self-inductance 0.1 H is connected to a DC source of emf 100 V as in circuit (1), and the electric power consumed in the coil is 100 W. It is connected a second time to an AC source of effective voltage 100 V and frequency 60 Hz as in circuit (2). Neglecting the internal resistance of the two sources, the electric power consumed in the coil .....

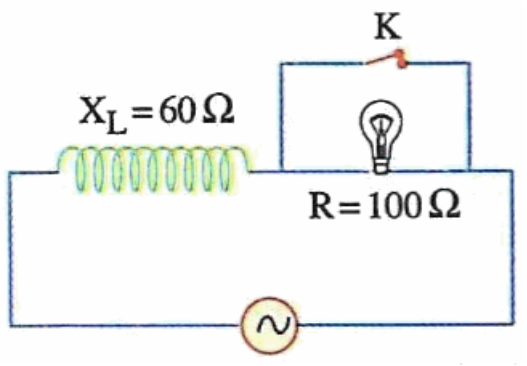


(A) stays 100 W
(B) becomes 187.5 W
(C) becomes 87.5 W
(D) becomes 12.5 W

45 An inductor of self-inductance 2 H is connected in series with a resistance of 1950 Ω and an AC source of frequency $500/(\pi)$ Hz. The phase angle between the current and the total voltage is 45°, so the ohmic resistance of the coil equals .....

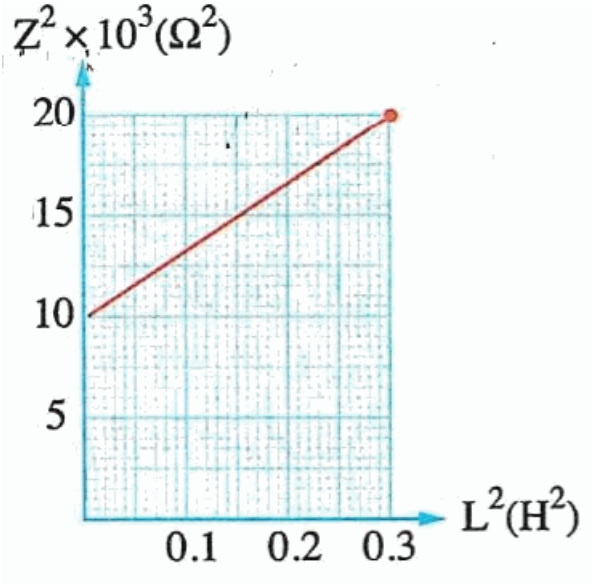
(A) 500 Ω
(B) 250 Ω
(C) 150 Ω
(D) 50 Ω

46 In the opposite circuit, an AC source of voltage 200 V is connected to a lamp of resistance 100 Ω and an inductor of inductive reactance 60 Ω, and a current of 2 A passes in the circuit. The electric power consumed in the lamp after switch (K) is opened is approximately .....



(A) 111 W
(B) 222 W
(C) 333 W
(D) 444 W

47 An AC circuit consists of an AC source of angular frequency (ω), an ohmic resistor (R) and an inductor of negligible ohmic resistance whose self-inductance can be changed. The opposite graph represents the relation between the square of the circuit impedance (Z^2) and the square of the self-inductance of the coil (L^2), so .....



(A) ohmic resistance (R): 10^2 Ω, angular frequency of the source (ω): 29.05 rad/s

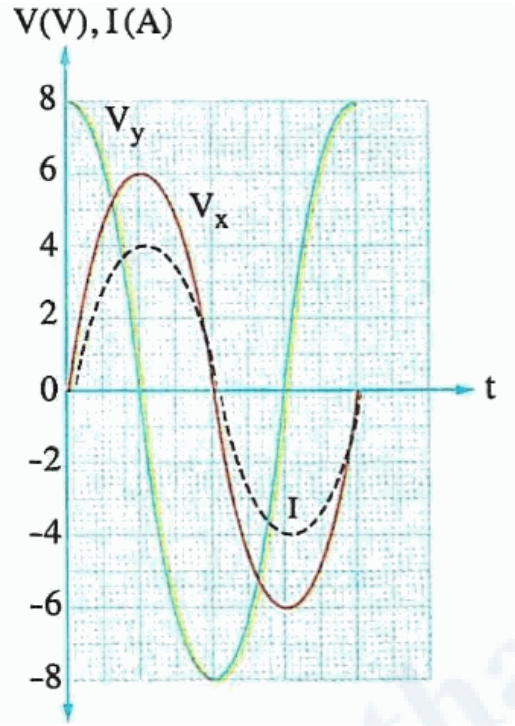
(B) ohmic resistance (R): 10^2 Ω, angular frequency of the source (ω): 182.6 rad/s

(C) ohmic resistance (R): 10^4 Ω, angular frequency of the source (ω): 29.05 rad/s

(D) ohmic resistance (R): 10^4 Ω, angular frequency of the source (ω): 182.6 rad/s

48 An AC circuit contains an AC source and two pure elements x and y connected in series. The opposite graph shows how each of the voltages (V_x) and (V_y) in volts and the current (I) in amperes change with time, so:

(1) the elements x and y are, respectively, ...



(A) an ohmic resistor, an inductor

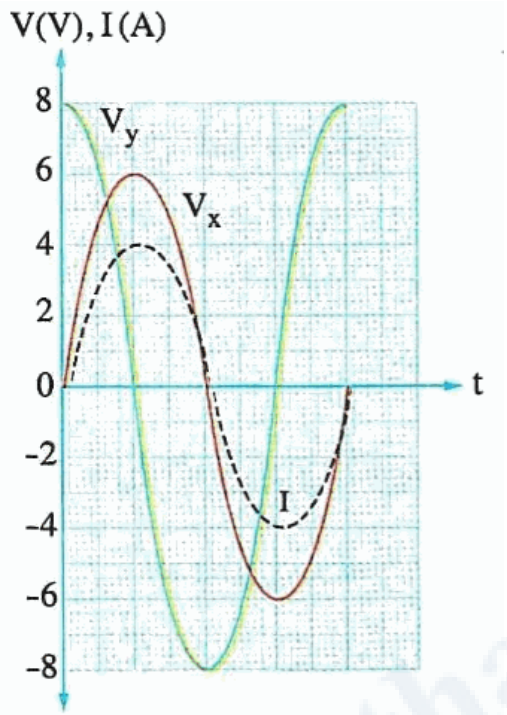
(B) an inductor, an ohmic resistor

(C) an ohmic resistor, a capacitor

(D) a capacitor, an inductor

49 An AC circuit contains an AC source and two pure elements x and y connected in series. The opposite graph shows how each of the voltages (V_x) and (V_y) in volts and the current (I) in amperes change with time, so:

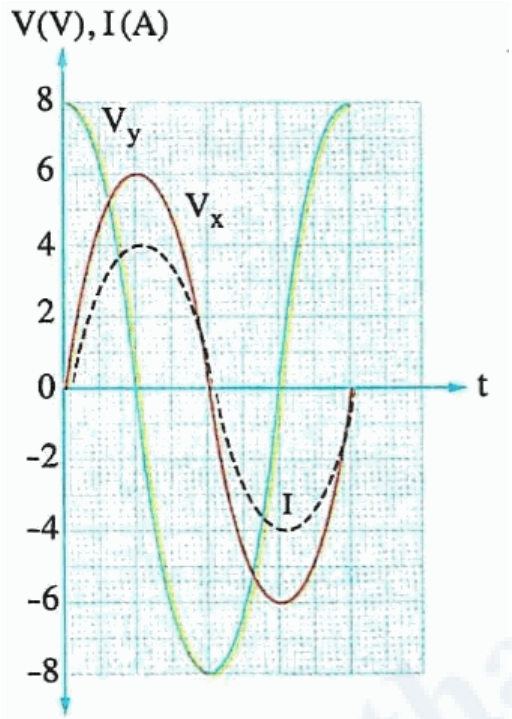
(2) the phase angle between the total voltage and the current equals .....



(A) 26.56° (B) 33.69° (C) 36.86° (D) 53.13°

50 An AC circuit contains an AC source and two pure elements x and y connected in series. The opposite graph shows how each of the voltages (V_x) and (V_y) in volts and the current (I) in amperes change with time, so:

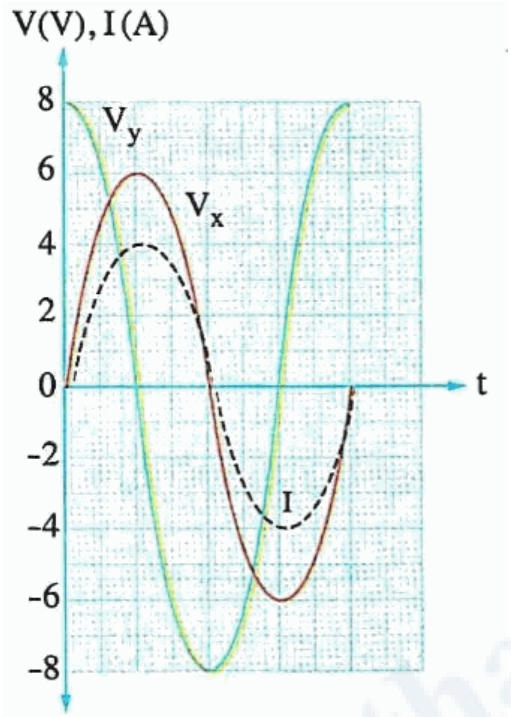
(3) the emf of the source equals .....



(A) 6 V (B) 7.07 V (C) 8 V (D) 14 V

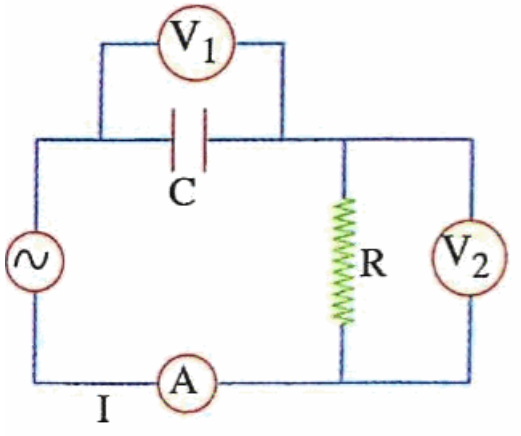
51 An AC circuit contains an AC source and two pure elements x and y connected in series. The opposite graph shows how each of the voltages (V_x) and (V_y) in volts and the current (I) in amperes change with time, so:

(4) the impedance of the circuit equals .....



(A) 1 Ω (B) 2 Ω (C) 2.5 Ω (D) 3.5 Ω

52 The opposite figure shows an AC circuit containing a capacitor C and an ohmic resistor R. Which of the following choices is correct?



(A) The potential difference V_2 and the current I are in phase

(B) The potential difference V_1 leads the potential difference V_2 in phase

(C) The potential difference V_1 and the current I are in phase

(D) The potential differences V_1, V_2 and the current I are all in phase

53 The impedance of an AC circuit containing a capacitor and an ohmic resistor is .....

(A) equal to the difference between the capacitive reactance and the resistance

(B) zero

(C) equal to the algebraic sum of the capacitive reactance and the resistance

(D) less than the algebraic sum of the capacitive reactance and the resistance

---

54 The current in an AC circuit with a variable capacitor and a rheostat connected in series increases when .....

(A) the capacitance is increased

(B) the capacitance is decreased

(C) the rheostat resistance is increased

(D) the frequency of the AC source is decreased

---

55 A capacitor C and an ohmic resistor R are connected in series to an AC generator (dynamo), and the capacitive reactance equals the resistance R. If the rotation frequency of the dynamo coil decreases, the relation between the potential difference across the capacitor and the potential difference across the resistor becomes .....

(A) $V_R > V_C$ (B) $V_C > V_R$ (C) $V_R = V_C = 0$ (D) $V_R = V_C \neq 0$

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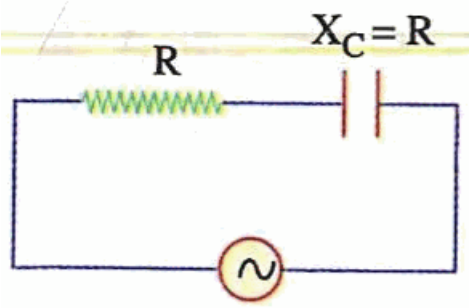
56 An AC source of frequency $50/(\pi)$ Hz is connected in a circuit containing an ohmic resistor of 1 kΩ and another component. The phase difference between the total voltage and the current in the circuit is $(\pi)/4$, so the other component in the circuit is .....

(A) a capacitor of capacitance 10 μF (B) a capacitor of capacitance 1 μF

(C) an inductor of self-inductance 5 H (D) an inductor of self-inductance 1 H

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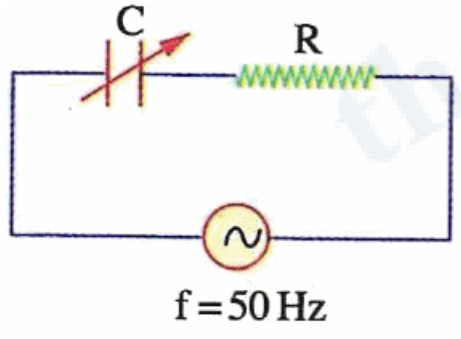
57 In the opposite circuit, the capacitive reactance equals the ohmic resistance (R), and the instantaneous potential difference across the source is given by $V = 20 \sin \omega t$. The instantaneous current in the circuit is given by .....



(A) $I = 20/R \sin(\omega t + (\pi)/4)$
(B) $I = (10\sqrt{(2)})/R \sin(\omega t + (\pi)/6)$
(C) $I = (10\sqrt{(2)})/R \sin(\omega t - (\pi)/4)$
(D) $I = (10\sqrt{(2)})/R \sin(\omega t + (\pi)/4)$

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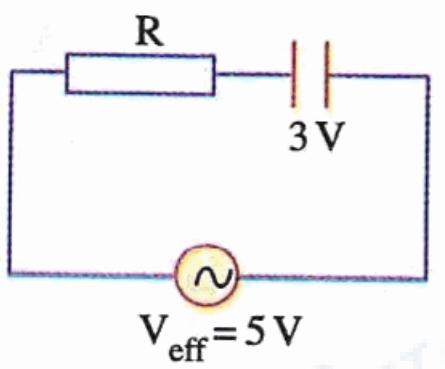
58 In the circuit shown in the figure, when the capacitance is C_1 the phase angle between the current and the total voltage is 30°. If the capacitance is changed to C_2, the phase angle becomes 60°, so .....



(A) $C_2 = C_1/3$
(B) $C_2 = (2\,C_1)/3$
(C) $C_2 = (2\,C_1)/5$
(D) $C_2 = (3\,C_1)/5$

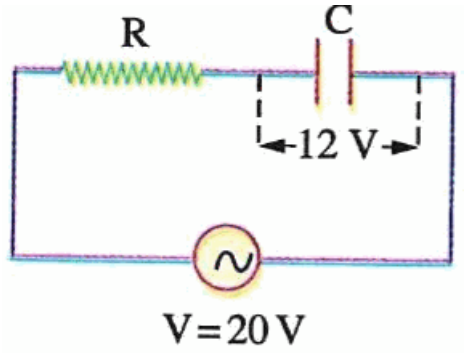
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59 In the AC circuit shown, if the potential difference across the capacitor C is 3 V, the potential difference across the resistor R equals .....



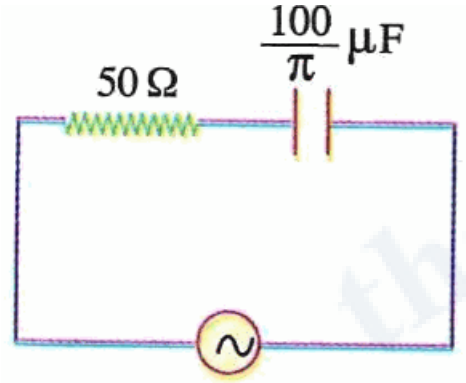
(A) 1 V
(B) 2 V
(C) 3 V
(D) 4 V

60 In the circuit shown, if the effective current in the circuit is 2 A, R equals .....



(A) 4 Ω (B) 6 Ω (C) 8 Ω (D) 12 Ω

61 The opposite figure shows an AC circuit. When the potential difference across the capacitor equals the potential difference across the ohmic resistor, the source frequency equals .....



(A) 50 Hz (B) 60 Hz (C) 100 Hz (D) 500 Hz

62 A capacitor of capacitance $7/22$ μF is connected to a non-inductive ohmic resistor of 1000 Ω. If an alternating current of frequency 500 Hz passes through them, then:

(1) the total impedance is .....

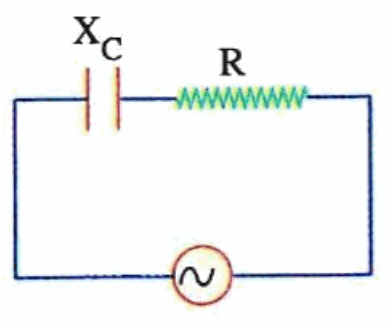
(A) 1414.2 Ω (B) 2000 Ω (C) 318.2 Ω (D) 5×10^4 Ω

63 A capacitor of capacitance $7/22$ μF is connected to a non-inductive ohmic resistor of 1000 Ω. If an alternating current of frequency 500 Hz passes through them, then:

(2) the total voltage lags behind the current by a phase angle of .....

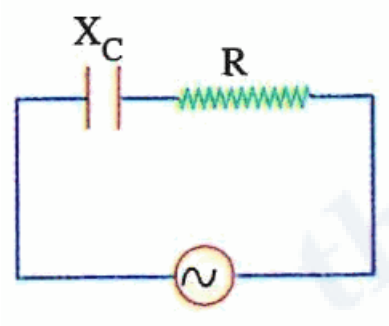
(A) 50° (B) 45° (C) 90° (D) 63.75°

64 In the opposite circuit, if the capacitive reactance X_C is three times the ohmic resistance R, the impedance Z equals .....



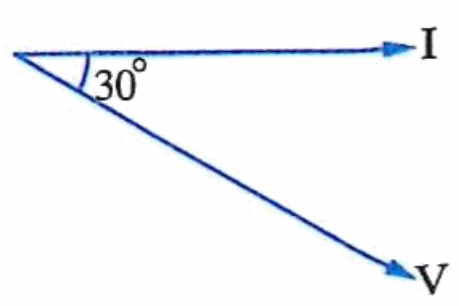
(A) $\sqrt{(2)}$ R (B) R (C) $\sqrt{(10)}$ R (D) 4 R

65 In the circuit shown, when a current of frequency f passes, $(X_C = R)$. If the frequency increases to 2 f, the impedance .....



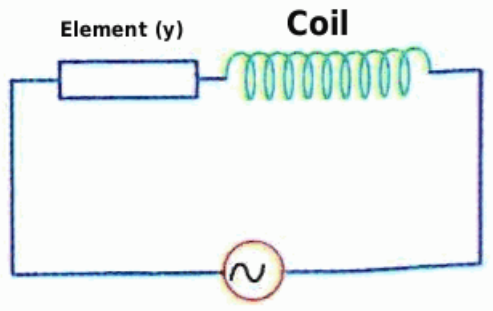
(A) doubles (B) is halved (C) becomes 1.1 R (D) becomes 0.5 R

66 The opposite figure shows the vectors of the current (I) and the total voltage (V) of an AC circuit containing two pure elements X and Y connected in series with an AC source. The elements X and Y could be .....



(A) an ohmic resistor and a capacitor (B) an ohmic resistor and a coil
(C) a coil and a capacitor (D) an ohmic resistor and an ohmic resistor

67 An inductor of negligible ohmic resistance is connected with an unknown element (y) and an AC source as in the figure. It is found that the total potential difference = the potential difference across the coil + the potential difference across y. So the element (y) is .....



