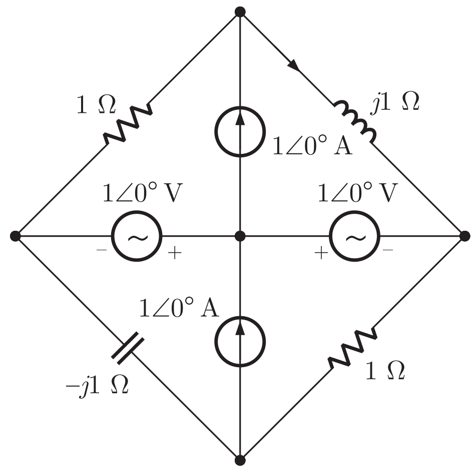
CHAPTER 2

ELECTRICAL CIRCUITS & FIELDS

YEAR 2012 **ONE MARK**

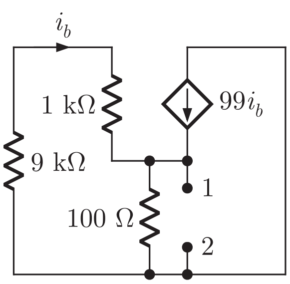
MCQ 2.1 In the circuit shown below, the current through the inductor is



(A) $\frac{2}{1+j}$ A (B) $\frac{-1}{1+j}$ A

(C) $\frac{1}{1+j}$ A (D) 0 A

MCQ 2.2 The impedance looking into nodes 1 and 2 in the given circuit is



(A) 50 Ω (B) 100 Ω

(C) 5 kΩ (D) 10.1 kΩ

MCQ 2.3 A system with transfer function $G(s) = \frac{(s^2+9)(s+2)}{(s+1)(s+3)(s+4)}$ is excited by $\sin(\omega t)$. The steady-state output of the system is zero at

(A) $\omega = 1$ rad/s (B) $\omega = 2$ rad/s

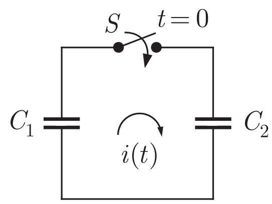
(C) $\omega = 3$ rad/s (D) $\omega = 4$ rad/s

MCQ 2.4 The average power delivered to an impedance $(4 - j3)\,\Omega$ by a current $5\cos(100\pi t + 100)$ A is

(A) 44.2 W (B) 50 W

(C) 62.5 W (D) 125 W

MCQ 2.5 In the following figure, C_1 and C_2 are ideal capacitors. C_1 has been charged to 12 V before the ideal switch S is closed at $t = 0$. The current $i(t)$ for all t is

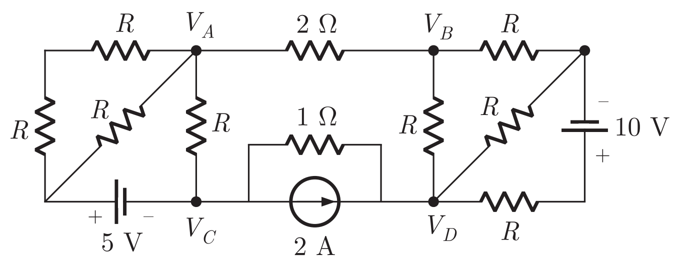


(A) zero (B) a step function

(C) an exponentially decaying function (D) an impulse function

YEAR 2012 **TWO MARKS**

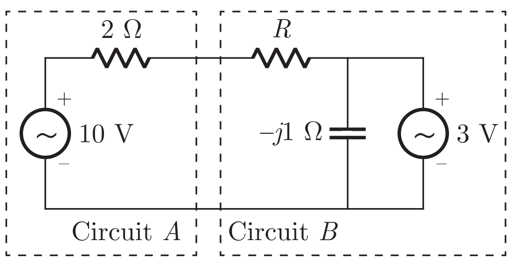
MCQ 2.6 If $V_A - V_B = 6$ V then $V_C - V_D$ is



(A) -5 V (B) 2 V

(C) 3 V (D) 6 V

MCQ 2.7 Assuming both the voltage sources are in phase, the value of R for which maximum power is transferred from circuit A to circuit B is



(A) $0.8\,\Omega$ (B) $1.4\,\Omega$

(C) $2\,\Omega$ (D) $2.8\,\Omega$

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Common Data for Questions 8 and 9 :

With 10 V dc connected at port A in the linear nonreciprocal two-port network shown below, the following were observed :

(i) 1 Ω connected at port B draws a current of 3 A

(ii) 2.5 Ω connected at port B draws a current of 2 A

MCQ 2.8 With 10 V dc connected at port A, the current drawn by 7 Ω connected at port B is

(A) 3/7 A (B) 5/7 A

(C) 1 A (D) 9/7 A

MCQ 2.9 For the same network, with 6 V dc connected at port A, 1 Ω connected at port B draws 7/3 A. If 8 V dc is connected to port A, the open circuit voltage at port B is

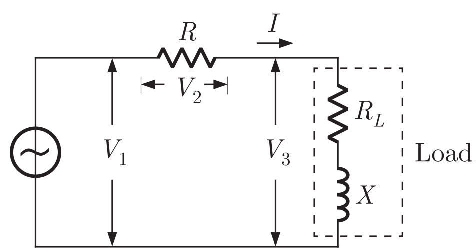
(A) 6 V (B) 7 V

(C) 8 V (D) 9 V

Linked Answer Question

Statement for Linked Answer Questions 10 and 11 :

In the circuit shown, the three voltmeter readings are $V_1 = 220$ V, $V_2 = 122$ V, $V_3 = 136$ V.



MCQ 2.10 The power factor of the load is

(A) 0.45 (B) 0.50

(C) 0.55 (D) 0.60

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MCQ 2.11 If $R_L = 5\,\Omega$, the approximate power consumption in the load is

(A) 700 W (B) 750 W

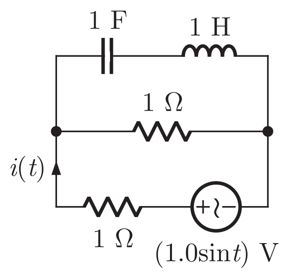
(C) 800 W (D) 850 W

YEAR 2011 ONE MARK

MCQ 2.12 The r.m.s value of the current $i(t)$ in the circuit shown below is

(A) $\frac{1}{2}$ A (B) $\frac{1}{\sqrt{2}}$ A

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

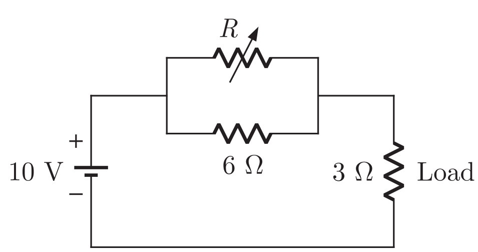


MCQ 2.13 The voltage applied to a circuit is $100\sqrt{2}\cos(100\pi t)$ volts and the circuit draws a current of $10\sqrt{2}\sin(100\pi t + \pi/4)$ amperes. Taking the voltage as the reference phasor, the phasor representation of the current in amperes is

(A) $10\sqrt{2}\angle -\pi/4$ (B) $10\angle -\pi/4$

(C) $10\angle +\pi/4$ (D) $10\sqrt{2}\angle +\pi/4$

MCQ 2.14 In the circuit given below, the value of R required for the transfer of maximum power to the load having a resistance of $3\,\Omega$ is



(A) zero (B) $3\,\Omega$

(C) $6\,\Omega$ (D) infinity

YEAR 2011 TWO MARKS

MCQ 2.15 A lossy capacitor C_x, rated for operation at 5 kV, 50 Hz is represented by an equivalent circuit with an ideal capacitor C_p in parallel with a resistor R_p.

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The value C_p is found to be 0.102 μF and value of $R_p = 1.25\,\text{M}\Omega$. Then the power loss and $\tan\delta$ of the lossy capacitor operating at the rated voltage, respectively, are

(A) 10 W and 0.0002 (B) 10 W and 0.0025

(C) 20 W and 0.025 (D) 20 W and 0.04

MCQ 2.16 A capacitor is made with a polymeric dielectric having an ε_r of 2.26 and a dielectric breakdown strength of 50 kV/cm. The permittivity of free space is 8.85 pF/m. If the rectangular plates of the capacitor have a width of 20 cm and a length of 40 cm, then the maximum electric charge in the capacitor is

(A) 2 μC (B) 4 μC

(C) 8 μC (D) 10 μC

Common Data questions: 17 & 18

The input voltage given to a converter is $v_i = 100\sqrt{2}\sin(100\pi t)$ V

The current drawn by the converter is

$$i_i = 10\sqrt{2}\sin(100\pi t - \pi/3) + 5\sqrt{2}\sin(300\pi t + \pi/4) + 2\sqrt{2}\sin(500\pi t - \pi/6)\text{ A}$$

MCQ 2.17 The input power factor of the converter is

(A) 0.31 (B) 0.44

(C) 0.5 (D) 0.71

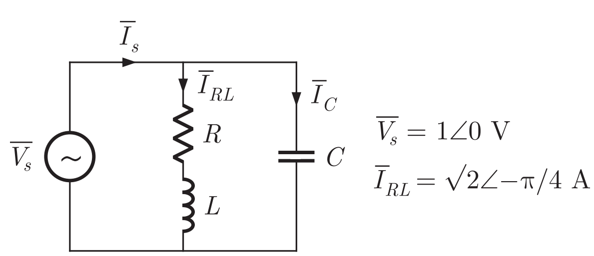
MCQ 2.18 The active power drawn by the converter is

(A) 181 W (B) 500 W

(C) 707 W (D) 887 W

Common Data questions: 19 & 20

An RLC circuit with relevant data is given below.