(A) an ohmic resistor

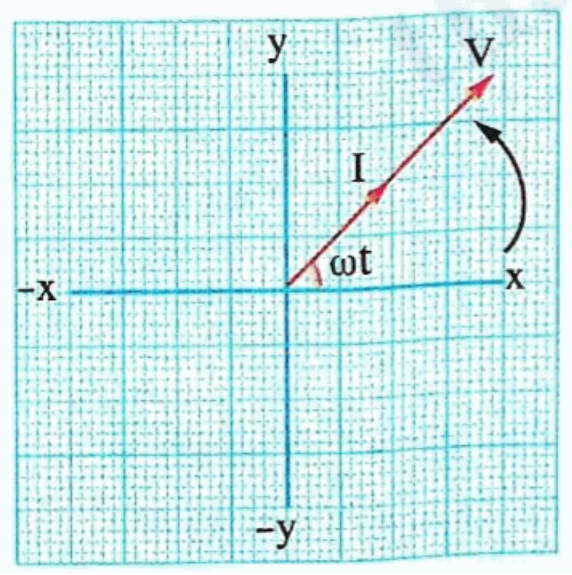
(B) an inductor of negligible ohmic resistance

(C) a capacitor

(D) an inductor with ohmic resistance

---

68 The opposite figure represents the vectors of the total voltage (V) and the current (I) in a series AC circuit made of an AC source and two pure elements (a, b). The elements (a, b) are .....



(A) an ohmic resistor and an inductor

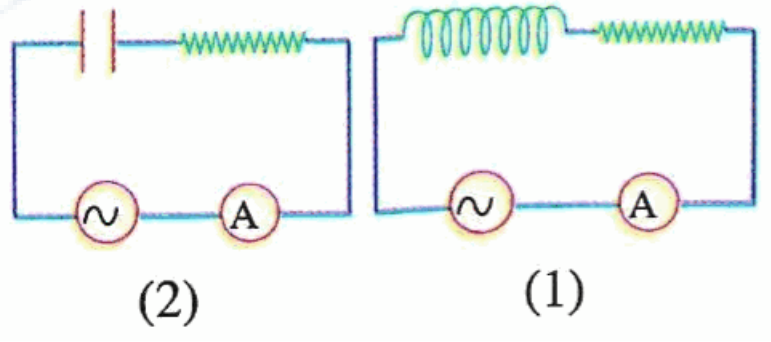
(B) an ohmic resistor and a capacitor

(C) two ohmic resistors

(D) an inductor and a capacitor

---

69 An AC source, a hot-wire ammeter and an ohmic resistor are connected once with an inductor of negligible ohmic resistance as in circuit (1), and once with a capacitor as in circuit (2). If the hot-wire ammeter reading is the same in both circuits, which of the following statements is NOT correct?



(A) The inductive reactance of the coil = the capacitive reactance of the capacitor

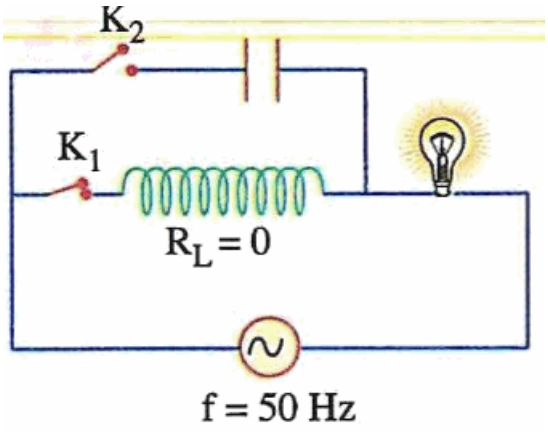
(B) The voltage across the coil = the voltage across the capacitor

(C) The current lags behind the total voltage by an angle θ in both circuits

(D) The impedances of the two circuits are equal

---

70 An AC source of frequency 50 Hz is connected with an inductor of self-inductance $1/(\pi)$ H and negligible ohmic resistance, a capacitor of capacitance $100/(\pi)$ μF and a lamp, as in the opposite circuit. What happens to the brightness of the lamp after switch (K_1) is opened and switch (K_2) is closed?



(A) It increases

(B) It decreases but does not become zero

(C) It does not change

(D) It becomes zero

---

71 A resistance of 300 Ω is connected in series with a capacitor of reactance 265 Ω and an AC source of frequency 100 Hz. If the potential difference across the capacitor = 5 V, then:

(1) the capacitance equals .....

(A) 0.42 μF (B) 0.9 μF (C) 3 μF (D) 6 μF

72 A resistance of 300 Ω is connected in series with a capacitor of reactance 265 Ω and an AC source of frequency 100 Hz. If the potential difference across the capacitor = 5 V, then:

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

(A) 0.008 A (B) 0.017 A (C) 0.019 A (D) 0.01 A

73 A resistance of 300 Ω is connected in series with a capacitor of reactance 265 Ω and an AC source of frequency 100 Hz. If the potential difference across the capacitor = 5 V, then:

(3) the potential difference across the resistor equals .....

(A) 4.7 V (B) 5 V (C) 5.7 V (D) 6 V

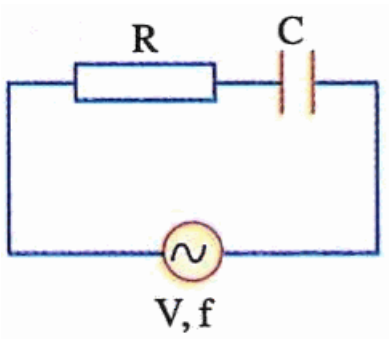
74 An AC source of emf 200 volts and frequency 50 hertz is connected in series with a capacitor of capacitance $100/(3\pi)$ microfarad and a lamp marked (25 watt, 100 volt). The current through the lamp filament is .....

(A) 0.15 A, so it does not light (B) 0.2 A, so it lights

(C) 0.4 A, so it melts (D) 0.45 A, so it melts

75 In the circuit shown, the phase angle between the current and the total voltage is 45°. The phase angle between them when:

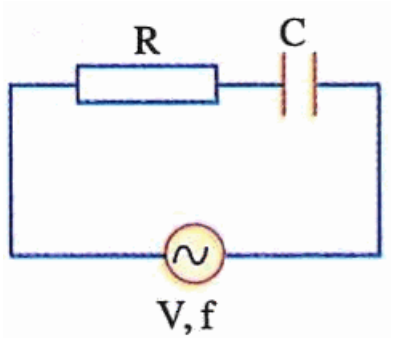
(1) the capacitor is connected in series with another capacitor of capacitance C becomes .....



(A) 26.57° (B) −63.4° (C) 63.4° (D) −26.57°

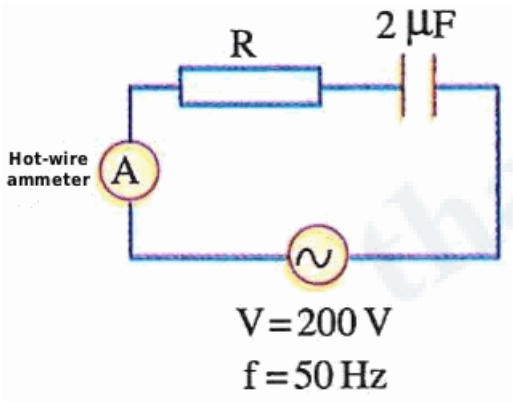
76 In the circuit shown, the phase angle between the current and the total voltage is 45°. The phase angle between them when:

(2) the resistor is connected in series with another resistor R becomes .....



(A) 26.57° (B) −63.4° (C) −26.57° (D) 63.4°

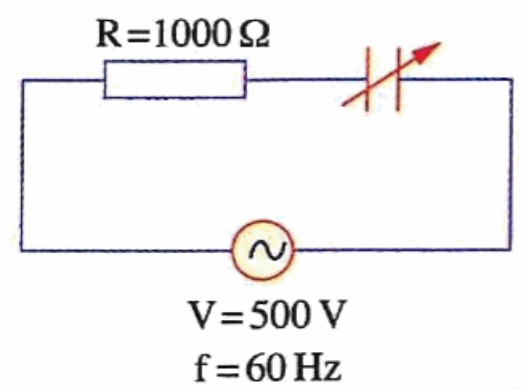
77 In the circuit shown, if the effective current in the circuit is 0.02 A, the resistance R is .....



(A) 11590.91 Ω (B) 10000 Ω (C) 9872.64 Ω (D) 8409.81 Ω

78 In the circuit shown, the capacitance at which:

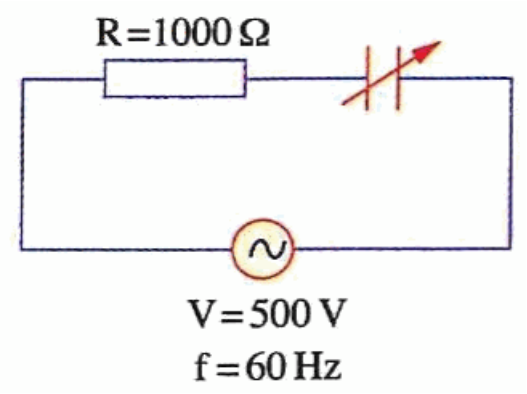
(1) the effective current is 0.25 A is .....



(A) 1.53 μF (B) 2.65 μF (C) 3.42 μF (D) 4.59 μF

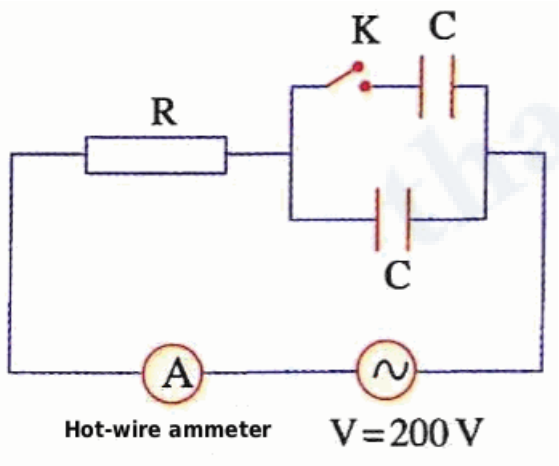
79 In the circuit shown, the capacitance at which:

(2) the phase angle between the current and the total voltage is (-45°) equals .....



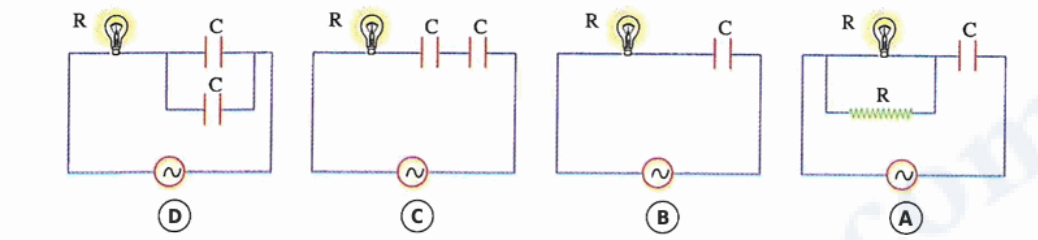
(A) 5.3 μF (B) 4.33 μF (C) 2.65 μF (D) 1.42 μF

80 In the circuit shown, the total ohmic resistance is 500 Ω and the hot-wire ammeter reads 0.2 A when switch K is open. Its reading when switch K is closed is .....



(A) 0.4 A (B) 0.3 A (C) 0.27 A (D) 0.2 A

81 In the following circuits, all the sources are identical, each capacitor has capacitance (C) and each lamp has resistance (R). In which of these circuits is the lamp brightest?



82 An AC circuit contains an inductor L of no resistance and a capacitor C connected in series. The potential difference V_L .....

(A) leads V_C in phase by 90°
(B) lags behind V_C in phase by 90°
(C) is in phase with V_C
(D) leads V_C in phase by 180°

83 An LC AC circuit consists of a source whose frequency can be changed, a capacitor and an inductor of negligible ohmic resistance connected in series. When the source frequency is (f), the capacitive reactance (X_C) is 500 Ω and the inductive reactance (X_L) is 100 Ω. The change in the phase angle between the total voltage and the current after:

(1) the source frequency is increased to (2 f) equals .....

(A) 0°
(B) 45°
(C) 90°
(D) 180°

84 An LC AC circuit consists of a source whose frequency can be changed, a capacitor and an inductor of negligible ohmic resistance connected in series. When the source frequency is (f), the capacitive reactance (X_C) is 500 Ω and the inductive reactance (X_L) is 100 Ω. The change in the phase angle between the total voltage and the current after:

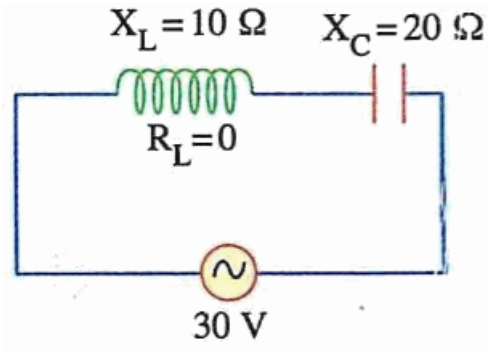
(2) the source frequency is increased to (5 f) equals .....

(A) 0°
(B) 45°
(C) 90°
(D) 180°

85 In a series AC circuit, it is found that the current at some instant is zero when the potential difference across the source is maximum. The AC source could be connected with .....

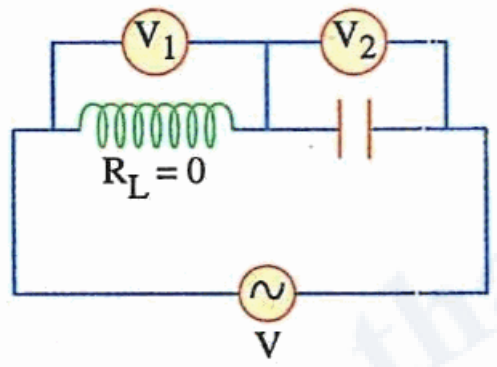
(A) an inductor of no ohmic resistance
(B) a capacitor
(C) an inductor of no resistance and a capacitor
(D) all of the above

86 The current in the opposite circuit equals .....



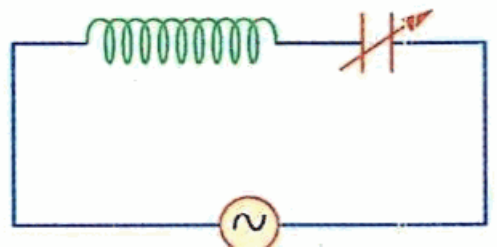
(A) 1 A (B) $3/(\sqrt{(5)})$ A (C) 2 A (D) 3 A

87 In the circuit shown, if $V_1 = V$, then V_2 equals .....



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

88 In the circuit shown, an AC source is connected in series with a variable capacitor of capacitive reactance $(X_C)_1$ and an inductor of no ohmic resistance with inductive reactance X_L, where $X_L > (X_C)_1$, and the effective current is I. If the capacitance is reduced to a quarter, $(X_C)_2$ becomes greater than X_L and the effective current doubles. The ratio $X_L/((X_C)_1)$ is .....

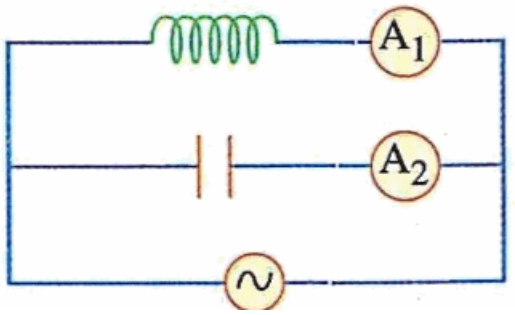


(A) 1/3 (B) 2/3 (C) 3/1 (D) 3/5

89 An AC source of frequency f is connected in series with a capacitor and an inductor of no ohmic resistance. The capacitive reactance is twice the inductive reactance. If the source frequency is doubled, the capacitive reactance becomes ..... the inductive reactance.

(A) twice (B) equal to (C) half (D) four times

90 When the source in the circuit shown is replaced by another source of the same voltage and a higher frequency, which of the following choices is correct?



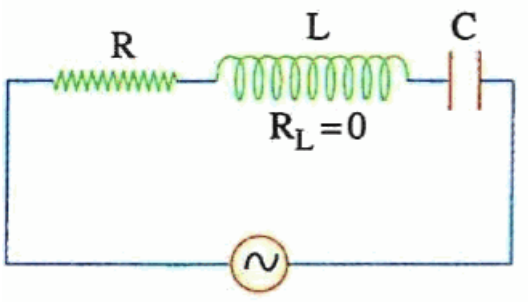
(A) Reading of hot-wire ammeter A_1: increases, reading of hot-wire ammeter A_2: decreases

(B) Reading of hot-wire ammeter A_1: decreases, reading of hot-wire ammeter A_2: increases

(C) Reading of hot-wire ammeter A_1: decreases, reading of hot-wire ammeter A_2: decreases

(D) Reading of hot-wire ammeter A_1: increases, reading of hot-wire ammeter A_2: increases

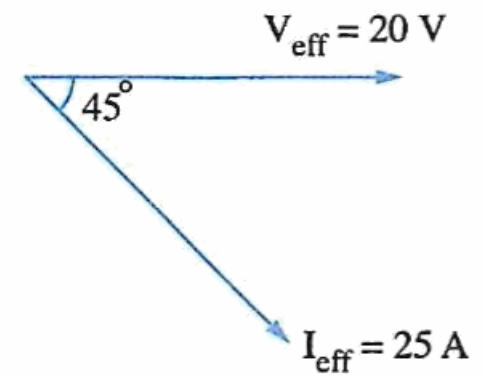
91 In which of the elements shown in the opposite circuit is electrical energy converted into heat energy?



(A) The ohmic resistor (R) (B) The inductor (L)

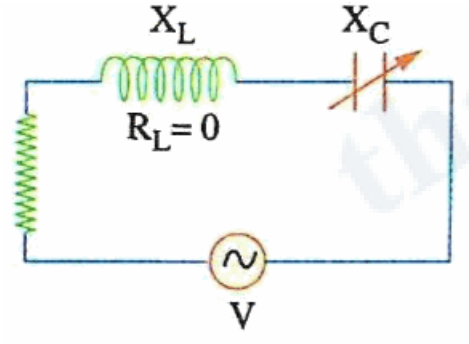
(C) The capacitor (C) (D) All three elements

92 The opposite figure shows a phasor diagram of the potential difference and the current in an AC circuit. This circuit could be .....



(A) RLC only (B) RL only (C) RC only (D) RL or RLC

93 In the opposite circuit, the capacitance was adjusted until $(X_C)_1 = 1/2\, X_L$, and the current in the circuit was I. If the capacitance is decreased gradually until $(X_C)_2 = 3/2\, X_L$, the current in the circuit .....



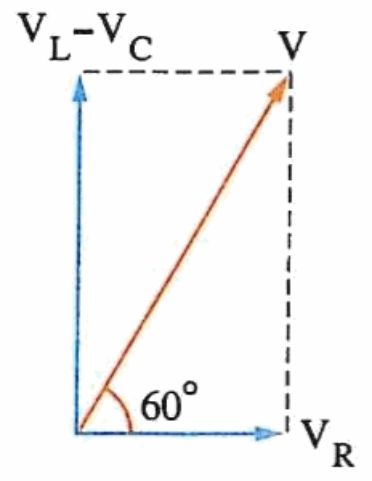
(A) decreases until it becomes zero

(B) decreases until it becomes zero, then increases

(C) increases

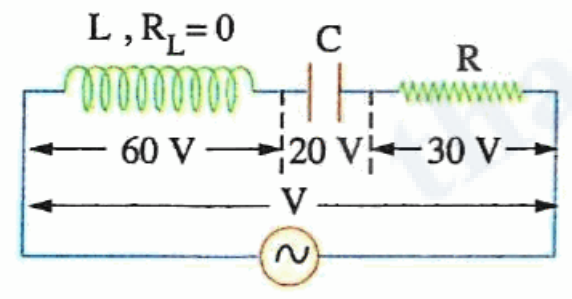
(D) increases then decreases until it reaches the same first value

94 The opposite figure shows the voltage vectors in an RLC circuit. The total impedance of the circuit equals .....



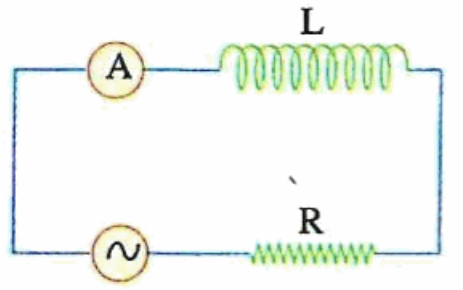
(A) *R/2* (B) *(3 R)/4* (C) R (D) 2 R

95 In the opposite circuit, the voltage of the AC source is .....



(A) 40 V (B) 50 V (C) 70 V (D) 110 V

96 When a capacitor is added in series to the circuit shown, the reading of the hot-wire ammeter does not change. In this case the capacitive reactance of the capacitor is ..... the inductive reactance of the coil.