MCQ 2.19 The power dissipated in the resistor R is

(A) 0.5 W (B) 1 W

(C) $\sqrt{2}$ W (D) 2 W

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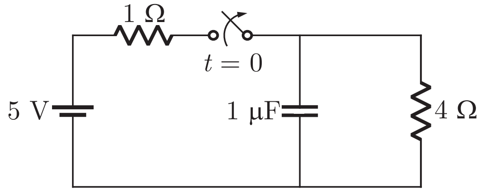
MCQ 2.20 The current $\overline{I_C}$ in the figure above is

(A) $-j2$ A
(B) $-j\frac{1}{\sqrt{2}}$ A
(C) $+j\frac{1}{\sqrt{2}}$ A
(D) $+j2$A

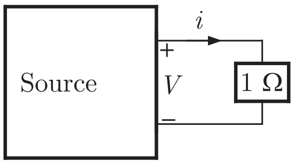
YEAR 2010 ONE MARK

MCQ 2.21 The switch in the circuit has been closed for a long time. It is opened at $t = 0$. At $t = 0^+$, the current through the 1 μF capacitor is



(A) 0 A
(B) 1 A
(C) 1.25 A
(D) 5 A

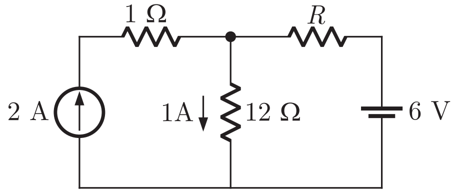
MCQ 2.22 As shown in the figure, a 1 Ω resistance is connected across a source that has a load line $v + i = 100$. The current through the resistance is



(A) 25 A
(B) 50 A
(C) 100 A
(C) 200 A

YEAR 2010 TWO MARKS

MCQ 2.23 If the 12 Ω resistor draws a current of 1 A as shown in the figure, the value of resistance R is



(A) 4 Ω
(B) 6 Ω
(C) 8 Ω
(D) 18 Ω

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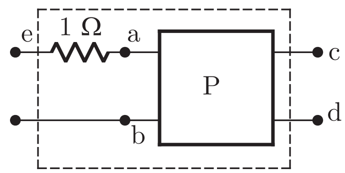
MCQ 2.24 The two-port network P shown in the figure has ports 1 and 2, denoted by terminals (a,b) and (c,d) respectively. It has an impedance matrix Z with parameters denoted by Z_{ij}. A $1\,\Omega$ resistor is connected in series with the network at port 1 as shown in the figure. The impedance matrix of the modified two-port network (shown as a dashed box) is



(A) $\begin{pmatrix} Z_{11}+1 & Z_{12}+1 \\ Z_{21} & Z_{22}+1 \end{pmatrix}$

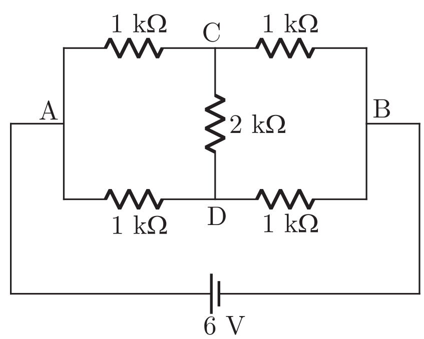
(B) $\begin{pmatrix} Z_{11}+1 & Z_{12} \\ Z_{21} & Z_{22}+1 \end{pmatrix}$

(C) $\begin{pmatrix} Z_{11}+1 & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix}$

(D) $\begin{pmatrix} Z_{11}+1 & Z_{12} \\ Z_{21}+1 & Z_{22} \end{pmatrix}$

YEAR 2009 ONE MARK

MCQ 2.25 The current through the $2\,\text{k}\Omega$ resistance in the circuit shown is



(A) 0 mA

(B) 1 mA

(C) 2 mA

(D) 6 mA

MCQ 2.26 How many 200 W/220 V incandescent lamps connected in series would consume the same total power as a single 100 W/220 V incandescent lamp ?

(A) not possible

(B) 4

(C) 3

(D) 2

YEAR 2009 TWO MARKS

MCQ 2.27 In the figure shown, all elements used are ideal. For time $t<0$, S_1 remained closed and S_2 open. At $t=0$, S_1 is opened and S_2 is closed. If the voltage V_{c2} across the capacitor C_2 at $t=0$ is zero, the voltage across the capacitor combination at $t=0^+$ will be

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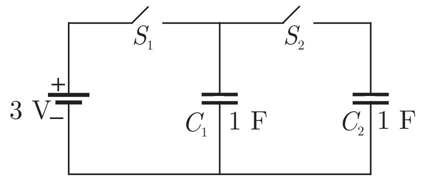
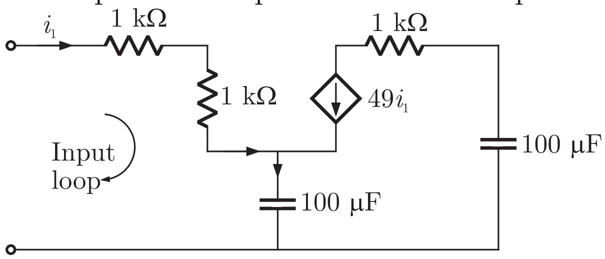


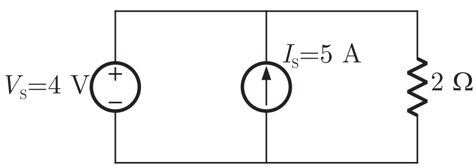
(A) 1 V
(B) 2 V
(C) 1.5 V
(D) 3 V

MCQ 2.28 The equivalent capacitance of the input loop of the circuit shown is



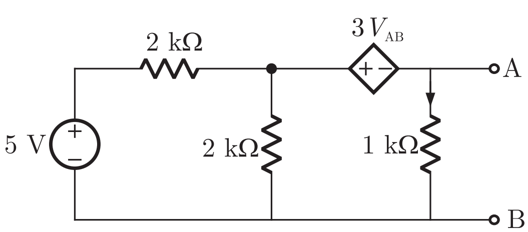
(A) 2 μF
(B) 100 μF
(C) 200 μF
(D) 4 μF

MCQ 2.29 For the circuit shown, find out the current flowing through the 2 Ω resistance. Also identify the changes to be made to double the current through the 2 Ω resistance.



(A) (5 A; Put $V_S = 30$ V)
(B) (2 A; Put $V_S = 8$ V)
(C) (5 A; Put $I_S = 10$ A)
(D) (7 A; Put $I_S = 12$ A)

Statement for Linked Answer Question 30 and 31 :



MCQ 2.30 For the circuit given above, the Thevenin's resistance across the terminals A and B is

(A) 0.5 kΩ
(B) 0.2 kΩ

(C) $1\,k\Omega$ (D) $0.11\,k\Omega$

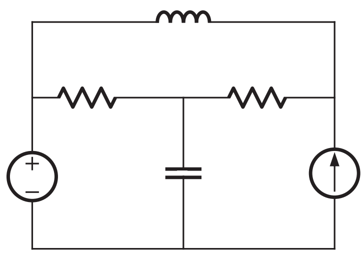
MCQ 2.31 For the circuit given above, the Thevenin's voltage across the terminals A and B is

(A) 1.25 V (B) 0.25 V

(C) 1 V (D) 0.5 V

YEAR 2008 ONE MARK

MCQ 2.32 The number of chords in the graph of the given circuit will be



(A) 3 (B) 4

(C) 5 (D) 6

MCQ 2.33 The Thevenin's equivalent of a circuit operation at $\omega = 5$ rads/s, has $V_{oc} = 3.71\angle - 15.9^\circ$ V and $Z_0 = 2.38 - j0.667\,\Omega$. At this frequency, the minimal realization of the Thevenin's impedance will have a

(A) resistor and a capacitor and an inductor

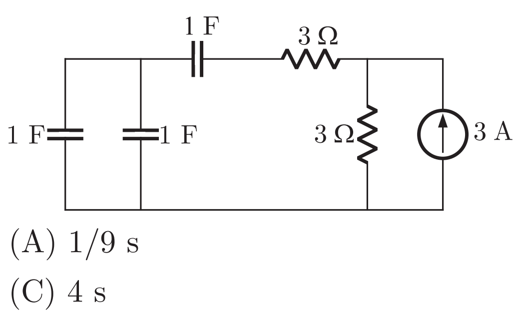
(B) resistor and a capacitor

(C) resistor and an inductor

(D) capacitor and an inductor

YEAR 2008 TWO MARKS

MCQ 2.34 The time constant for the given circuit will be



(A) 1/9 s (B) 1/4 s

(C) 4 s (D) 9 s

MCQ 2.35 The resonant frequency for the given circuit will be

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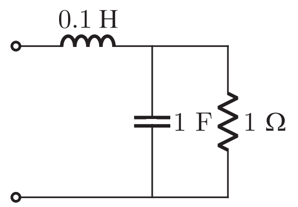
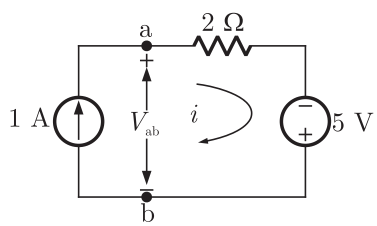


(A) 1 rad/s (B) 2 rad/s

(C) 3 rad/s (D) 4 rad/s

MCQ 2.36 Assuming ideal elements in the circuit shown below, the voltage V_{ab} will be