(A) half (B) equal to (C) twice (D) three times

97 An AC circuit consists of a resistor R, an inductor L of negligible ohmic resistance and a capacitor C connected in series, where $X_C = 2\,X_L = 2\,R$. The total potential difference .....

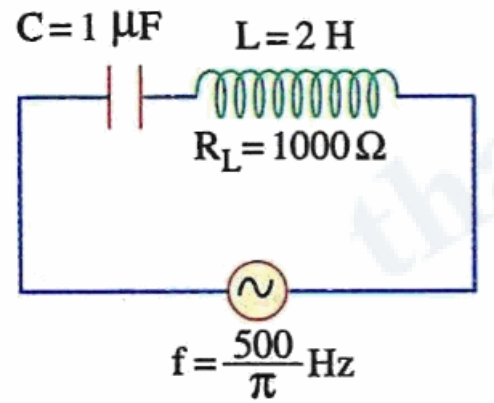
(A) leads V_R in phase by 90°
(B) leads V_R in phase by 45°
(C) lags behind V_R in phase by 90°
(D) lags behind V_R in phase by 45°

98 A series RLC AC circuit has a total impedance of 20 Ω, an ohmic resistance of 10 Ω, and the inductive reactance of the coil is greater than the capacitive reactance of the capacitor. So the phase angle between the total voltage and the current equals .....

(A) 30°
(B) 45°
(C) 60°
(D) 90°

99 In the AC circuit shown:

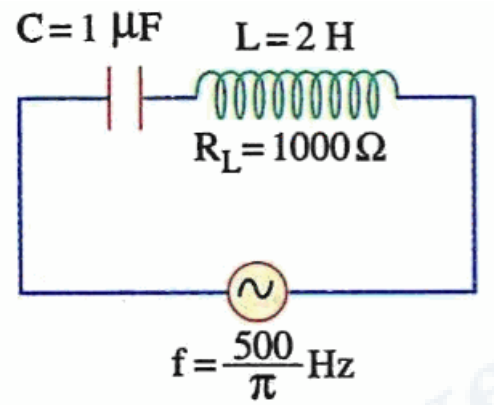
(1) the total impedance is .....



(A) 1000 Ω
(B) 2000 Ω
(C) 5000 Ω
(D) $1000\sqrt{(2)}$ Ω

100 In the AC circuit shown:

(2) the phase angle between the total voltage and the current is .....



(A) 90°
(B) 30°
(C) 45°
(D) 0°

101 If the phase angle between the total voltage and the current in an RLC circuit is 45° and $(R = X_C)$, the ratio of the inductive reactance of the coil to the capacitive reactance of the capacitor (X_L/X_C) equals .....

(A) 2/1 (B) (√(2))/1 (C) 1/2 (D) 1/1

102 An AC circuit contains a source of frequency $500/(\pi)$ Hz and effective voltage 200 V, an inductor of self-inductance 0.08 H and ohmic resistance 30 Ω, and a capacitor, all connected in series. If the total impedance of the circuit is 50 Ω, the phase angle between the total voltage and the current equals .....

(A) 42.19° (B) 46.12° (C) 49.17° (D) 53.13°

103 An AC source of effective voltage 50 V and frequency $500/(\pi)$ Hz is connected in series with an ohmic resistor of 300 Ω, a coil of negligible ohmic resistance and self-inductance 0.9 H, and a capacitor of capacitance 2 μF, so:

(1) the impedance of the circuit equals .....

(A) 500 Ω (B) 806.23 Ω (C) 1431.78 Ω (D) 1700 Ω

104 An AC source of effective voltage 50 V and frequency $500/(\pi)$ Hz is connected in series with an ohmic resistor of 300 Ω, a coil of negligible ohmic resistance and self-inductance 0.9 H, and a capacitor of capacitance 2 μF, so:

(2) the current in the circuit equals .....

(A) 0.03 A (B) 0.1 A (C) 0.17 A (D) 0.25 A

105 An AC source of effective voltage 50 V and frequency $500/(\pi)$ Hz is connected in series with an ohmic resistor of 300 Ω, a coil of negligible ohmic resistance and self-inductance 0.9 H, and a capacitor of capacitance 2 μF, so:

(3) the power consumed in the circuit equals .....

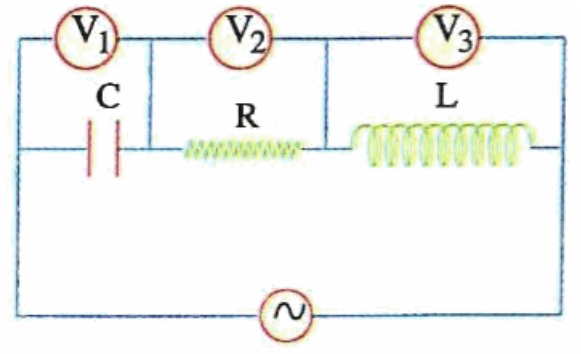
(A) 4 W (B) 3 W (C) 2 W (D) 1.47 W

106 A circuit consists of a resistance of 15 Ω, a coil of self-inductance 0.08 H and a capacitor of capacitance 30 μF, all connected in series with an AC generator (dynamo) whose coil has an angular velocity of 500 rad/s. The total voltage .....

(A) leads the current by 81.9° (B) lags behind the current by 60.65°

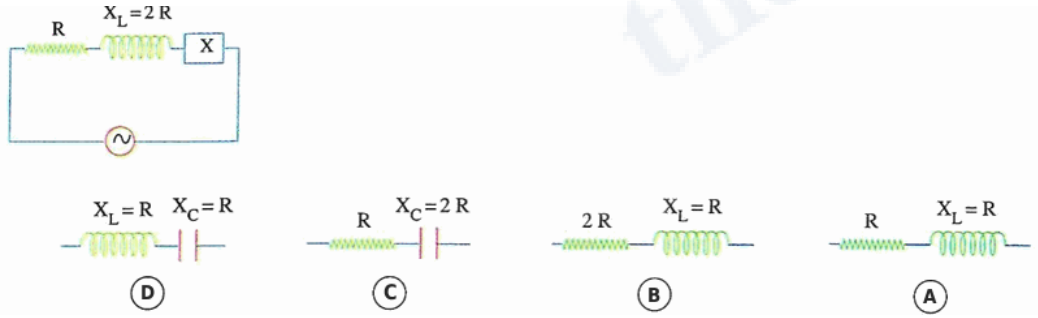
(C) leads the current by 60.65° (D) lags behind the current by 81.9°

107 An inductor of negligible ohmic resistance, an ohmic resistor and a capacitor are connected in series with an AC source as in the opposite figure. The voltmeter readings are related by $V_2 = V_3 = 2\,V_1$. When a soft iron rod is put inside the coil, the readings of voltmeters V_1 and V_2, respectively, ...



(A) decrease, decrease
(B) decrease, increase
(C) increase, decrease
(D) increase, increase

108 Which of the following choices represents the components that can be placed at position X so that the phase angle between the total voltage and the current becomes 45°? (The ohmic resistance of the coils is negligible.)



109 An electric circuit consists of a capacitor of capacitive reactance 80 Ω, an inductor of self-inductance 0.28 H, and an ohmic resistor that is a wire 12 m long with a cross-sectional area of 7×10^{-5} m² and a resistivity of 35×10^{-6} Ω.m, all connected in series with an AC source of negligible internal resistance, frequency 50 Hz and effective emf 20 V, so:

(1) the maximum current in the circuit is .....

(A) 2 A
(B) 2.828 A
(C) 3 A
(D) 3.828 A

110 An electric circuit consists of a capacitor of capacitive reactance 80 Ω, an inductor of self-inductance 0.28 H, and an ohmic resistor that is a wire 12 m long with a cross-sectional area of 7×10^{-5} m² and a resistivity of 35×10^{-6} Ω.m, all connected in series with an AC source of negligible internal resistance, frequency 50 Hz and effective emf 20 V, so:

(2) the effective potential differences across the capacitor and across the coil, respectively, are approximately .....

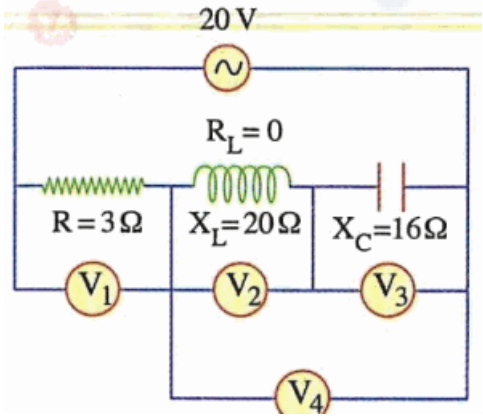
(A) 248.86 V, 226.24 V
(B) 176 V, 160 V
(C) 160 V, 176 V
(D) 226.24 V, 248.86 V

111 A coil of self-inductance $7/220$ henry and ohmic resistance 4 ohm is connected in series with a capacitor of capacitive reactance 5 ohm and a variable ohmic resistor (R). The ends of the group are connected to an AC source of emf 13 volt, frequency 50 hertz and negligible internal resistance. If the effective current in the coil must not exceed one ampere, the least ohmic resistance (R) that must be used to keep the circuit safe equals .....

(A) 4 Ω
(B) 8 Ω
(C) 10 Ω
(D) 12 Ω

112 From the circuit shown:

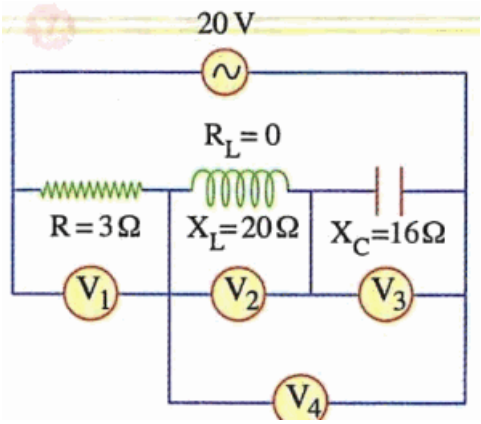
(1) the total impedance of the circuit is .....



(A) 5 Ω
(B) 7 Ω
(C) 24 Ω
(D) 39 Ω

113 From the circuit shown:

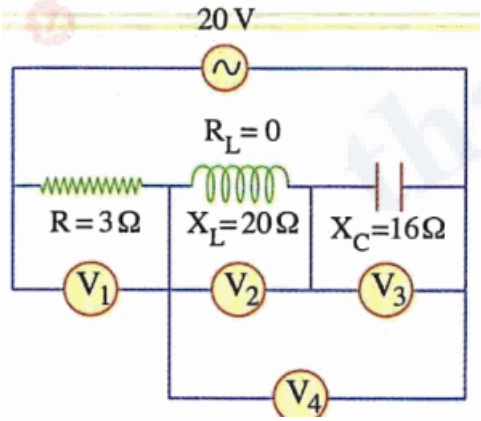
(2) the current in the circuit equals .....



(A) 0.51 A (B) 1 A (C) 2.85 A (D) 4 A

114 From the circuit shown:

(3) the readings of the four voltmeters V_1, V_2, V_3, V_4 are .....



(A) V_1: 80 V, V_2: 12 V, V_3: 16 V, V_4: 20 V

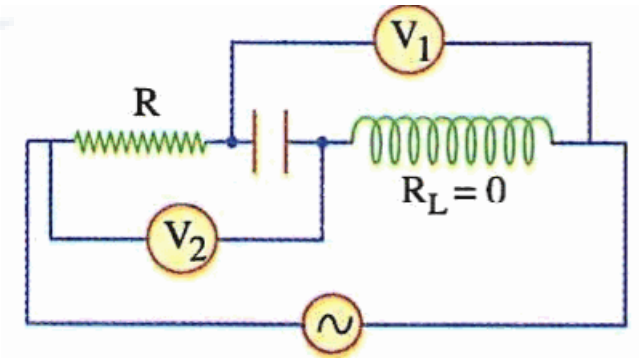
(B) V_1: 12 V, V_2: 20 V, V_3: 20 V, V_4: 0 V

(C) V_1: 12 V, V_2: 80 V, V_3: 64 V, V_4: 16 V

(D) V_1: 64 V, V_2: 16 V, V_3: 12 V, V_4: 144 V

115 In the opposite circuit, the current in the circuit is 1 A, the inductive reactance of the coil is 180 Ω and each voltmeter reads 100 V, so:

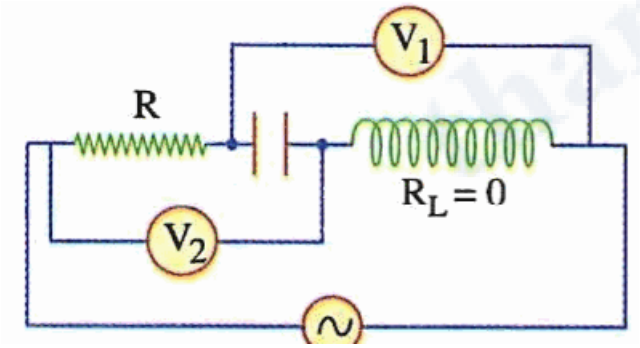
(1) the capacitive reactance of the capacitor equals .....



(A) 60 Ω (B) 80 Ω (C) 180 Ω (D) 280 Ω

116 In the opposite circuit, the current in the circuit is 1 A, the inductive reactance of the coil is 180 Ω and each voltmeter reads 100 V, so:

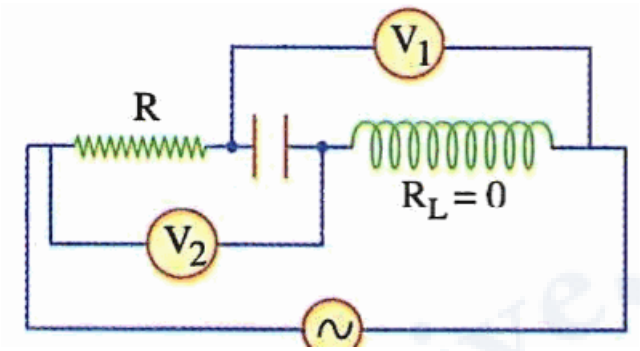
(2) the resistance (R) equals .....



(A) 60 Ω (B) 80 Ω (C) 180 Ω (D) 280 Ω

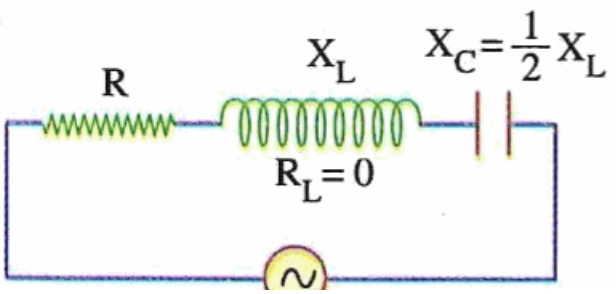
117 In the opposite circuit, the current in the circuit is 1 A, the inductive reactance of the coil is 180 Ω and each voltmeter reads 100 V, so:

(3) the phase angle between the total voltage and the current in the circuit equals .....



(A) 0° (B) 29° (C) 51° (D) 59°

118 In the circuit shown, the phase angle between the total voltage and the current is 30°. When the capacitor is connected in parallel with another identical capacitor, the phase angle between the total voltage and the current becomes .....



(A) 22.65° (B) 36.24° (C) 40.89° (D) 50.92°

119 An AC circuit contains a coil of self-inductance 0.2 H and ohmic resistance 500 Ω, a variable capacitor and an AC source of voltage 400 V and frequency $5000/(\pi)$ Hz, all connected in series. The capacitance that makes the total voltage lag behind the current by $(\pi)/4$ equals .....

(A) 5×10^{-8} F (B) 4×10^{-8} F (C) 6×10^{-6} F (D) 4×10^{-6} F

120 Figure (1) shows an RLC AC circuit, and figure (2) shows graphically how the total voltage (V) of the circuit and the current (I) in it change with time (t). The capacitive reactance (X_C) of the capacitor equals .....

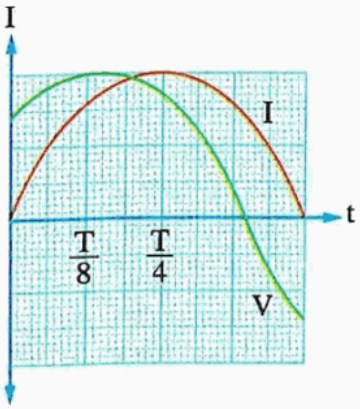


Figure (2)

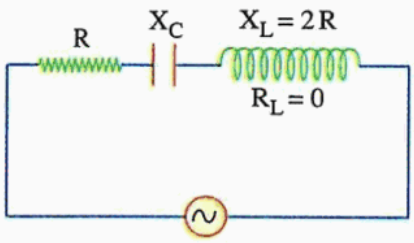
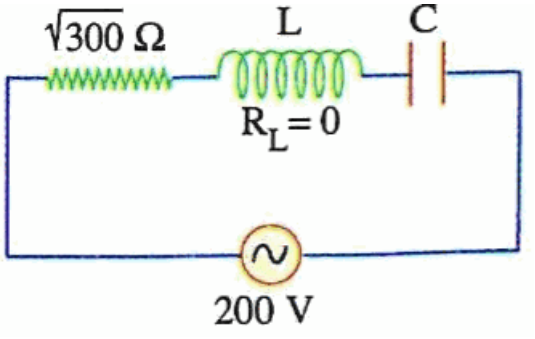


Figure (1)

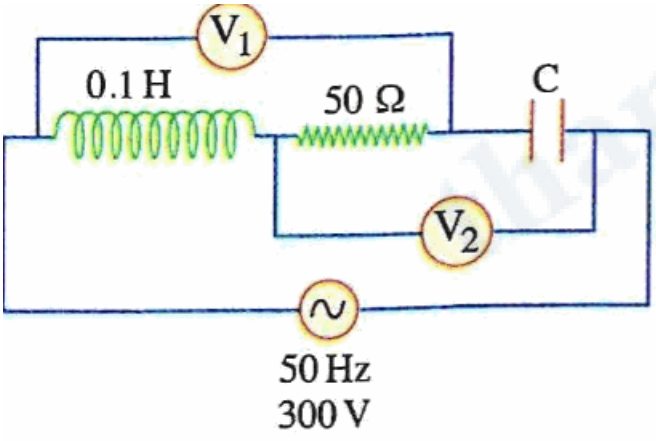
(A) $R/2$ (B) R (C) $3/2$ R (D) 3 R

121 In the opposite circuit, when only the capacitor is removed, the total voltage leads the current in phase by 30°, and when only the coil is removed, the total voltage lags behind the current in phase by 60°. The current in the circuit shown in the figure is approximately .....



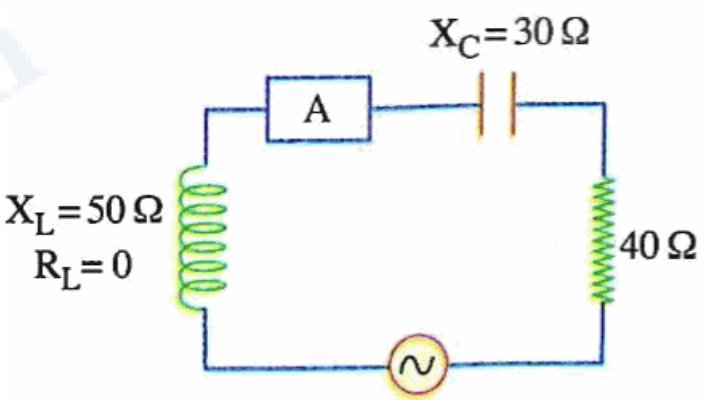
(A) 3.78 A (B) 7.56 A (C) 9.45 A (D) 18.92 A

122 In the opposite circuit, if the ratio of the readings of the two voltmeters (V_1/V_2) is $1/2$, the capacitance (C) is approximately .....