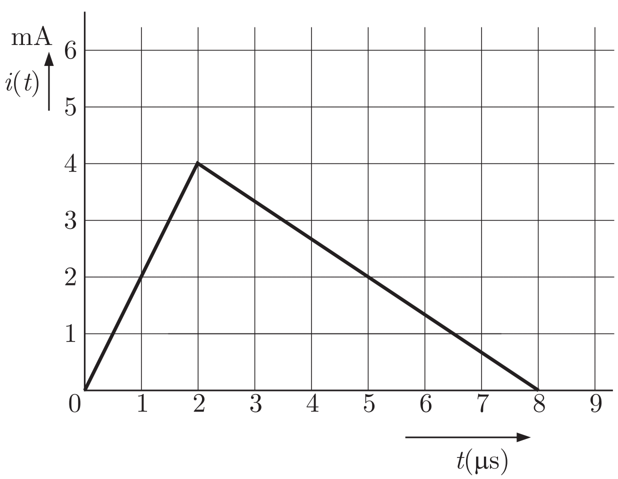


(A) -3 V (B) 0 V

(C) 3 V (D) 5 V

Statement for Linked Answer Question 38 and 39.

The current $i(t)$ sketched in the figure flows through a initially uncharged 0.3 nF capacitor.



MCQ 2.37 The charge stored in the capacitor at $t = 5\ \mu$s, will be

(A) 8 nC (B) 10 nC

(C) 13 nC (D) 16 nC

MCQ 2.38 The capacitor charged upto 5 ms, as per the current profile given in the

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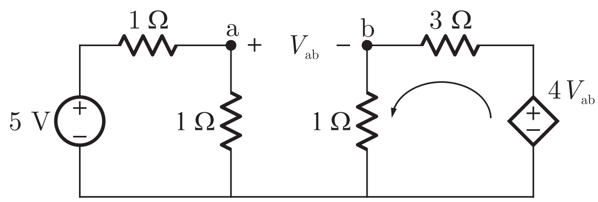
figure, is connected across an inductor of 0.6 mH. Then the value of voltage across the capacitor after 1 μs will approximately be

(A) 18.8 V (B) 23.5 V

(C) -23.5 V (D) -30.6 V

MCQ 2.39 In the circuit shown in the figure, the value of the current i will be given by



(A) 0.31 A (B) 1.25 A

(C) 1.75 A (D) 2.5 A

MCQ 2.40 Two point charges $Q_1 = 10\ \mu$C and $Q_2 = 20$ mC are placed at coordinates (1,1,0) and $(-1,-1,0)$ respectively. The total electric flux passing through a plane $z = 20$ will be

(A) 7.5 μC (B) 13.5 μC

(C) 15.0 μC (D) 22.5 μC

MCQ 2.41 A capacitor consists of two metal plates each 500×500 mm^2 and spaced 6 mm apart. The space between the metal plates is filled with a glass plate of 4 mm thickness and a layer of paper of 2 mm thickness. The relative primitivities of the glass and paper are 8 and 2 respectively. Neglecting the fringing effect, the capacitance will be (Given that $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m)

(A) 983.3 pF (B) 1475 pF

(C) 637.7 pF (D) 9956.25 pF

MCQ 2.42 A coil of 300 turns is wound on a non-magnetic core having a mean circumference of 300 mm and a cross-sectional area of 300 mm^2. The inductance of the coil corresponding to a magnetizing current of 3 A will be (Given that $\mu_0 = 4\pi \times 10^{-7}$ H/m)

(A) 37.68 μH (B) 113.04 μH

(C) 3.768 μH (D) 1.1304 μH

YEAR 2007 ONE MARK

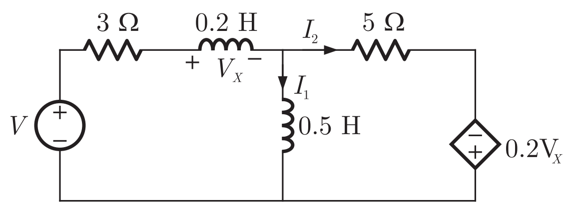
MCQ 2.43 Divergence of the vector field
$V(x,y,z) = -(x\cos xy + y)\hat{i} + (y\cos xy)\hat{j} + (\sin z^2 + x^2 + y^2)\hat{k}$ is

(A) $2z\cos z^2$ (B) $\sin xy + 2z\cos z^2$

(C) $x\sin xy - \cos z$ (D) None of these

YEAR 2007 **TWO MARKS**

MCQ 2.44 The state equation for the current I_1 in the network shown below in terms of the voltage V_X and the independent source V, is given by