(A) 60 μF (B) 30 μF (C) 15 μF (D) 7.5 μF

123 In the circuit shown, if the total voltage lags behind the current by 45°, the element A is .....



(A) an inductor of inductive reactance 20 Ω

(B) an inductor of inductive reactance 80 Ω

(C) a capacitor of capacitive reactance 20 Ω

(D) a capacitor of capacitive reactance 60 Ω

---

124 An electric generator whose coil has negligible resistance consists of 500 turns, each of area $7/11$ m², placed in a uniform magnetic field of flux density 5×10^{-4} T and rotating at a frequency of 50 Hz. Its ends are connected in series with a capacitor of capacitive reactance 110 Ω, an ohmic resistor of 40 Ω and an inductor of inductive reactance 80 Ω and negligible ohmic resistance, so:

(1) the maximum voltage across the inductor equals .....

(A) 40 V (B) $40\sqrt{(2)}$ V (C) 80 V (D) 110 V

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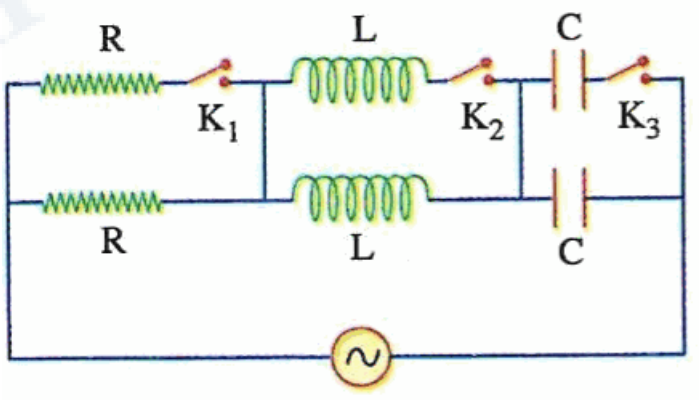
125 An electric generator whose coil has negligible resistance consists of 500 turns, each of area $7/11$ m², placed in a uniform magnetic field of flux density 5×10^{-4} T and rotating at a frequency of 50 Hz. Its ends are connected in series with a capacitor of capacitive reactance 110 Ω, an ohmic resistor of 40 Ω and an inductor of inductive reactance 80 Ω and negligible ohmic resistance, so:

(2) the effective value of the alternating current in the circuit equals .....

(A) 0.707 A (B) 1 A (C) 1.41 A (D) 2 A

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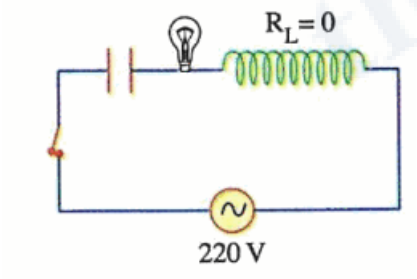
126 In the opposite circuit, $X_C = 2\,X_L = 2\,R$ and the total voltage lags behind the source current by 45°. Which switches are closed so that the phase angle between the total voltage and the source current becomes zero?



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

127 The opposite figure shows a circuit containing an AC source of emf 220 V, a capacitor of capacitive reactance 800 Ω, a coil of inductive reactance 800 Ω, an electric lamp of resistance 600 Ω and a switch, all connected in series. The current:

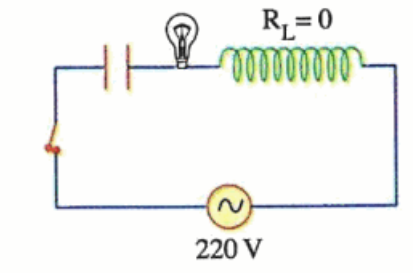
(1) in the circuit equals .....



(A) *1/10* A (B) *4/10* A (C) *11/40* A (D) *11/30* A

128 The opposite figure shows a circuit containing an AC source of emf 220 V, a capacitor of capacitive reactance 800 Ω, a coil of inductive reactance 800 Ω, an electric lamp of resistance 600 Ω and a switch, all connected in series. The current:

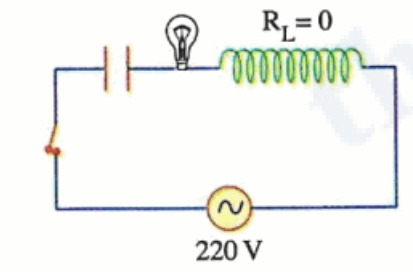
(2) when only the capacitor is removed from the circuit equals .....



(A) 0.16 A (B) 0.22 A (C) 0.36 A (D) 0.4 A

129 The opposite figure shows a circuit containing an AC source of emf 220 V, a capacitor of capacitive reactance 800 Ω, a coil of inductive reactance 800 Ω, an electric lamp of resistance 600 Ω and a switch, all connected in series. The current:

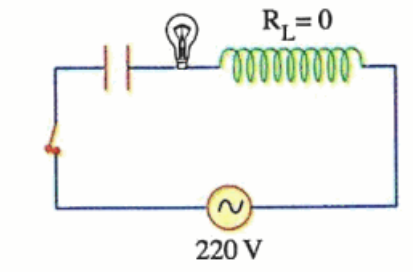
(3) when only the coil is removed from the circuit equals .....



(A) 0.4 A (B) 0.36 A (C) 0.22 A (D) 0.16 A

130 The opposite figure shows a circuit containing an AC source of emf 220 V, a capacitor of capacitive reactance 800 Ω, a coil of inductive reactance 800 Ω, an electric lamp of resistance 600 Ω and a switch, all connected in series. The current:

(4) when both the capacitor and the coil are removed from the circuit equals .....



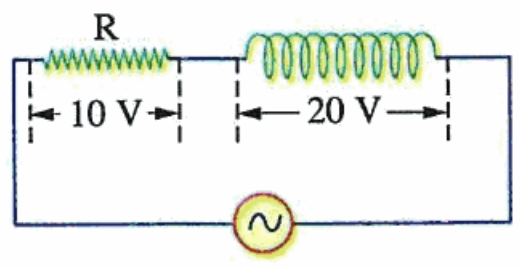
(A) *11/30* A (B) *11/40* A (C) *4/10* A (D) *3/10* A

Essay questions — 22 questions

1 An ohmic resistor R is connected in series with an inductor of self-inductance L and ohmic resistance R and an AC source. The potential differences across the coil and across the ohmic resistor are as shown in the opposite figure. Find:

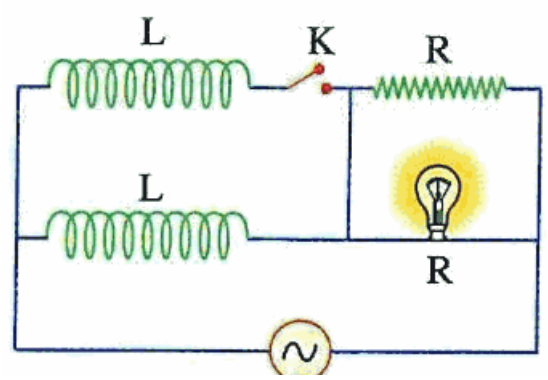
(1) the ratio of the inductive reactance of the coil to its ohmic resistance.

(2) the potential difference between the source terminals.



2 Two identical resistance wires (x, y): wire x is wound double (non-inductively) as a solenoid, and wire y is wound singly as an inductor. The two coils are connected in series to an AC source. Explain why the potential difference across each coil is different from the other.

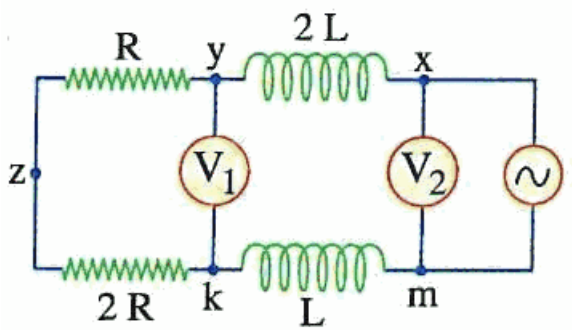
3 In the opposite circuit, the two coils are identical and have negligible ohmic resistance. What happens, with explanation, to the brightness of the lamp and to the phase angle between the total voltage and the current in the circuit when switch K is closed?



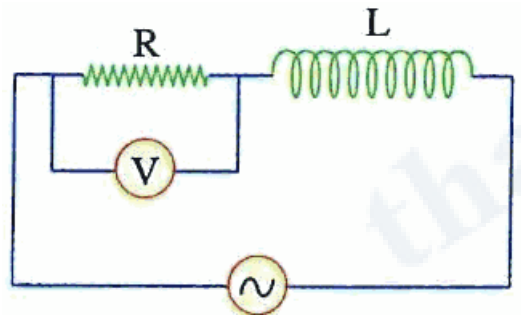
4 In the AC circuit shown in the opposite figure, the readings of the two voltmeters V_1 and V_2 are 30 V and 50 V respectively. If the two coils have negligible ohmic resistance, find:

(1) the potential difference between points x and y

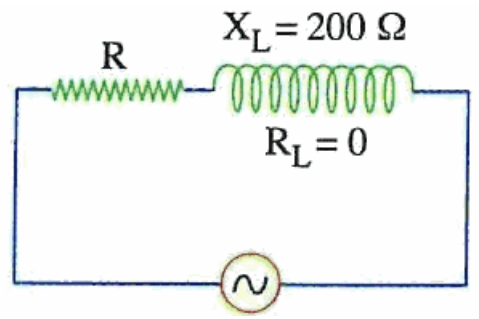
(2) the potential difference between points z and m



5 In the opposite circuit, what happens to the voltmeter reading if the turns of the coil are moved apart from each other uniformly?



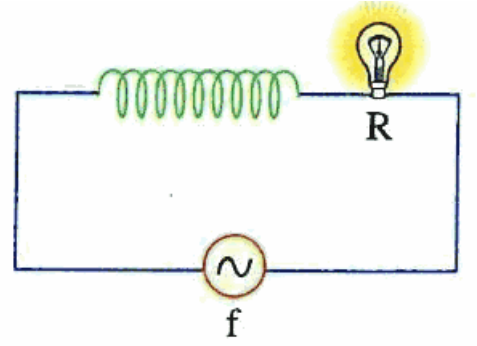
6 In the circuit shown, what happens to the current in the circuit when an ohmic resistor of 200 Ω is put in place of the inductor?



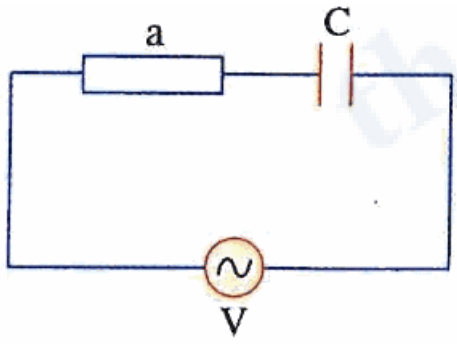
7 In the circuit shown in the figure, a lamp of resistance R and an inductor of inductive reactance $X_L = R$ and negligible ohmic resistance are connected to an AC source. Show what happens to the brightness of the lamp when:

(1) the source frequency is doubled while its emf stays constant.

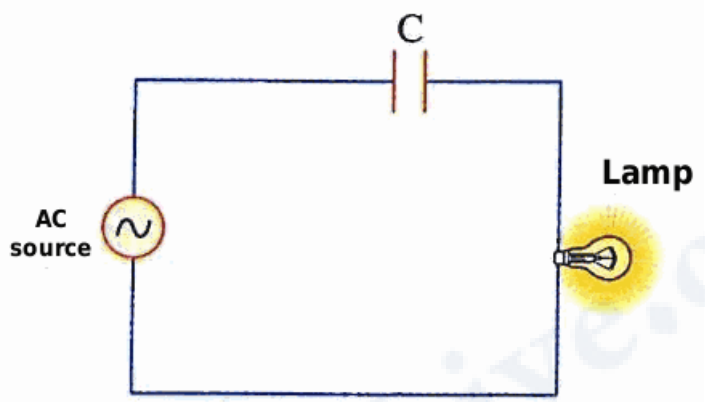
(2) both the source frequency and its emf are doubled.



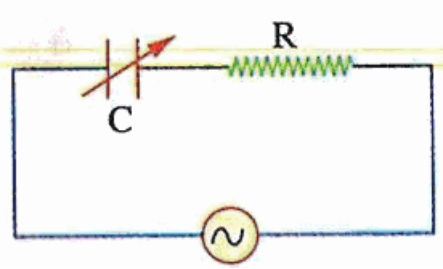
8 In the circuit shown in the figure, the capacitive reactance of capacitor C equals the ohmic resistance of wire a. If the wire is stretched uniformly until its length doubles, calculate the change in the phase angle between the total voltage and the current in the circuit.



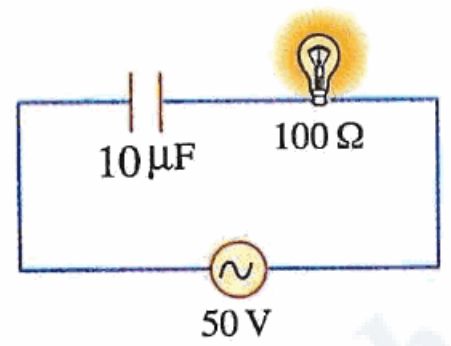
9 The opposite figure shows an AC circuit consisting of a capacitor, a glowing lamp and an AC source whose effective voltage is constant and whose frequency can be changed. Explain why the lamp filament glows less when the source frequency decreases.



10 In the circuit shown in the figure, the phase angle between the current and the total voltage is -30°. Show how the capacitance can be changed so that the phase angle becomes -60°



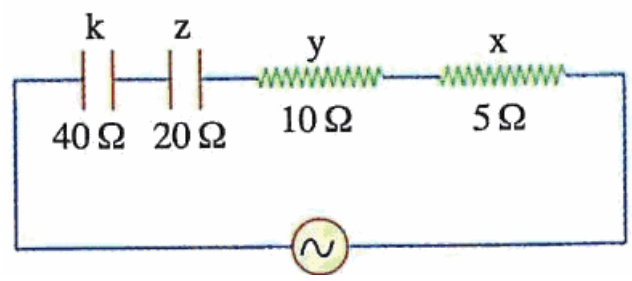
11 In the opposite circuit, if the maximum charge collected on the capacitor plates is $300\sqrt{(2)}\ \mu C$, calculate the power consumed in the lamp.



12 In the opposite circuit, how can you, by removing only one component from the circuit:

(1) increase the phase angle between the total voltage and the current to the largest possible value?

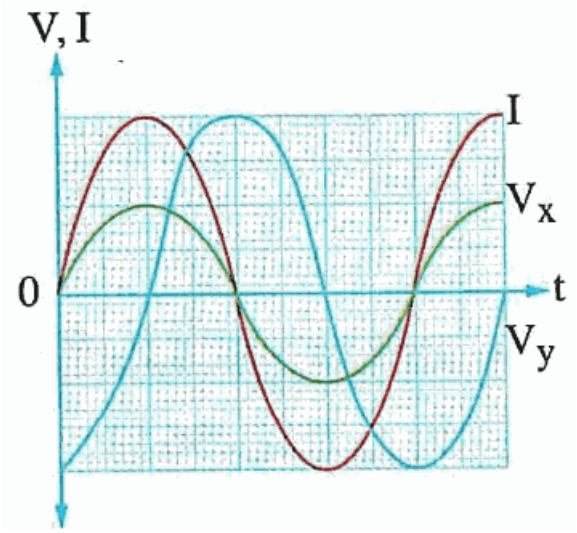
(2) increase the current to the largest possible value?



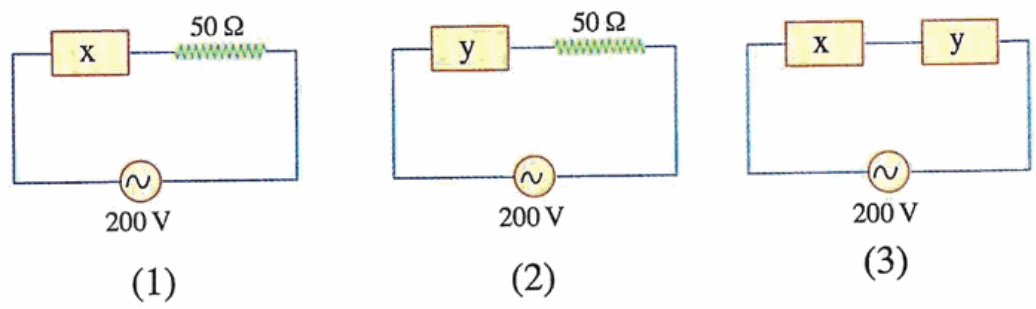
13 An AC source of negligible internal resistance and two pure elements x and y are connected together in series. The opposite graph shows how the current and the potential difference across each element change with time:

(1) Identify the types of the two elements x and y

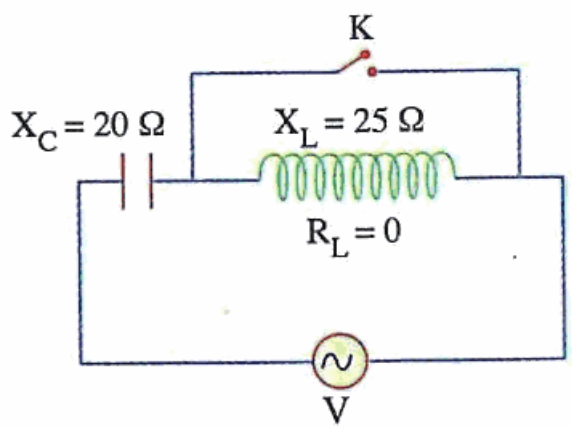
(2) Find the phase angle between the total voltage and the current in the circuit.



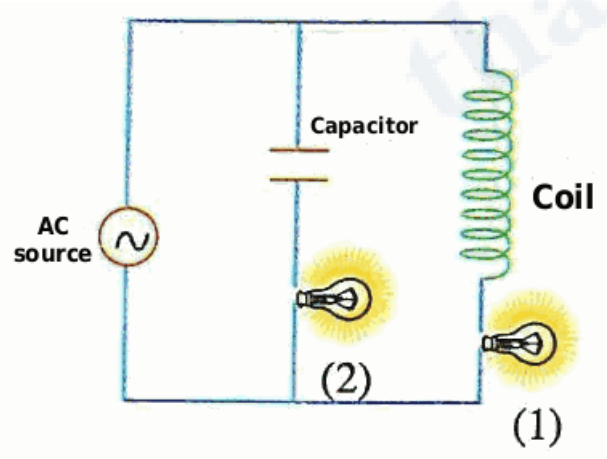
14 An AC circuit consists of an ohmic resistor of 50 Ω, a pure element (x) and an AC source of voltage 200 V as in figure (1), and the phase angle between the total voltage and the current is (-45°). When element (x) is replaced by another pure element (y) as in figure (2), the phase angle becomes (30°). If elements (x) and (y) are connected together in series with the source as in figure (3), what is the current in the circuit in figure (3)?



15 In the circuit shown in the opposite figure, what happens to the current in the circuit when switch K is closed?



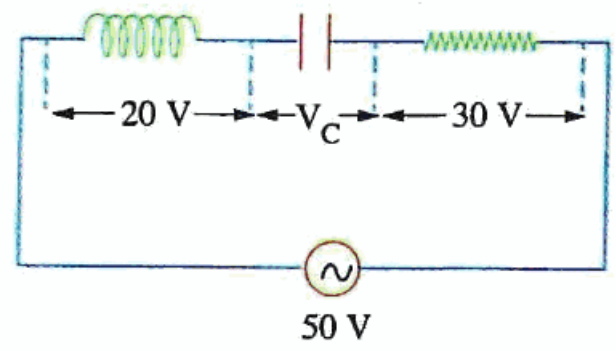
16 An AC source with a constant effective voltage and a variable frequency is connected to two identical lamps, an inductor of negligible ohmic resistance and a capacitor as in the opposite figure. Given that the inductive reactance of the coil equals the capacitive reactance of the capacitor, explain why, when the source frequency is increased, lamp (2) becomes brighter than lamp (1).



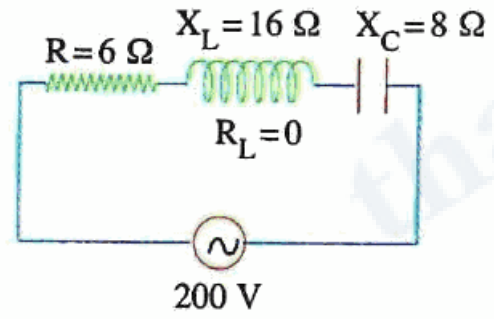
17 The opposite circuit is an RLC circuit connected to an AC source:

(1) Calculate the potential difference across the capacitor plates (V_C).

(2) Explain why the potential difference across the capacitor plates (V_C) can be greater than the source voltage (V).



18 The opposite figure shows an RLC AC circuit. Calculate the electric power consumed in the circuit.



19 A circuit consists of a capacitor of capacitive reactance 30 Ω, an ohmic resistor of 44 Ω and a coil of inductive reactance 90 Ω and ohmic resistance 36 Ω, connected in series with an AC source of frequency 60 Hz and voltage 200 V. Calculate:

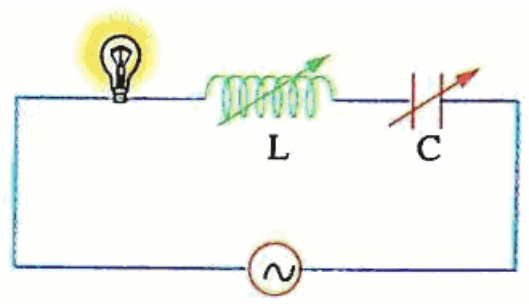
(1) the current in the circuit.

(2) the potential difference across the coil.

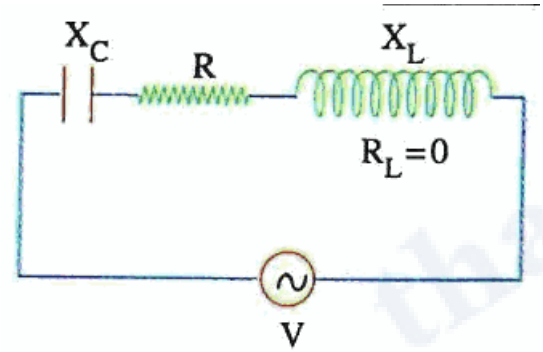
20 In the circuit shown, if $X_L = 2X_C$, what happens to the brightness of the lamp when:

(1) L is doubled?

(2) C is doubled?



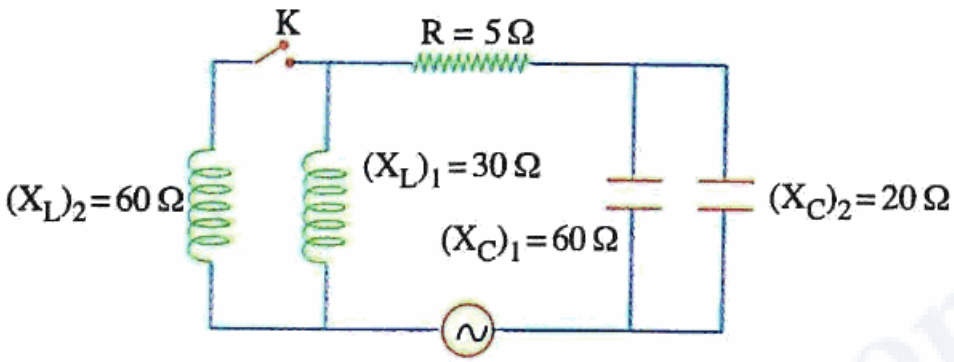
21 In the circuit shown in the figure, $(X_C < X_L)$. Explain why the phase angle between the total voltage (V) and the current (I) in the circuit increases after the capacitor is removed.



22 In the circuit shown in the figure, if the two coils have negligible ohmic resistance, what is the phase angle between the total voltage and the current in the circuit when switch K is:

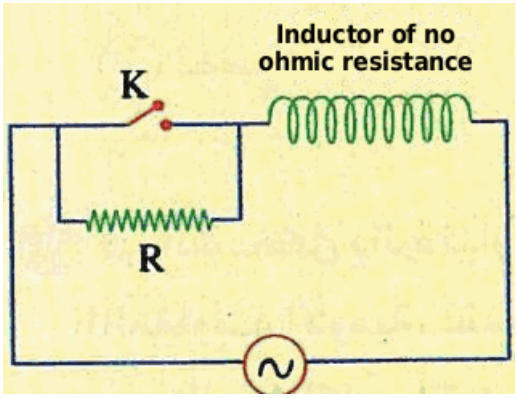
(1) open?

(2) closed?



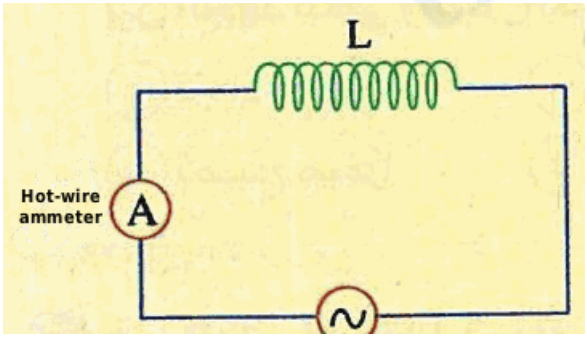
Past exam questions — 24 questions

1 In the opposite AC circuit, when switch K is closed, the phase angle between the total voltage and the current ..... (Trial exam / May 2021)



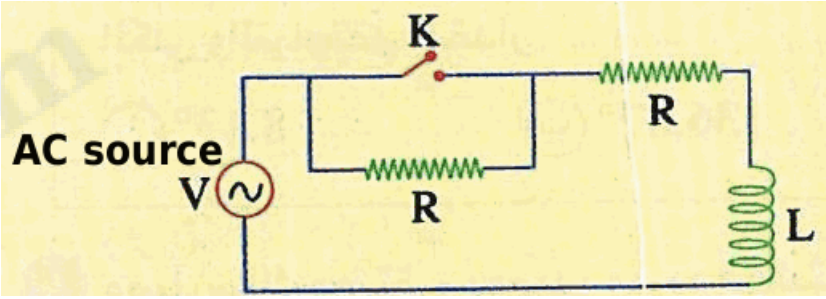
(A) does not change (B) increases (C) decreases (D) becomes zero

2 The opposite figure shows an AC circuit consisting of an AC source of maximum voltage 250 V, an inductor of negligible ohmic resistance and a hot-wire ammeter of ohmic resistance 12 Ω, connected in series. If the ammeter reads 10 A, the inductive reactance of the coil equals ..... (Trial exam / May 2021)



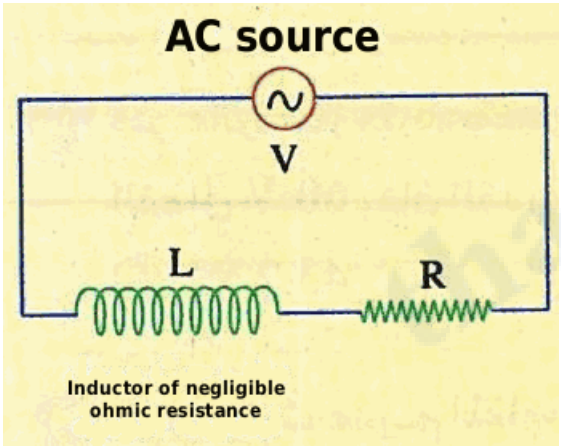
(A) 17.67 Ω (B) 12.98 Ω (C) 21.93 Ω (D) 5.68 Ω

3 In the circuit shown, when switch (K) is closed, the phase angle between the total voltage (V) and the current (I) ..... (Trial exam / June 2021)



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

4 In the circuit shown, when the source is replaced by another of lower frequency with (V) constant, ... (1st session 2021)



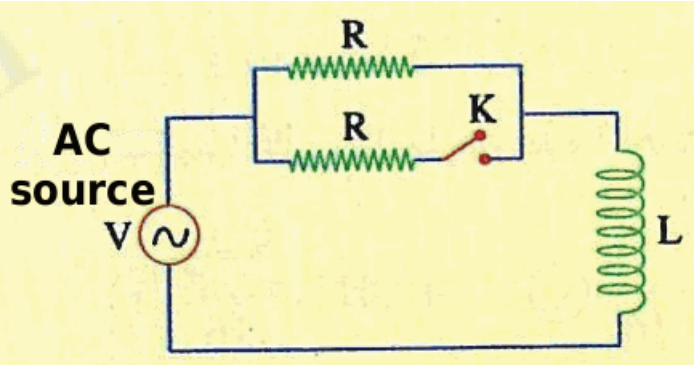
(A) inductive reactance of the coil: decreases, phase angle between the total voltage and the current: increases

(B) inductive reactance of the coil: increases, phase angle between the total voltage and the current: decreases

(C) inductive reactance of the coil: decreases, phase angle between the total voltage and the current: decreases

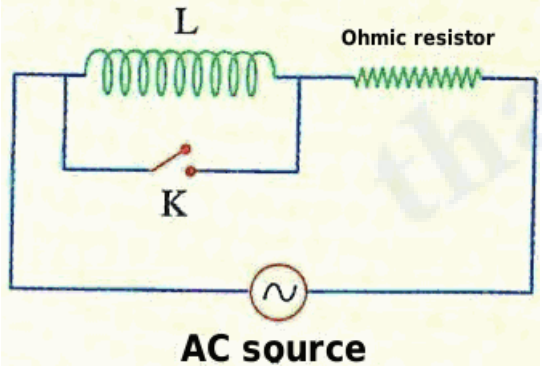
(D) inductive reactance of the coil: increases, phase angle between the total voltage and the current: increases

5 In the circuit shown, when switch (K) is closed, the phase angle between the total voltage (V) and the current (I) ..... (2nd session 2021, Sample exam 2025)



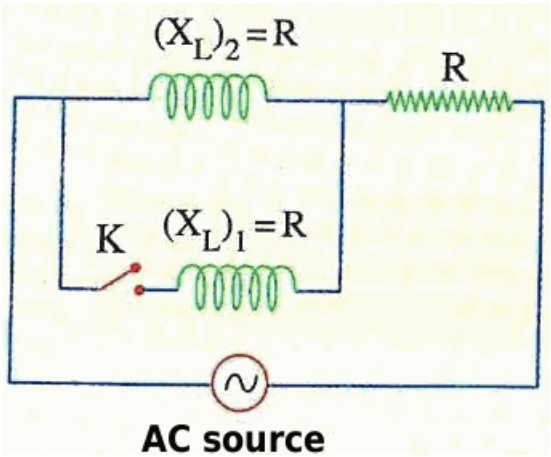
(A) decreases (B) stays constant (C) increases (D) becomes zero

6 The figure shows a circuit with an ohmic resistor and an inductor (L) of negligible ohmic resistance, and the phase angle between the total voltage and the current is (θ). When switch (K) is closed, the phase angle between the voltage and the current ..... (1st session 2022)



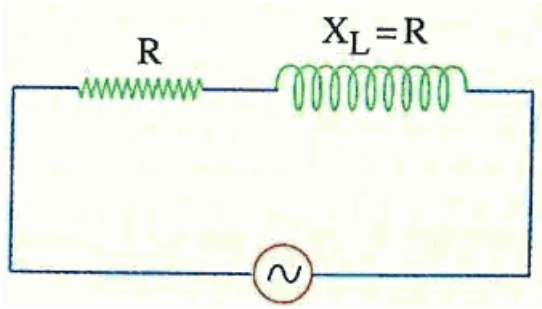
(A) becomes zero
(B) does not change
(C) increases
(D) decreases but does not reach zero

7 The figure shows an AC circuit with an ohmic resistor and two inductors of negligible ohmic resistance. When switch (K) was open, the phase angle between the total voltage and the current was (θ). If switch (K) is closed, the phase angle between the total voltage and the current ..... (2nd session 2022)



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

8 In the opposite circuit, an inductor (of negligible ohmic resistance) has its turns spread uniformly. When *1/4* of the length of the coil is cut off and the rest is connected in the circuit without changing the other factors, the phase angle between the total voltage and the current decreases by ..... (1st session 2023)



(A) *8.13°*
(B) *36.87°*
(C) *30.96°*
(D) *14.04°*

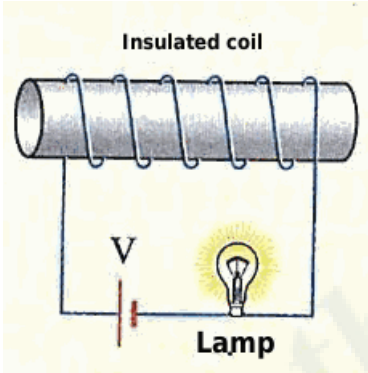
9 A straight wire is connected to an AC source and the effective current in it is I. Then the wire is wound as an inductor and connected to the same source. The effective current in it ..... (Sample exam 2025)

(A) decreases
(B) stays constant
(C) increases
(D) the answer cannot be determined

10 In an AC circuit, an inductor of inductive reactance 40 Ω and ohmic resistance 30 Ω is connected to an AC source of effective voltage 60 V. The electric power consumed in the circuit equals ..... (Sample exam 2025)

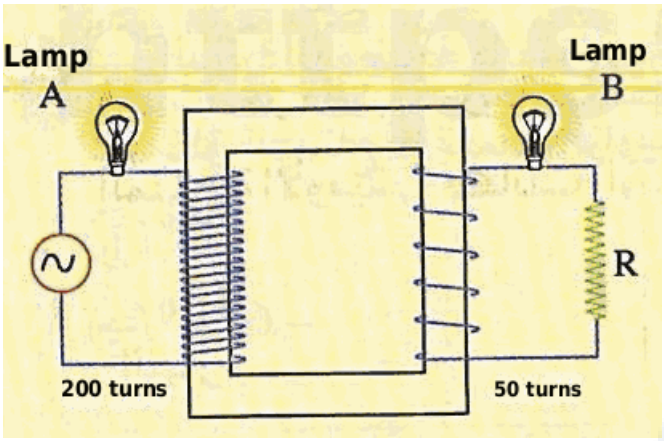
(A) 43.2 W (B) 51.4 W (C) 72 W (D) 120 W

11 An inductor of no ohmic resistance is connected in series with an electric lamp of ohmic resistance R and a battery of emf V and negligible internal resistance. The current in the circuit is I and the power consumed in the lamp is P_w. When an AC source of effective voltage V is connected instead of the battery, the current in the circuit is 0.75 I. The power consumed in the lamp and the phase angle between the total voltage and the current in this case are, respectively, ... (Sample exam 2025)



(A) $9P_w/16$, 41.41° (B) $9P_w/16$, 36.89° (C) $3P_w/4$, 48.6° (D) $3P_w/4$, 41.41°

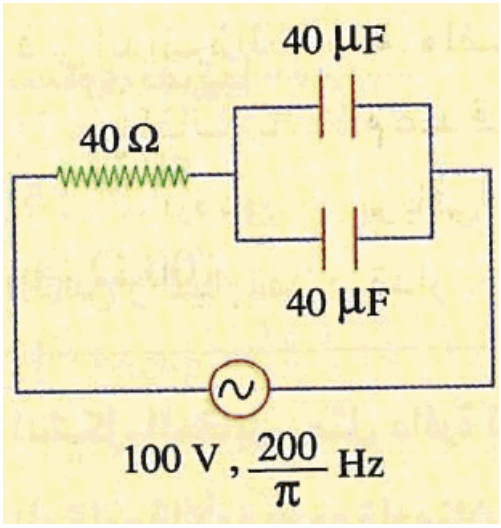
12 The figure shows an ideal transformer. When the AC source is replaced by a battery whose emf equals the effective voltage of the AC source, the brightness of lamps A and B, respectively, ... (Sample exam 2025)



(A) A: increases, B: becomes zero (B) A: does not change, B: increases

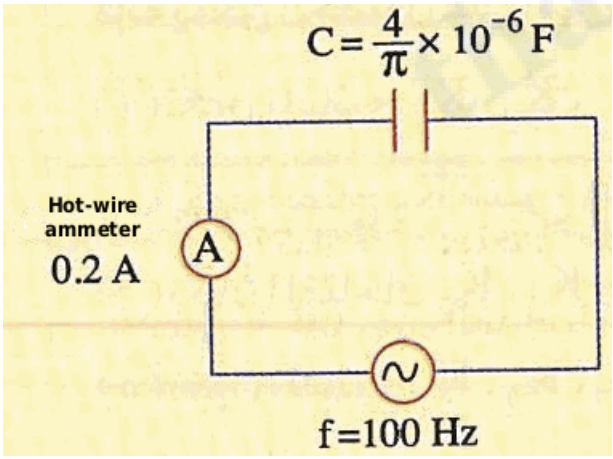
(C) A: becomes zero, B: becomes zero (D) A: does not change, B: becomes zero

13 In the circuit shown, the phase angle between the total potential difference V_t and the current I = ... (1st session 2022)



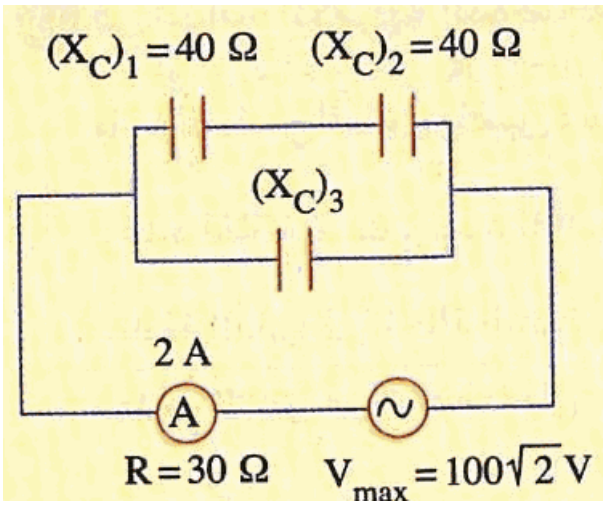
(A) 38° (B) 35° (C) -38° (D) -35°

14 A circuit contains a hot-wire ammeter of resistance 50 Ω, a capacitor and an AC source as in the figure. The maximum emf of the source equals ..... (2nd session 2021)



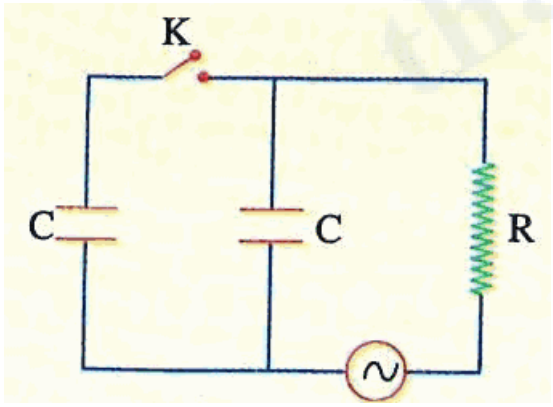
(A) 250.19 V (B) 353.84 V (C) 194.17 V (D) 318.62 V

15 An AC source producing a maximum emf of $100\sqrt{(2)}$ V is connected to three capacitors and a hot-wire ammeter as in the figure. Using the data shown, the capacitive reactance $(X_C)_3$ equals ..... (2nd session 2022)



(A) 80 Ω (B) 20 Ω (C) 40 Ω (D) 50 Ω

16 In the circuit shown, the phase angle between the total voltage and the current was (-45°). When switch K is closed, the angle becomes ..... (Sample exam 2025)