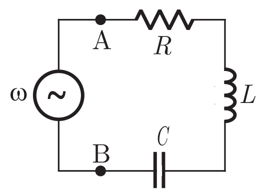
(A) $\frac{dI_1}{dt} = -1.4V_X - 3.75I_1 + \frac{5}{4}V$

(B) $\frac{dI_1}{dt} = 1.4V_X - 3.75I_1 - \frac{5}{4}V$

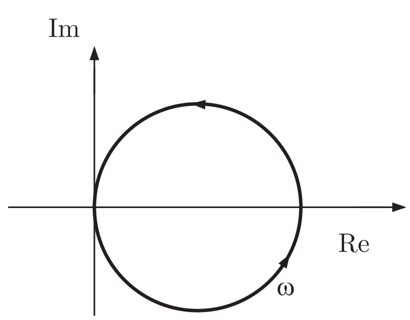
(C) $\frac{dI_1}{dt} = -1.4V_X + 3.75I_1 + \frac{5}{4}V$

(D) $\frac{dI_1}{dt} = -1.4V_X + 3.75I_1 - \frac{5}{4}V$

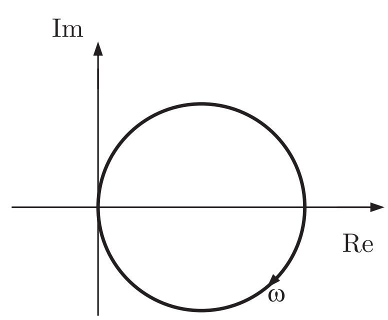
MCQ 2.45 The R-L-C series circuit shown in figure is supplied from a variable frequency voltage source. The admittance - locus of the R-L-C network at terminals AB for increasing frequency ω is



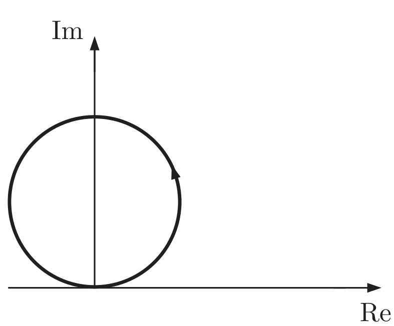
(A)



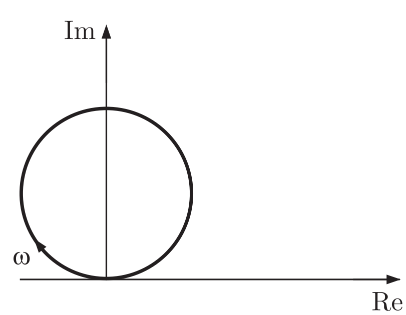
(B)



(C)



(D)



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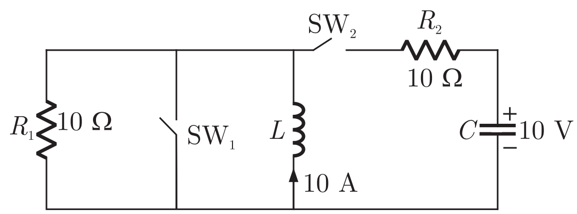
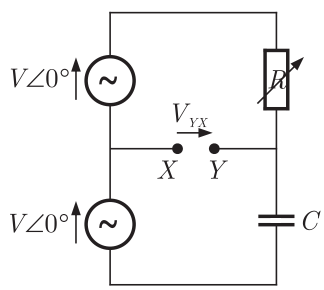
MCQ 2.46 In the circuit shown in figure. Switch SW_1 is initially closed and SW_2 is open. The inductor L carries a current of 10 A and the capacitor charged to 10 V with polarities as indicated. SW_2 is closed at $t = 0$ and SW_1 is opened at $t = 0$. The current through C and the voltage across L at $(t = 0^+)$ is

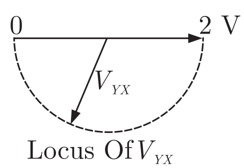


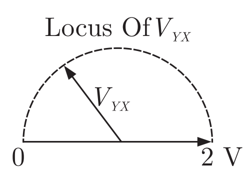
(A) 55 A, 4.5 V (B) 5.5 A, 45 V

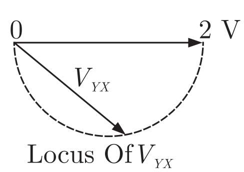
(C) 45 A, 5.5 A (D) 4.5 A, 55 V

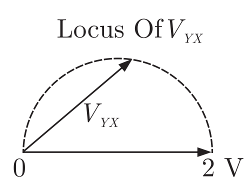
MCQ 2.47 In the figure given below all phasors are with reference to the potential at point "O". The locus of voltage phasor V_{YX} as R is varied from zero to infinity is shown by



(A)


(B)


(C)


(D)


MCQ 2.48 A 3 V DC supply with an internal resistance of $2\,\Omega$ supplies a passive non-linear resistance characterized by the relation $V_{NL} = I_{NL}^2$. The power dissipated in the non linear resistance is

(A) 1.0 W (B) 1.5 W

(C) 2.5 W (D) 3.0 W

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MCQ 2.49 The matrix A given below in the node incidence matrix of a network. The columns correspond to branches of the network while the rows correspond to nodes. Let $V = [V_1 V_2 ..... V_6]^T$ denote the vector of branch voltages while $I = [i_1 i_2 ..... i_6]^T$ that of branch currents. The vector $E = [e_1\ e_2\ e_3\ e_4]^T$ denotes the vector of node voltages relative to a common ground.

$$\begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & -1 & 1 & 0 \\ -1 & 0 & 0 & 0 & -1 & -1 \\ 0 & 0 & -1 & 1 & 0 & 1 \end{bmatrix}$$

Which of the following statement is true ?

(A) The equations $V_1 - V_2 + V_3 = 0, V_3 + V_4 - V_5 = 0$ are KVL equations for the network for some loops

(B) The equations $V_1 - V_3 - V_6 = 0, V_4 + V_5 - V_6 = 0$ are KVL equations for the network for some loops

(C) $E = AV$

(D) $AV = 0$ are KVI equations for the network

MCQ 2.50 A solid sphere made of insulating material has a radius R and has a total charge Q distributed uniformly in its volume. What is the magnitude of the electric field intensity, E, at a distance $r(0 < r < R)$ inside the sphere ?

(A) $\frac{1}{4\pi\varepsilon_0}\frac{Qr}{R^3}$

(B) $\frac{3}{4\pi\varepsilon_0}\frac{Qr}{R^3}$

(C) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

(D) $\frac{1}{4\pi\varepsilon_0}\frac{QR}{r^3}$

Statement for Linked Answer Question 51 and 52.

An inductor designed with 400 turns coil wound on an iron core of 16 cm^2 cross sectional area and with a cut of an air gap length of 1 mm. The coil is connected to a 230 V, 50 Hz ac supply. Neglect coil resistance, core loss, iron reluctance and leakage inductance, ($\mu_0 = 4\pi \times 10^{-7}$ H/M)

MCQ 2.51 The current in the inductor is

(A) 18.08 A

(B) 9.04 A

(C) 4.56 A

(D) 2.28 A

MCQ 2.52 The average force on the core to reduce the air gap will be

(A) 832.29 N

(B) 1666.22 N

(C) 3332.47 N

(D) 6664.84 N

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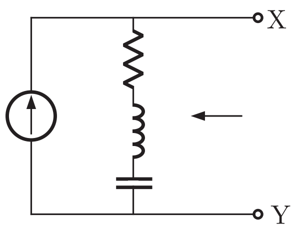
YEAR 2006 ONE MARK

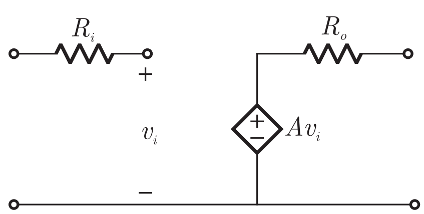
MCQ 2.53 In the figure the current source is $1\angle 0$ A, $R = 1\,\Omega$, the impedances are $Z_C = -j\,\Omega$ and $Z_L = 2j\,\Omega$. The Thevenin equivalent looking into the circuit across X-Y is



(A) $\sqrt{2}\angle 0$ V, $(1+2j)\,\Omega$
(B) $2\angle 45^\circ$ V, $(1-2j)\,\Omega$
(C) $2\angle 45^\circ$ V, $(1+j)\,\Omega$
(D) $\sqrt{2}\angle 45^\circ$ V, $(1+j)\,\Omega$

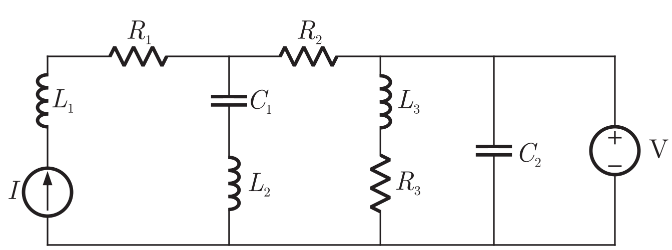
YEAR 2006 TWO MARKS

MCQ 2.54 The parameters of the circuit shown in the figure are $R_i = 1\,\text{M}\Omega$ $R_0 = 10\ \Omega$, $A = 10^6$ V/V If $v_i = 1\ \mu$V, the output voltage, input impedance and output impedance respectively are



(A) 1 V, ∞, 10 Ω
(B) 1 V, 0, 10 Ω
(C) 1 V, 0, ∞
(D) 10 V, ∞, 10 Ω

MCQ 2.55 In the circuit shown in the figure, the current source $I = 1$ A, the voltage source $V = 5$ V, $R_1 = R_2 = R_3 = 1\,\Omega$, $L_1 = L_2 = L_3 = 1$ H, $C_1 = C_2 = 1$ F