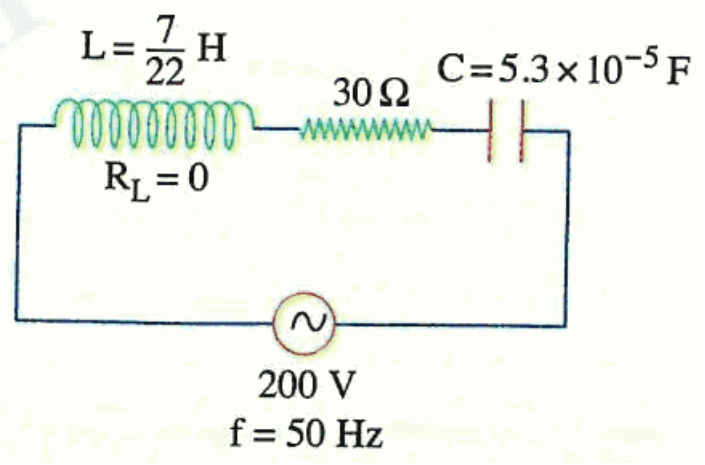


(A) 0° (B) -26.6° (C) -63.4° (D) -90°

17 An AC source of frequency $100/(\pi)$ Hz and effective voltage 20 V is connected in series with an ohmic resistor of 3 Ω and a capacitor of capacitance 1250 μF. The charge collected on one plate of the capacitor when it is fully charged is ..... (Sample exam 2025)

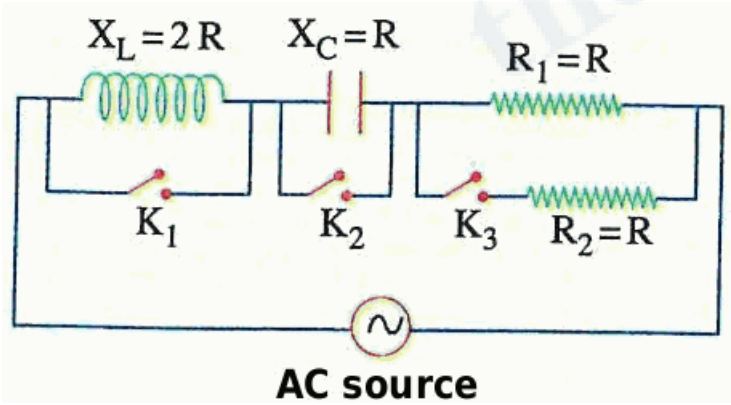
(A) 0.020 C (B) 0.025 C (C) 0.028 C (D) 0.035 C

18 The opposite figure shows an RLC circuit connected to an AC source of emf 200 V and frequency 50 Hz. The total impedance of the circuit is approximately ..... (Trial exam / May 2021)



(A) 40 Ω (B) 50 Ω (C) 100 Ω (D) 30 Ω

19 The opposite figure shows an AC circuit with a capacitor, an inductor of negligible ohmic resistance, two resistors R_1 and R_2 and three switches K_1, K_2 and K_3. The largest electric power consumed is obtained when ..... (1st session 2024)



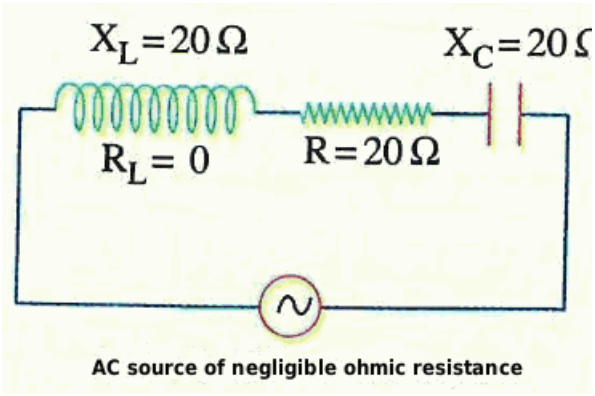
(A) switches K_1, K_2 and K_3 are open

(B) switch K_2 is open and switches K_1 and K_3 are closed

(C) switches K_2 and K_3 are closed and switch K_1 is open

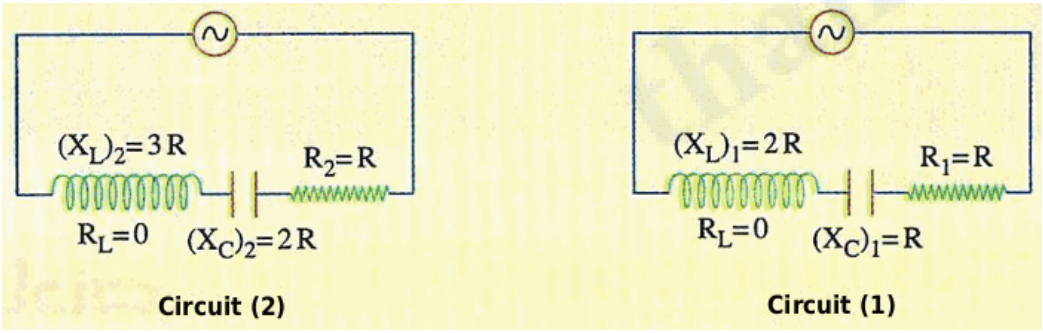
(D) switches K_1, K_2 and K_3 are closed

20 In the circuit shown in the figure, if the coil is replaced by another one of the same length, the same cross-sectional area and the same wire material, but with twice the number of turns of the original coil, the ratio of (the circuit impedance in the second case) to (the circuit impedance in the first case) = ... (1st session 2024)



(A) $\sqrt{(10)}$ (B) $20\sqrt{(10)}$ (C) $1/(\sqrt{(10)})$ (D) $1/(20\sqrt{(2)})$

21 From the data shown on the two circuits (1) and (2), the ratio (Z_1/Z_2) = ... (2nd session 2024)

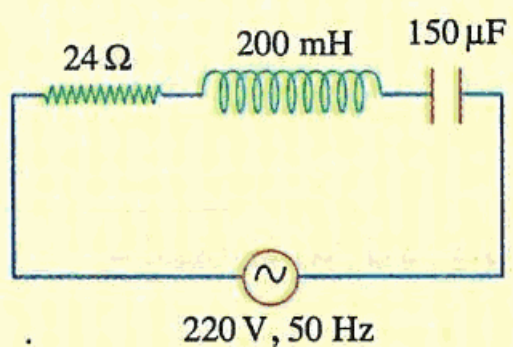


(A) $1/2$ (B) $1/1$ (C) $(\sqrt{(2)})/1$ (D) $2/3$

22 In a series (RLC) AC circuit, the phase angle between the potential difference across the coil (V_L) and the potential difference across the capacitor (V_C) is ..... (Sample exam 2025)

(A) 180° (B) 90° (C) -90° (D) 0°

23 In the circuit shown in the figure, an AC source of 220 V, 50 Hz is connected in series with a capacitor, an ohmic resistor and an inductor of negligible ohmic resistance. What are the total impedance of the circuit and the phase angle between the total voltage and the current? (Given: $\pi = 3.14$) (2nd session 2025)



(A) impedance: 24 Ω, phase angle: 0°

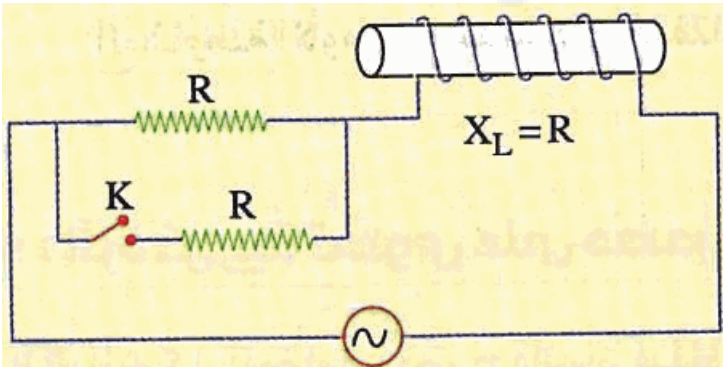
(B) impedance: 21.22 Ω, phase angle: 74.21°

(C) impedance: 48 Ω, phase angle: 60°

(D) impedance: 48 Ω, phase angle: 30.2°

---

24 The figure shows an electric circuit. Explain what happens to the phase angle between the total voltage and the current after switch (K) is closed. (Trial exam 2023)



Answer key and solutions

Multiple choice questions

1 B	2 A	3 B	4 B	5 D	6 C	7 A	8 D	9 C	10 A
11 D	12 C	13 C	14 B	15 C	16 A	17 A	18 A	19 B	20 B
21 C	22 B	23 C	24 C	25 C	26 B	27 A	28 B	29 D	30 B
31 C	32 B	33 A	34 C	35 B	36 A	37 B	38 D	39 B	40 C
41 D	42 C	43 D	44 C	45 D	46 A	47 B	48 A	49 D	50 B
51 C	52 A	53 D	54 A	55 B	56 A	57 D	58 A	59 D	60 C
61 C	62 A	63 B	64 C	65 C	66 A	67 B	68 C	69 C	70 C
71 D	72 C	73 C	74 C	75 C	76 B	77 C	78 A	79 C	80 B
81 D	82 D	83 A	84 D	85 D	86 D	87 B	88 C	89 C	90 B
91 A	92 D	93 D	94 D	95 B	96 C	97 D	98 C	99 D	100 C
101 A	102 D	103 A	104 B	105 B	106 B	107 A	108 B	109 B	110 C
111 B	112 A	113 D	114 C	115 B	116 A	117 D	118 C	119 B	120 B
121 B	122 B	123 D	124 C	125 A	126 C	127 D	128 B	129 C	130 A

1 **Answer (B)**

$I = V/Z$ and the voltage is constant, so the current increases when the impedance $Z = \sqrt{(R^2 + {X_L}^2)}$ decreases

Decreasing the frequency decreases $X_L = 2\pi fL$, so Z decreases and the current increases

Increasing the frequency, increasing R or adding an iron core all increase Z

2 **Answer (A)**

Putting in the iron rod increases the self-inductance L, so X_L increases and Z increases

So the current decreases and the voltmeter reading $V = IR$ decreases

3 **Answer (B)**

$Z = \sqrt{(R^2 + (2\pi fL)^2)}$ at $f = 0$ gives $Z = R$, not zero

Then it increases with f at an increasing rate, which is graph (B)

4 **Answer (B)**

In the first case the source is AC: $I_1 = V/Z$

In the second case the source is DC: $I_2 = V/R$ because the coil has no reactance

$I_1/I_2 = R/Z < 1$ because $Z > R$

5 **Answer (D)**

$Z = \sqrt{(R^2 + X_L{}^2)} = \sqrt{(6^2 + 8^2)} = 10\ \Omega$

6 **Answer (C)**

$Z = \sqrt{(R^2 + X_L{}^2)} = \sqrt{(12^2 + 18^2)} = 21.6\ \Omega$

7 **Answer (A)**

Doubling the frequency doubles the reactance: $X_L' = 2 \times 18 = 36\ \Omega$

$Z = \sqrt{(12^2 + 36^2)} = 37.95\ \Omega$

8 **Answer (D)**

$X_L = 2R$, so $\tan\varphi = X_L/R = 2$

$\varphi = \tan^{-1}2 = 63.4°$

9 **Answer (C)**

$X_L = R \Rightarrow Z_1 = \sqrt{(R^2 + R^2)} = \sqrt{(2)}\ R$

When the frequency doubles, $X_L' = 2R$, so $Z_2 = \sqrt{(R^2 + (2R)^2)} = \sqrt{(5)}\ R$

$Z_2/Z_1 = \sqrt{(5/2)} = 1.6$

10 **Answer (A)**

$\tan\varphi = X_L/R = (\sqrt{(3)}\ R)/R = \sqrt{(3)}$

$\varphi = 60° = (\pi)/3$

11 **Answer (D)**

Before closing K: the circuit is R with X_L in series, so $\tan\varphi = R/R = 1 \Rightarrow \varphi = 45^\circ$

After closing K: the two resistors are in parallel, $R/2$, so $\tan\varphi = R/(R/2) = 2 \Rightarrow \varphi = 63.4^\circ$

So the angle increases by $63.4 - 45 = 18.4^\circ$

12 **Answer (C)**

$P = I^2R \Rightarrow 5/8 = I^2 \times 10 \Rightarrow I = 0.25\ A$

$Z = V/I = 6.5/0.25 = 26\ \Omega \Rightarrow X_L = \sqrt{(26^2 - 10^2)} = 24\ \Omega$

$\omega = 2\pi f = 2\pi \times 30/(\pi) = 60\ rad/s \Rightarrow L = 24/60 = 0.4\ H$

13 **Answer (C)**

$Z = \sqrt{(R^2 + X_L{}^2)} = \sqrt{(2^2 + 1^2)} = \sqrt{(5)}\ \Omega$

$I = V/Z = 6/(\sqrt{(5)})\ A$

$P = I^2R = 36/5 \times 2 = 14.4\ W$

14 **Answer (B)**

Lamp resistance with a coil of negligible resistance: $Z = V/I = 220/4 = 55\ \Omega$

$X_L = \sqrt{(Z^2 - R^2)} = \sqrt{(55^2 - 44^2)} = 33\ \Omega$

$L = X_L/(2\pi f) = 33/(2\pi \times 42) = 0.125\ H$

15 **Answer (C)**

$V_L = V_R$ and the current is the same, so $X_L = R = 8\ \Omega$

$2\pi f \times 1/(50\pi) = 8 \Rightarrow f/25 = 8$

$f = 200\ Hz$

16 **Answer (A)**

$X_L = 2\pi fL = 2\pi \times 50 \times 0.01 = 3.14\ \Omega$

$\tan\varphi = X_L/R = 3.14 \Rightarrow \varphi = 72.3^\circ$

The current lags behind the voltage: $\Delta t = frac\varphi 360^\circ \times T = 72.3/360 \times 0.02 = 0.004\ s$

17 **Answer (A)**

$f = 50\ Hz \Rightarrow T = 20\ ms$ and the lead $2.5\ ms = 1/8T$, so $\varphi = 45^\circ$

$\tan\varphi = X_L/R = 1$ and doubling the frequency doubles X_L, so $\tan\varphi' = 2 \Rightarrow \varphi' = 63.4^\circ$

The voltage leads the current in an RL circuit, and the new period is $T' = 10\ ms$

$\Delta t = 63.4/360 \times 10 \times 10^{-3} = 1.76 \times 10^{-3}\ s$

18 **Answer (A)**

V_2 is the coil voltage and V_1 is the resistor voltage $V_R = 10\ V$

The coil voltage is perpendicular to the resistor voltage: $V^2 = V_R^2 + V_L^2$

$V_L = \sqrt{(20^2 - 10^2)} = 10\sqrt{(3)}\ V$

19 **Answer (B)**

At first $V_1 = V_2$, so $X_L = R$

After doubling the rotation speed, the reactance X_L doubles and the emf doubles, while R does not change

The current is the same in the circuit: $V_1 = IX_L = 2IR$ and $V_2 = IR$

So $V_1 > V_2$

20 **Answer (B)**

$X_L = 2\pi fL = 2\pi \times 50 \times 7/440 = 5\ \Omega$ (taking $\pi = 22/7$)

$Z = \sqrt{(R^2 + X_L^2)} = \sqrt{(12^2 + 5^2)} = 13\ \Omega$

21 **Answer (C)**

$X_L = 2\pi fL \Rightarrow 50 = 2 \times 22/7 \times f \times 7/44$

$50 = f$, so $f = 50\ Hz$

22 **Answer (B)**

$Z = \sqrt{(R^2 + X_L^2)} = \sqrt{(30^2 + 50^2)} = 58.31\ \Omega$

23 **Answer (C)**

$Z = \sqrt{(R^2 + X_L^2)} = \sqrt{(30^2 + 40^2)} = 50\ \Omega$

24 **Answer (C)**

$Z = 50\ \Omega$ from the previous part

$I = V/Z = 5/50 = 0.1\ A$

25 **Answer (C)**

$\tan\varphi = X_L/R = 40/30 = 4/3$

$\varphi = 53.13^\circ$

26 **Answer (B)**

The brightness depends on $P = I^2R$, so we need the largest current in the lamp

(B): a DC source, so the coil acts only as a resistance R: $I = 2V/(R + R) = V/R$

(A): $I = V/2R$, (C): $I = V/Z < V/2R$ because $Z > 2R$, (D): $I = (V/2)/Z < V/4R$

So the largest current is in circuit (B)

27 **Answer (A)**

$X_L = 2\pi fL = 2\pi \times 50 \times 7/35 = 62.8\ \Omega$

$Z = \sqrt{(30^2 + 62.8^2)} = 69.6\ \Omega$

$I = V/Z = 100/69.6 = 1.44\ A$

28 **Answer (B)**

$\tan\varphi = X_L/R = 62.8/30 = 2.09$

$\varphi = 64.49^\circ$

29 **Answer (D)**

$V_R = IR = 1.44 \times 30 = 43.2\ V$

$V_L = IX_L = 1.44 \times 62.8 = 90.52\ V$

30 **Answer (B)**

$I = V_R/R = 45/15 = 3\ A$

The coil voltage is perpendicular to the resistor voltage: $V_L = \sqrt{(60^2 - 45^2)} = 39.69\ V$

$X_L = V_L/I = 39.69/3 = 13.23\ \Omega$

31 **Answer (C)**

$V^2 = V_R^2 + V_L^2$, so the coil voltage is $V_L = \sqrt{(60^2 - 45^2)} = 39.69\ V$

32 **Answer (B)**

$R = X$, so $\tan\varphi = X/R = 1$

$\varphi = 45^\circ$

33 **Answer (A)**

Before closing: the total resistance is $R + R + R = 3R$ and the reactance $2X_L$, so $\tan\varphi = 2X_L/3R$

When K is closed, the second branch is shorted, so the resistance becomes R and the reactance X_L: $\tan\varphi' = X_L/R$, which is larger

The impedance decreases, so the current increases, and the phase angle increases

34 **Answer (C)**

The coil has a resistance R, so the voltage across it leads the current by an angle θ less than 90° and greater than zero

This is figure (C), where the voltage vector is above the current vector

35 **Answer (B)**

The phase angle depends on the ratio X_L/R of the coil, which is the same for the two identical coils

Before opening: $\tan\varphi = X_L/R = \tan 45^\circ = 1$

After opening K the two coils are in series: $\tan\varphi = 2X_L/2R = 1$, so the angle stays 45°

36 **Answer (A)**

The hot-wire ammeter has a resistance R_A, the coil has no resistance, and the current is the same

$V_A/V_L = IR_A/IX_L = R_A/X_L = 5/12$

37 **Answer (B)**

The ammeter voltage is perpendicular to the coil voltage: $V_A : V_L = 5 : 12$ and the resultant is $\sqrt{(5^2 + 12^2)} = 13$

Each unit $= 260/13 = 20\ V$

$Z = V/I = 260/2 = 130\ \Omega$

38 **Answer (D)**

$V_A = 5 \times 20 = 100\ V$

$R_A = V_A/I = 100/2 = 50\ \Omega$

39 **Answer (B)**

$V_L = 12 \times 20 = 240\ V$

$X_L = V_L/I = 240/2 = 120\ \Omega$

40 **Answer (C)**

In the first case the two coils are in series: $Z = V/I = 100/1 = 100\ \Omega$, so $X_1 + X_2 = 100$

$V_{ab} = IX_1 = 80\ V \Rightarrow X_1 = 80\ \Omega$

After opening K_1 and closing K_2: the first coil is with R and $V_{ab} = 80\ V$, so the current is also $I = 1\ A$

$Z = 100\ \Omega \Rightarrow R = \sqrt{(100^2 - 80^2)} = 60\ \Omega$

41 **Answer (D)**

With direct current there is no reactance: $R = V/I = 11/2.2 = 5\ \Omega$

With AC: $Z = 13/1 = 13\ \Omega \Rightarrow X_L = \sqrt{(13^2 - 5^2)} = 12\ \Omega$

$L = X_L/(2\pi f) = 12/(2\pi \times 50) = 0.038\ H$

42 **Answer (C)**

$X_L = 2\pi fL = 2 \times 22/7 \times 50 \times 7/275 = 8\ \Omega$

$Z = \sqrt{(6^2 + 8^2)} = 10\ \Omega$

$I = V/Z = 6/10 = 0.6\ A$

43 **Answer (D)**

Direct current is not affected by the inductive reactance, only by the ohmic resistance

$I = V/R = 6/6 = 1\ A$

44 **Answer (C)**

In circuit (1) the source is DC: $P = (V^2)/R \Rightarrow R = (100^2)/100 = 100\ \Omega$

In circuit (2): $X_L = 2\pi fL = 2\pi \times 60 \times 0.1 = 37.7\ \Omega$

$Z^2 = 100^2 + 37.7^2 = 11421 \Rightarrow I^2 = (100^2)/11421 = 0.8756$

$P = I^2R = 0.8756 \times 100 = 87.5\ W$

45 **Answer (D)**

$\omega = 2\pi f = 2\pi \times 500/(\pi) = 1000\ rad/s \Rightarrow X_L = \omega L = 2000\ \Omega$

The phase angle is 45°, so the total resistance equals the reactance: $R_t = 2000\ \Omega$

Coil resistance $= 2000 - 1950 = 50\ \Omega$

46 **Answer (A)**

Before opening K the lamp is shorted, so the circuit is the coil only: $Z = 200/2 = 100\ \Omega$

Coil resistance $r = \sqrt{(100^2 - 60^2)} = 80\ \Omega$

After opening K: $R_t = 80 + 100 = 180\ \Omega$ and $Z = \sqrt{(180^2 + 60^2)} = 189.7\ \Omega$

$I = 200/189.7 = 1.054\ A \Rightarrow P = I^2R = 1.054^2 \times 100 = 111\ W$

47 **Answer (B)**

$Z^2 = R^2 + \omega^2L^2$, so the relation is a straight line: the intercept is R^2 and the slope is ω^2

Intercept $= 10 \times 10^3 = 10^4 \Rightarrow R = 10^2\ \Omega$

Slope $= ((20 - 10) \times 10^3)/0.3 = 3.33 \times 10^4 = \omega^2 \Rightarrow \omega = 182.6\ rad/s$

48 **Answer (A)**

The current I starts from zero together with the voltage V_x, so they are in phase: x is an ohmic resistor

The voltage V_y is at its peak at $t = 0$, so it leads the current by 90°: y is an inductor

49 **Answer (D)**

From the graph: the maximum resistor voltage is $V_x = 6\ V$ and the maximum coil voltage is $V_y = 8\ V$

$tan\varphi = V_L/V_R = 8/6 \Rightarrow \varphi = 53.13^\circ$

50 **Answer (B)**

$V_{max} = \sqrt{(V_R^2 + V_L^2)} = \sqrt{(6^2 + 8^2)} = 10\ V$

The effective emf of the source $= 10/(\sqrt{(2)}) = 7.07\ V$

51 **Answer (C)**

The maximum current from the graph is $I_{max} = 4\ A$ and the maximum source voltage is $10\ V$

$Z = (V_{max})/(I_{max}) = 10/4 = 2.5\ \Omega$

52 **Answer (A)**

V_2 is the resistor voltage, which is in phase with the current

But V_1, the capacitor voltage, lags behind the current by 90°

53 **Answer (D)**

$Z = \sqrt{(R^2 + X_C^2)}$ because the resistor voltage and the capacitor voltage are perpendicular

So it is less than the algebraic sum $R + X_C$

54 **Answer (A)**

$I = V/Z$ and $Z = \sqrt{(R^2 + X_C^2)}$, so the current increases when Z decreases

Increasing the capacitance decreases $X_C = 1/(2\pi fC)$, so Z decreases and the current increases

55 **Answer (B)**

At first $V_R = V_C$, so $R = X_C$

When the frequency decreases, $X_C = 1/(2\pi fC)$ increases, so $X_C > R$

The current is the same: $V_C = IX_C > V_R = IR$

56 **Answer (A)**

$\omega = 2\pi f = 2\pi \times 50/(\pi) = 100\ rad/s$

The phase angle is $(\pi)/4$, so the reactance equals the resistance: $X = R = 1000\ \Omega$

$X_C = 1/(\omega C) = 1/(100 \times 10 \times 10^{-6}) = 1000\ \Omega$

So the component is a capacitor of $10\ \mu F$

57 **Answer (D)**

$Z = \sqrt{(R^2 + X_C^2)} = \sqrt{(2)}\ R \Rightarrow I_{max} = (V_{max})/Z = 20/(\sqrt{(2)}\ R) = (10\sqrt{(2)})/R$

$tan\varphi = X_C/R = 1 \Rightarrow \varphi = 45^\circ$ and in a capacitor circuit the current leads the voltage

$I = (10\sqrt{(2)})/Rsin(\omega t + (\pi)/4)$

58 **Answer (A)**

$tan\varphi = X_C/R$ and $X_C \propto 1/C$, so $tan\varphi \propto 1/C$

$C_2/C_1 = (tan\varphi_1)/(tan\varphi_2) = fractan\ 30^\circ tan\ 60^\circ = (1/\sqrt{(3)})/(\sqrt{(3)}) = 1/3$

59 **Answer (D)**

The resistor voltage is perpendicular to the capacitor voltage: $V^2 = V_R^2 + V_C^2$

$V_R = \sqrt{(5^2 - 3^2)} = 4\ V$

60 **Answer (C)**

$V_R = \sqrt{(V^2 - V_C^2)} = \sqrt{(20^2 - 12^2)} = 16\ V$

$R = V_R/I = 16/2 = 8\ \Omega$

61 **Answer (C)**

$V_C = V_R$ and the current is the same, so $X_C = R = 50\ \Omega$

$1/(2\pi f C) = 50 \Rightarrow f = 1/(2\pi \times 50 \times 100/(\pi) \times 10^{-6}) = 100\ Hz$

62 **Answer (A)**

$X_C = 1/(2\pi fC) = 1/(2 \times 22/7 \times 500 \times 7/22 \times 10^{-6}) = 1000\ \Omega$

$Z = \sqrt{(R^2 + X_C^2)} = \sqrt{(1000^2 + 1000^2)} = 1414.2\ \Omega$

63 **Answer (B)**

$tan\varphi = X_C/R = 1000/1000 = 1$

$\varphi = 45^\circ$

64 **Answer (C)**

$Z = \sqrt{(R^2 + X_C^2)} = \sqrt{(R^2 + (3R)^2)} = \sqrt{(10)}\ R$

65 **Answer (C)**

$X_C = R \Rightarrow Z = \sqrt{(2)}\, R$ and when the frequency doubles $X_C' = R/2$

$Z' = \sqrt{(R^2 + (R/2)^2)} = (\sqrt{(5)})/2R = 1.1\, R$

66 **Answer (A)**

The voltage vector lags behind the current vector by 30°, so the current leads the voltage by less than 90°

This happens in a resistor-capacitor circuit; with a coil and a capacitor the angle is 90°

67 **Answer (B)**

The total voltage equals the algebraic sum of the voltages of the coil and the element y, so they are in phase

So y is an inductor of negligible resistance like the first one, and their voltages are in phase (both lead the current)

68 **Answer (C)**

The voltage and current vectors are on the same line, so they are in phase

So the elements a and b are two ohmic resistors

69 **Answer (C)**

The ammeter reading and the voltage are the same in both circuits, so the impedance is the same:

$R^2 + X_L{}^2 = R^2 + X_C{}^2$, so $X_L = X_C$ and therefore $V_L = V_C$

The wrong statement is (C): in the coil circuit the current lags behind the voltage, and in the capacitor circuit it leads it

70 **Answer (C)**

$X_L = 2\pi fL = 2\pi \times 50 \times 1/(\pi) = 100\ \Omega$

$X_C = 1/(2\pi fC) = 1/(2\pi \times 50 \times 100/(\pi) \times 10^{-6}) = 100\ \Omega$

The two reactances are equal, so the impedance $Z = \sqrt{(R^2 + 100^2)}$ does not change, and the brightness does not change

71 **Answer (D)**

$X_C = 1/(2\pi fC) \Rightarrow C = 1/(2\pi \times 100 \times 265) = 6 \times 10^{-6}\ F = 6\ \mu F$

72 **Answer (C)**

$I = V_C/X_C = 5/265 = 0.019\ A$

73 **Answer (C)**

$I = V_C/X_C = 5/265 = 0.0189\ A$

$V_R = IR = 0.0189 \times 300 = 5.7\ V$

74 **Answer (C)**

Lamp resistance $R = (V^2)/P = (100^2)/25 = 400\ \Omega$ and its rated current $I = P/V = 0.25\ A$

$X_C = 1/(2\pi fC) = 1/(2\pi \times 50 \times 100/(3\pi) \times 10^{-6}) = 300\ \Omega$

$Z = \sqrt{(400^2 + 300^2)} = 500\ \Omega \Rightarrow I = 200/500 = 0.4\ A$

The current is greater than $0.25\ A$, so the filament melts

75 **Answer (C)**

At first $\tan\varphi = X_C/R = 1$

Another capacitor C in series makes $X_C' = 2X_C$ (the equivalent capacitance is $C/2$), so $\tan\varphi' = 2$

$\varphi' = 63.4^\circ$

76 **Answer (B)**

At first $X_C = R$

Another resistor R in series makes the resistance $2R$, so $\tan\varphi' = X_C/2R = 1/2$

$\varphi' = 26.57^\circ$

77 **Answer (C)**

$Z = V/I = 200/0.02 = 10000\ \Omega$

$X_C = 1/(2\pi fC) = 1/(2\pi \times 50 \times 2 \times 10^{-6}) = 1591.5\ \Omega$

$R = \sqrt{(Z^2 - X_C^2)} = \sqrt{(10000^2 - 1591.5^2)} = 9872.6\ \Omega$

78 **Answer (A)**

$Z = V/I = 500/0.25 = 2000\ \Omega$

$X_C = \sqrt{(Z^2 - R^2)} = \sqrt{(2000^2 - 1000^2)} = 1732\ \Omega$

$C = 1/(2\pi fX_C) = 1/(2\pi \times 60 \times 1732) = 1.53\ \mu F$

79 **Answer (C)**

A phase angle of 45° means $\tan\varphi = X_C/R = 1 \Rightarrow X_C = R = 1000\ \Omega$

$C = 1/(2\pi fX_C) = 1/(2\pi \times 60 \times 1000) = 2.65\ \mu F$

80 **Answer (B)**

K open: one capacitor, $Z = 200/0.2 = 1000\ \Omega \Rightarrow X_C = \sqrt{(1000^2 - 500^2)} = 866\ \Omega$

K closed: the two capacitors are in parallel, so $X_C' = 866/2 = 433\ \Omega$

$Z' = \sqrt{(500^2 + 433^2)} = 661\ \Omega \Rightarrow I = 200/661 = 0.3\ A$

81 **Answer (D)**

The brightness increases as the current increases, that is, as the total impedance of the circuit decreases

(D): the two capacitors are in parallel, so the reactance is $X_C/2$, the smallest reactance of all the circuits

(B): X_C and (C): $2X_C$, and in (A) the resistor in parallel with the lamp takes half the current

$Z = \sqrt{(R^2 + X^2)}$ is smallest in (D), so the current is largest

82 **Answer (D)**

The coil voltage V_L leads the current by 90° and the capacitor voltage V_C lags behind the current by 90°

So the difference between them is 180°: V_L leads V_C by 180°

83 **Answer (A)**

Before the increase: $X_C - X_L = 500 - 100 > 0$, so the circuit is capacitive and the phase angle is -90° (the current leads the voltage)

At $2f$: $X_L = 200\ \Omega$ and $X_C = 250\ \Omega$; still $X_C > X_L$, so the angle is -90°

The change in the angle is 0°

84 **Answer (D)**

Before the increase: $X_C > X_L$, so the angle is -90°

At $5f$: $X_L = 500\ \Omega$ and $X_C = 100\ \Omega$, so now $X_L > X_C$ and the angle is $+90^\circ$

The change in the angle is $90 - (-90) = 180^\circ$

85 **Answer (D)**

The current is zero when the voltage is maximum, which means the phase angle is 90°

This happens with a coil of no resistance, with a capacitor, and with a coil and a capacitor together

86 **Answer (D)**

$X = |X_L - X_C| = |10 - 20| = 10\ \Omega$ and the circuit has negligible resistance, so $Z = X$

$I = V/Z = 30/10 = 3\ A$

87 **Answer (B)**

The coil and the capacitor are in series: their voltages are opposite in phase

The source voltage is $V = |V_C - V_L|$ and $V_L = V_1 = V$

So $V_C = V_2 = 2V$ (greater than V_L)

88 **Answer (C)**

Let $(X_C)_1 = x$: $I = V/(X_L - x)$

The capacitance is reduced to a quarter, so the reactance becomes $4x$, and the current doubles: $2I = V/(4x - X_L)$

Dividing the two relations: $1/2 = (4x - X_L)/(X_L - x)$, so $X_L - x = 8x - 2X_L$

$3X_L = 9x \Rightarrow X_L/((X_C)_1) = 3$

89 **Answer (C)**

$X_C = 2X_L$; then the frequency doubles, so X_L doubles and X_C is halved

$X_C' = X_C/2 = X_L$ while $X_L' = 2X_L$

So the capacitive reactance becomes half the inductive reactance

90 **Answer (B)**

The voltage is constant and the frequency increases

The coil: $X_L = 2\pi fL$ increases, so the current I_1 (reading of A_1) decreases

The capacitor: $X_C = 1/(2\pi fC)$ decreases, so the current I_2 (reading of A_2) increases

91 **Answer (A)**

The ohmic resistor is the one that converts electrical energy into heat energy

The coil of no resistance and the capacitor store energy and then return it to the circuit, so they consume no power

92 **Answer (D)**

The current vector lags behind the voltage vector by $45°$, so the circuit is inductive

This happens in an RL circuit, or in an RLC circuit if $X_L > X_C$

93 **Answer (D)**

The impedance is $Z = \sqrt{(R^2 + (X_L - X_C)^2)}$ and the current is $I = V/Z$

As the capacitance decreases, X_C increases from $1/2X_L$, so the difference $X_L - X_C$ decreases until it vanishes at $X_C = X_L$ (resonance), where the current is maximum

Then X_C increases up to $3/2X_L$, so the difference becomes $1/2X_L$ as at the start, and the current returns to its first value

So the current increases then decreases until it reaches the same first value

94 **Answer (D)**

$V_R = V\cos 60^\circ = V/2$, so $V/V_R = 2$

The current is the same, so $Z = V/I = 2\,V_R/I = 2R$

95 **Answer (B)**

The coil and capacitor voltages are opposite: $V_L - V_C = 60 - 20 = 40\ V$

$V = \sqrt{(V_R^2 + (V_L - V_C)^2)} = \sqrt{(30^2 + 40^2)} = 50\ V$

96 **Answer (C)**

The ammeter reading did not change, so the impedance did not change

$\sqrt{(R^2 + X_L^2)} = \sqrt{(R^2 + (X_L - X_C)^2)} \Rightarrow (X_L - X_C)^2 = X_L^2$

The solution $X_C = 0$ is rejected because a capacitor was added, so the other solution is $X_L - X_C = -X_L$

$X_C = 2X_L$

97 **Answer (D)**

$X_C = 2R$ and $X_L = R$, so the net reactance is $X = X_L - X_C = -R$ and the circuit is capacitive

$\tan\varphi = X/R = -1 \Rightarrow \varphi = -45^\circ$

V_R is in phase with the current, and the total voltage lags behind it by 45°

98 **Answer (C)**

$\cos\varphi = R/Z = 10/20 = 1/2$

$\varphi = 60^\circ$

99 **Answer (D)**

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

$X_L = \omega L = 1000 \times 2 = 2000\ \Omega$, $X_C = 1/(\omega C) = 1/(1000 \times 10^{-6}) = 1000\ \Omega$

$Z = \sqrt{(R^2 + (X_L - X_C)^2)} = \sqrt{(1000^2 + 1000^2)} = 1000\sqrt{(2)}\ \Omega$

100 **Answer (C)**

$\tan\varphi = (X_L - X_C)/R = (2000 - 1000)/1000 = 1$

$\varphi = 45^\circ$

101 **Answer (A)**

$\tan\varphi = (|X_L - X_C|)/R = \tan 45^\circ = 1$ and $R = X_C$

$|X_L - X_C| = X_C \Rightarrow X_L = 2X_C$ (the solution $X_L = 0$ is rejected)

$X_L/X_C = 2/1$

102 **Answer (D)**

$\omega = 1000\ rad/s \Rightarrow X_L = \omega L = 1000 \times 0.08 = 80\ \Omega$

$\cos\varphi = R/Z = 30/50 = 0.6$

$\varphi = 53.13^\circ$

103 **Answer (A)**

$\omega = 2\pi f = 1000\ rad/s$, so $X_L = 1000 \times 0.9 = 900\ \Omega$ and $X_C = 1/(1000 \times 2 \times 10^{-6}) = 500\ \Omega$

$Z = \sqrt{(300^2 + (900 - 500)^2)} = 500\ \Omega$

104 **Answer (B)**

$I = V/Z = 50/500 = 0.1\ A$

105 **Answer (B)**

$P = I^2R = (0.1)^2 \times 300 = 3\ W$ (power is consumed in the resistor only)

106 **Answer (B)**

$X_L = \omega L = 500 \times 0.08 = 40\ \Omega$ and $X_C = 1/(\omega C) = 1/(500 \times 30 \times 10^{-6}) = 66.67\ \Omega$

$\tan\varphi = (X_L - X_C)/R = (40 - 66.67)/15 = -1.78 \Rightarrow \varphi = -60.65^\circ$

$X_C > X_L$, so the circuit is capacitive: the total voltage lags behind the current by 60.65°

107 **Answer (A)**

$V_2 = V_3 = 2V_1$, that is $V_R = V_L = 2V_C$, so $R = X_L = 2X_C$

The iron rod increases L, so X_L increases and $Z = \sqrt{(R^2 + (X_L - X_C)^2)}$ increases because $X_L > X_C$

So the current decreases and both readings $V_1 = IX_C$ and $V_2 = IR$ decrease

108 **Answer (B)**

We need $\tan\varphi = X/R = 1$ after adding the component

In (B): $R_t = R + 2R = 3R$ and $X = 2R + R = 3R$, so $\tan\varphi = 1$

In (A): $\tan\varphi = 3R/2R$, in (C): $X = 0$, and in (D): $\tan\varphi = 2R/R$, so they do not give 45°

109 **Answer (B)**

$X_L = 2\pi fL = 2\pi \times 50 \times 0.28 = 88\ \Omega$ and $R = (\rho\ell)/A = (35 \times 10^{-6} \times 12)/(7 \times 10^{-5}) = 6\ \Omega$

$Z = \sqrt{(R^2 + (X_L - X_C)^2)} = \sqrt{(6^2 + (88 - 80)^2)} = 10\ \Omega$

$I_{rms} = 20/10 = 2\ A \Rightarrow I_{max} = 2\sqrt{(2)} = 2.828\ A$

110 **Answer (C)**

$V_C = IX_C = 2 \times 80 = 160\ V$

$V_L = IX_L = 2 \times 88 = 176\ V$

111 **Answer (B)**

$X_L = 2\pi fL = 2 \times 22/7 \times 50 \times 7/220 = 10\ \Omega$

The least resistance giving $I \leq 1\ A$ is at $I = 1\ A$: $Z = 13/1 = 13\ \Omega$

$R_t = \sqrt{(Z^2 - (X_L - X_C)^2)} = \sqrt{(13^2 - 5^2)} = 12\ \Omega$

$R = 12 - 4 = 8\ \Omega$

112 **Answer (A)**

The coil and the capacitor are opposite: $X = |X_L - X_C| = |20 - 16| = 4\ \Omega$

$Z = \sqrt{(R^2 + X^2)} = \sqrt{(3^2 + 4^2)} = 5\ \Omega$

113 **Answer (D)**

$Z = 5\ \Omega$ from the previous part

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

114 **Answer (C)**

$V_1 = IR = 4 \times 3 = 12\ V$, $V_2 = IX_L = 4 \times 20 = 80\ V$, $V_3 = IX_C = 4 \times 16 = 64\ V$

V_4 is across the coil and the capacitor together: $V_4 = I\ (X_L - X_C) = 4 \times 4 = 16\ V$

115 **Answer (B)**

V_1 is across the coil and the capacitor: $V_1 = I\ |X_L - X_C| \Rightarrow |180 - X_C| = 100/1 = 100$

$X_C = 80\ \Omega$ ($X_C = 280\ \Omega$ is rejected because $V_2 = 100\ V$ must be greater than the capacitor voltage)

116 **Answer (A)**

V_2 is across the resistor and the capacitor: $V_2 = I\sqrt{(R^2 + X_C{}^2)} \Rightarrow R^2 + 80^2 = 100^2$

$R = 60\ \Omega$

117 **Answer (D)**

$\tan\varphi = (X_L - X_C)/R = (180 - 80)/60 = 5/3$

$\varphi = 59^\circ$

118 **Answer (C)**

$\tan 30^\circ = (X_L - X_C)/R = (X_L - 1/2X_L)/R \Rightarrow X_L = 2R\tan 30^\circ = 1.155\ R$

Connecting an identical capacitor in parallel doubles the capacitance, so $X_C' = X_L/4$

$\tan\varphi' = (X_L - 1/4X_L)/R = 0.75 \times 1.155 = 0.866$

$\varphi' = 40.89^\circ$

119 **Answer (B)**

$\omega = 2\pi f = 2\pi \times 5000/(\pi) = 10^4\ rad/s \Rightarrow X_L = \omega L = 2000\ \Omega$

The voltage lags behind the current by $(\pi)/4$, so the circuit is capacitive: $\tan(\pi)/4 = (X_C - X_L)/R = 1$

$X_C = 2000 + 500 = 2500\ \Omega \Rightarrow C = 1/(\omega X_C) = 1/(10^4 \times 2500) = 4 \times 10^{-8}\ F$

120 **Answer (B)**

From figure (2), the peak of V is at $T/8$ and the peak of I is at $T/4$, so the voltage leads the current by $T/8$, that is $\varphi = 45^\circ$

$\tan\varphi = (X_L - X_C)/R = (2R - X_C)/R = 1$

$X_C = R$

121 **Answer (B)**

Removing the capacitor: $\tan 30^\circ = X_L/R \Rightarrow X_L = \sqrt{(300)} \times 1/(\sqrt{(3)}) = 10\ \Omega$

Removing the coil: $\tan 60^\circ = X_C/R \Rightarrow X_C = \sqrt{(300)} \times \sqrt{(3)} = 30\ \Omega$

$Z = \sqrt{(R^2 + (X_L - X_C)^2)} = \sqrt{(300 + 20^2)} = 26.46\ \Omega$

$I = 200/26.46 = 7.56\ A$

122 **Answer (B)**

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

V_1 is across the coil and the resistor, V_2 is across the resistor and the capacitor, and the current is the same

$V_1/V_2 = (\sqrt{(R^2 + X_L^2)})/(\sqrt{(R^2 + X_C^2)}) = 1/2 \Rightarrow R^2 + X_C^2 = 4\ (50^2 + 31.4^2) = 13948$

$X_C = \sqrt{(13948 - 2500)} = 107\ \Omega \Rightarrow C = 1/(2\pi \times 50 \times 107) = 30\ \mu F$

123 **Answer (D)**

$R = 40\ \Omega$, $X_L = 50\ \Omega$ and $X_C = 30\ \Omega$; the voltage lags behind the current by 45°, so the circuit is capacitive and the net reactance equals $-R = -40\ \Omega$

The net reactance without A: $50 - 30 = +20\ \Omega$

So element A must have a reactance of $-60\ \Omega$, that is a capacitor of capacitive reactance $60\ \Omega$

124 **Answer (C)**

$V_{max} = NBA\,2\pi f = 500 \times 5 \times 10^{-4} \times 7/11 \times 2 \times 22/7 \times 50 = 50\ V$

$Z = \sqrt{(R^2 + (X_L - X_C)^2)} = \sqrt{(40^2 + (80 - 110)^2)} = 50\ \Omega$

$I_{max} = 50/50 = 1\ A$, so the maximum voltage across the coil is $V_L = I_{max}X_L = 1 \times 80 = 80\ V$

125 **Answer (A)**

$I_{max} = 1\ A$ from the previous part

$I_{rms} = (I_{max})/(\sqrt{(2)}) = 0.707\ A$

126 **Answer (C)**

The lower branch alone: $R = X_L = x$ and $X_C = 2x$, so $tan\varphi = (x - 2x)/x = -1$, that is the voltage lags by $45°$

To make the angle zero we need $X_C = X_L$: closing K_3 connects an identical capacitor in parallel, so the capacitance doubles and $X_C' = x = X_L$

So resonance happens and $\varphi = 0$

127 **Answer (D)**

$X_L = X_C = 800\ \Omega$, so they cancel each other and the impedance is $Z = R = 600\ \Omega$

$I = V/Z = 220/600 = 11/30\ A$

128 **Answer (B)**

After removing the capacitor, $R = 600\ \Omega$ and $X_L = 800\ \Omega$ remain

$Z = \sqrt{(600^2 + 800^2)} = 1000\ \Omega \Rightarrow I = 220/1000 = 0.22\ A$

129 **Answer (C)**

After removing the coil, $R = 600\ \Omega$ and $X_C = 800\ \Omega$ remain

$Z = \sqrt{(600^2 + 800^2)} = 1000\ \Omega \Rightarrow I = 220/1000 = 0.22\ A$

130 **Answer (A)**

Removing the capacitor and the coil leaves only the resistor: $Z = R = 600\ \Omega$

$I = 220/600 = 11/30\ A$

Essay questions

1 **Model answer**

(1) $V_{coil} = \sqrt{((V_R)_{coil}^2 + V_L^2)} : 20 = \sqrt{(10^2 + V_L^2)}$, $V_L = 10\sqrt{(3)}$ V

$V_L/((V_R)_{coil}) = X_L/R = (10\sqrt{(3)})/10 = (\sqrt{(3)})/1$

(2) $V = \sqrt{(V_R^2 + V_L^2)} = \sqrt{((10 + 10)^2 + (10\sqrt{(3)})^2)} = 10\sqrt{(7)}$ V

2 **Model answer**

Because wire x has only an ohmic resistance $(R_x = R)$, while wire y has become an inductor with an inductive reactance (X_L) and an ohmic resistance $(R_y = R)$, and its impedance is given by $Z_y = \sqrt{(R^2 + X_L^2)}$

The two coils are in series, so the total potential difference divides between them in the ratio of the wire resistance R to the coil impedance Z_y, and since $Z_y \neq R$, $V_y \neq V_x$

3 **Model answer**

The lamp gets brighter and the phase angle decreases, because when switch K is closed the total inductive reactance decreases, which leads to:

a decrease in the total impedance, so the current in the circuit increases $(I = V/Z)$ and the lamp gets brighter.

a decrease in the phase angle between the total voltage and the current $(tan\theta = X_L/R)$.

4 **Model answer**

(1) $V_L = \sqrt{(50^2 - 30^2)} = 40$ V

The coils L and 2L are in series: $V_{xy} = 40 \times 2L/3L = 80/3$ V

(2) $V_{km} = 40 - 80/3 = 40/3$ V , $V_{zk} = 30 \times 2R/3R = 20$ V

$V_{mz} = \sqrt{((40/3)^2 + 20^2)} = 24.04$ V

5 **Model answer**

The voltmeter reading increases, because when the turns of the coil are moved apart uniformly the self-inductance of the coil decreases $(L = (\mu A N^2)/(\ell))$, so the inductive reactance decreases $(X_L = 2\pi f L)$, so the circuit impedance decreases $(Z = \sqrt{(R^2 + X_L^2)})$, so the current in the circuit increases $(I = V/Z)$ and the potential difference across the resistor increases $(V_R = IR)$.

6 **Model answer**

The current in the circuit decreases, because the impedance in the first case is $Z_1 = \sqrt{(R^2 + 200^2)}$ and in the second case it becomes $Z_2 = R + 200$, so the impedance increases and the current in the circuit decreases $(I = V/Z)$.

7 **Model answer**

(1) When the source frequency is doubled, the inductive reactance of the coil doubles ($X_L = 2\pi f L$), so the circuit impedance increases and the current in the circuit decreases ($I = V/Z$), so the lamp gets dimmer.

(2) When the source frequency is doubled, the inductive reactance doubles, so the circuit impedance increases to less than double ($Z = \sqrt{(R^2 + X_L^2)}$). Since the emf is doubled, the current in the circuit increases and the lamp gets brighter.

8 **Model answer**

Before stretching wire a: $\tan\theta_1 = (-X_C)/R = -1$, $\theta_1 = -45^\circ$

After stretching the wire: $A_1\ell_1 = A_2\ell_2$, so $A_1/A_2 = 2$, and $R = (\rho_e\ \ell)/A$, so $R_2 = 4R$

$\tan\theta_2 = (-R)/4R = -1/4$, $\theta_2 = -14.04^\circ$

$\Delta\theta = -14.04 - (-45) = 30.96^\circ$

9 **Model answer**

Because the capacitive reactance is inversely proportional to the source frequency ($X_C = 1/(2\pi f C)$), so when the source frequency decreases X_C increases, the total impedance of the circuit increases, the current decreases and the lamp filament glows less.

10 **Model answer**

$\tan\theta = (-X_C)/R$, $X_C = 1/(2\pi f C)$

$(\tan\theta_1)/(\tan\theta_2) = C_2/C_1 = (\tan(-30))/(\tan(-60)) = 1/3$

The phase angle becomes -60° when the capacitance is reduced to $1/3$ of its first value.

11 **Model answer**

$(V_C)_{max} = (Q_{max})/C = (300\sqrt{(2)})/10 = 30\sqrt{(2)}$ V , $(V_C)_{eff} = 30$ V

$V = \sqrt{(V_R^2 + V_C^2)} : 50 = \sqrt{(V_R^2 + 30^2)}$, $V_R = 40$ V

$P_w = (V_R^2)/R = (40^2)/100 = 16$ W

12 **Model answer**

(1) By removing component y, because the phase angle is given by ($\tan\theta = (-X_C)/R$), so it is largest when the ohmic resistance in the circuit is smallest, that is by removing the component with the larger ohmic resistance (resistor y).

(2) By removing component k, because the current is ($I = V/Z$) and ($Z = \sqrt{(X_C^2 + R^2)}$), so to make the current largest the impedance must be smallest, by removing the component with the larger reactance (capacitor k).

13 **Model answer**

(1) The current and the potential difference of component x are in phase, so x is an ohmic resistor. The potential difference across component y lags behind the current by $90°$, so y is a capacitor.

(2) $\tan\theta = (-V_C)/V_R = (-2)/1 = -2$, $\theta = -63.43°$

14 **Model answer**

In figure (1): $\theta = -45°$, so element (x) is a capacitor and $X_C = 50\ \Omega$

In figure (2): $\theta = 30°$, so element (y) is an inductor and $X_L = 50 \tan 30° = 28.87\ \Omega$

In figure (3): $Z_3 = |X_L - X_C| = 21.13\ \Omega$

$I = 200/21.13 = 9.47\ A$

15 **Model answer**

The current in the circuit decreases to a quarter, because the total reactance before closing K is $X_1 = 25 - 20 = 5\ \Omega$

After closing K (the coil is shorted): $X_2 = X_C = 20\ \Omega$

$I_1/I_2 = X_2/X_1 = 20/5 = 4$, $I_2 = I_1/4$

16 **Model answer**

Because when the source frequency increases at constant voltage, the inductive reactance of the coil increases, so the current in lamp (1) decreases, and the capacitive reactance of the capacitor decreases, so the current in lamp (2) increases.

Since the two lamps were equally bright before the frequency increased, after the increase lamp (2) becomes brighter than lamp (1).

17 **Model answer**

(1) $V = \sqrt{(V_R^2 + (V_L - V_C)^2)}$: $50^2 = 30^2 + (20 - V_C)^2$, $V_C = 60\ V$

(2) Because in an RLC circuit the voltages are added as vectors, not algebraically, where $V = \sqrt{(V_R^2 + (V_L - V_C)^2)}$

18 **Model answer**

$Z = \sqrt{(6^2 + (16 - 8)^2)} = 10\ \Omega$

$I = 200/10 = 20\ A$

$P_w = I^2 R = 20^2 \times 6 = 2400\ W$

19 **Model answer**

(1) $Z = \sqrt{((44 + 36)^2 + (90 - 30)^2)} = 100\ \Omega$, $I = 200/100 = 2\ A$

(2) $V_{coil} = I\sqrt{(R_{coil}^2 + X_L^2)} = 2\sqrt{(36^2 + 90^2)} = 193.8\ V$

20 **Model answer**

(1) When L is doubled, the inductive reactance of the coil doubles, so the circuit impedance increases ($Z = \sqrt{(R^2 + (X_L - X_C)^2)}$), the current in the circuit decreases and the lamp gets dimmer.

(2) When C is doubled, the capacitive reactance of the capacitor decreases, so the total impedance of the circuit increases, the current decreases and the lamp gets dimmer.

21 **Model answer**

Before removing the capacitor: $\tan\theta_1 = (X_L - X_C)/R$, after removing the capacitor: $\tan\theta_2 = X_L/R$

So after removing the capacitor the total reactance of the circuit increases, and the phase angle between the total voltage and the current increases.

22 **Model answer**

(1) The two capacitors are in parallel: $1/X_C = 1/60 + 1/20$, $X_C = 15\ \Omega$

$\tan\theta = (30 - 15)/5 = 3$, $\theta = 71.57°$

(2) The two coils are in parallel: $X_L = (30 \times 60)/(30 + 60) = 20\ \Omega$

$\tan\theta = (20 - 15)/5 = 1$, $\theta = 45°$

Past exam questions

1	2	3	4	5	6	7	8	9	10
B	B	A	C	C	A	B	A	A	A
11	12	13	14	15	16	17	18	19	20
A	A	C	B	A	B	C	B	D	A
21	22	23	24						
B	A	C	—						

1 **Answer (B)**

Closing K shorts the resistor R, so the circuit becomes an inductor only.

So the phase angle increases to $90°$

2 **Answer (B)**

$V_{eff} = 250/(\sqrt{(2)}) = 176.8\ V$

$Z = 176.8/10 = 17.68\ \Omega$

$X_L = \sqrt{(17.68^2 - 12^2)} = 12.98\ \Omega$

3 **Answer (A)**

Closing K shorts one of the two resistors, so the total resistance decreases.

$\tan\theta = X_L/R$, so the phase angle increases.

4 **Answer (C)**

$X_L = 2\pi f L$, so the inductive reactance decreases as the frequency decreases.

$\tan\theta = X_L/R$, so the phase angle decreases.

5 **Answer (C)**

Closing K puts the two resistors in parallel, so the total resistance is halved.

$\tan\theta = X_L/R$, so the phase angle increases.

6 **Answer (A)**

Closing K shorts the coil, so only the ohmic resistor remains.

So the phase angle becomes zero.

7 **Answer (B)**

Closing K puts the two coils in parallel, so the inductive reactance decreases from R to $R/2$

$\tan\theta = X_L/R$, so the angle decreases but does not reach zero.

8 **Answer (A)**

$L = (\mu A N^2)/(\ell)$; cutting off a quarter gives $N' = 3/4N$ and $\ell' = 3/4\ell$, so $L' = 3/4L$

Before cutting: $\tan\theta_1 = 1$, $\theta_1 = 45^\circ$

After cutting: $\tan\theta_2 = 0.75$, $\theta_2 = 36.87^\circ$

$\Delta\theta = 8.13^\circ$

9 **Answer (A)**

Winding the wire as a coil adds an inductive reactance, so the impedance increases and the current decreases.

10 **Answer (A)**

$Z = \sqrt{(30^2 + 40^2)} = 50\ \Omega$

$I = 60/50 = 1.2\ A$

$P_w = I^2 R = 1.44 \times 30 = 43.2\ W$

11 **Answer (A)**

$P_w \propto I^2$, so the power becomes $(0.75)^2 P_w = 9/16 P_w$

$\cos\theta = R/Z = (I')/I = 0.75$

$\theta = 41.41^\circ$

12 **Answer (A)**

With the battery the primary coil has no inductive reactance, so the current increases and lamp A gets brighter

The flux does not change, so no current is induced in the secondary coil and lamp B goes out

13 **Answer (C)**

$\omega = 400\ rad/s$, the two capacitors are in parallel: $C = 80\ \mu F$

$X_C = 1/(400 \times 80 \times 10^{-6}) = 31.25\ \Omega$

$\tan\theta = (-31.25)/40$, $\theta = -38^\circ$

14 **Answer (B)**

$X_C = 1/(2\pi \times 100 \times 4/(\pi) \times 10^{-6}) = 1250\ \Omega$

$Z = \sqrt{(1250^2 + 50^2)} = 1251\ \Omega$

$V_{eff} = 0.2 \times 1251 = 250.2\ V$

$V_{max} = \sqrt{(2)} \times 250.2 = 353.8\ V$

15 **Answer (A)**

$V_{eff} = 100\ V$, $Z = 100/2 = 50\ \Omega$

$X_C = \sqrt{(50^2 - 30^2)} = 40\ \Omega$

$(X_C)_1 + (X_C)_2 = 80\ \Omega$ in parallel with $(X_C)_3$

$(80\ (X_C)_3)/(80 + (X_C)_3) = 40 \Rightarrow (X_C)_3 = 80\ \Omega$

16 **Answer (B)**

Before closing, $\tan\theta = -1$, that is $X_C = R$

After closing, the capacitance doubles, so $X_C = R/2$

$\tan\theta = -1/2$, $\theta = -26.6^\circ$

17 **Answer (C)**

$\omega = 200\ rad/s$, $X_C = 1/(200 \times 1250 \times 10^{-6}) = 4\ \Omega$

$Z = \sqrt{(3^2 + 4^2)} = 5\ \Omega$, $I = 4\ A$, $V_C = 16\ V$

$Q_{max} = C\ V_{max} = 1250 \times 10^{-6} \times 16\sqrt{(2)} = 0.028\ C$

18 **Answer (B)**

$X_L = 2 \times 22/7 \times 50 \times 7/22 = 100\ \Omega$

$X_C = 1/(2\pi \times 50 \times 5.3 \times 10^{-5}) = 60\ \Omega$

$Z = \sqrt{(30^2 + 40^2)} = 50\ \Omega$

19 **Answer (D)**

The largest power is at the smallest impedance: closing K_1 shorts the coil, closing K_2 shorts the capacitor, and closing K_3 puts the two resistors in parallel.

So $Z = R/2$, which is the smallest value.

20 **Answer (A)**

Before replacing, $X_L = X_C$, so $Z_1 = R = 20\ \Omega$

$L \propto N^2$, so $X_L = 80\ \Omega$

$Z_2 = \sqrt{(20^2 + (80 - 20)^2)} = 20\sqrt{(10)}\ \Omega$

$Z_2/Z_1 = \sqrt{(10)}$

21 **Answer (B)**

$Z_1 = \sqrt{(R^2 + (2R - R)^2)} = \sqrt{(2)}R$

$Z_2 = \sqrt{(R^2 + (3R - 2R)^2)} = \sqrt{(2)}R$

$Z_1/Z_2 = 1$

22 **Answer (A)**

V_L leads the current by 90° and V_C lags behind it by 90°, so the difference between them is 180°

23 **Answer (C)**

$X_L = 2 \times 3.14 \times 50 \times 0.2 = 62.8\ \Omega$

$X_C = 1/(2 \times 3.14 \times 50 \times 150 \times 10^{-6}) = 21.2\ \Omega$

$Z = \sqrt{(24^2 + 41.6^2)} = 48\ \Omega$

$\tan\theta = 41.6/24 = \sqrt{(3)}$, $\theta = 60^\circ$

24 **Model answer**

The phase angle increases, because the total ohmic resistance decreases (closing K puts the two resistors in parallel), and according to the relation $(\tan\theta = X_L/R)$ the phase angle increases.