The currents (in A) through R_3 and through the voltage source V respectively will be

(A) 1, 4
(B) 5, 1
(C) 5, 2
(D) 5, 4

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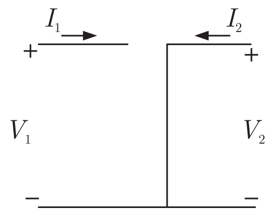
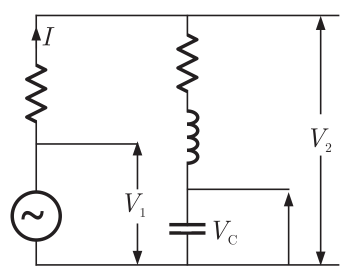
MCQ 2.56 The parameter type and the matrix representation of the relevant two port parameters that describe the circuit shown are



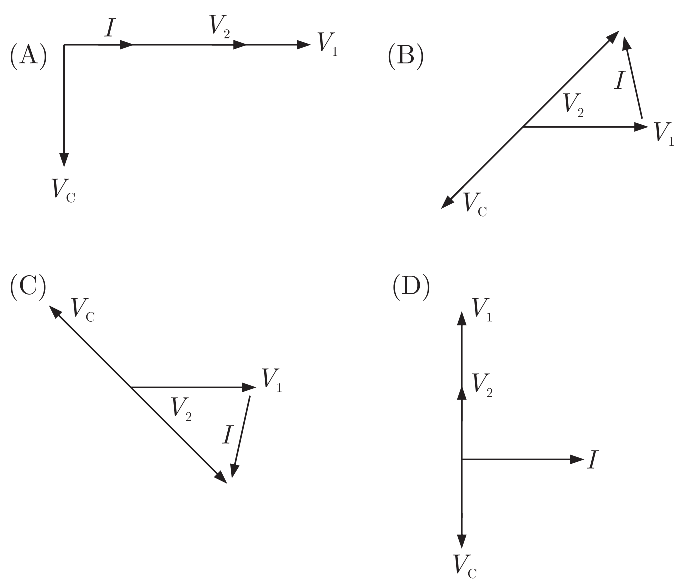
(A) z parameters, $\begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$ (B) h parameters, $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

(C) h parameters, $\begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$ (D) z parameters, $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

MCQ 2.57 The circuit shown in the figure is energized by a sinusoidal voltage source V_1 at a frequency which causes resonance with a current of I.



The phasor diagram which is applicable to this circuit is



MCQ 2.58 An ideal capacitor is charged to a voltage V_0 and connected at $t = 0$ across an ideal inductor L. (The circuit now consists of a capacitor and inductor alone). If we let $\omega_0 = \frac{1}{\sqrt{LC}}$, the voltage across the capacitor at time $t > 0$

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is given by

(A) V_0 (B) $V_0 \cos(\omega_0 t)$

(C) $V_0 \sin(\omega_0 t)$ (D) $V_0 e^{-\omega_0 t} \cos(\omega_0 t)$

MCQ 2.59 An energy meter connected to an immersion heater (resistive) operating on an AC 230 V, 50 Hz, AC single phase source reads 2.3 units (kWh) in 1 hour. The heater is removed from the supply and now connected to a 400 V peak square wave source of 150 Hz. The power in kW dissipated by the heater will be

(A) 3.478 (B) 1.739

(C) 1.540 (D) 0.870

MCQ 2.60 Which of the following statement holds for the divergence of electric and magnetic flux densities ?

(A) Both are zero

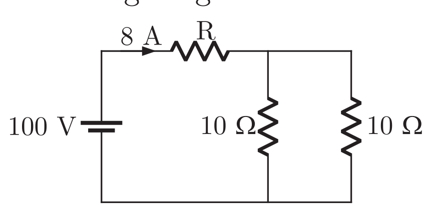
(B) These are zero for static densities but non zero for time varying densities.

(C) It is zero for the electric flux density

(D) It is zero for the magnetic flux density

YEAR 2005 ONE MARK

MCQ 2.61 In the figure given below the value of R is



(A) 2.5 Ω (B) 5.0 Ω

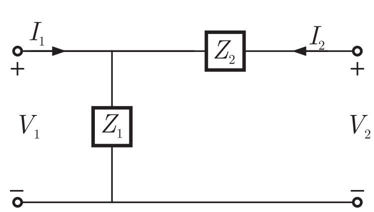
(C) 7.5 Ω (D) 10.0 Ω

MCQ 2.62 The RMS value of the voltage $u(t) = 3 + 4\cos(3t)$ is

(A) $\sqrt{17}$ V (B) 5 V

(C) 7 V (D) $(3 + 2\sqrt{2})$ V

MCQ 2.63 For the two port network shown in the figure the Z-matrix is given by



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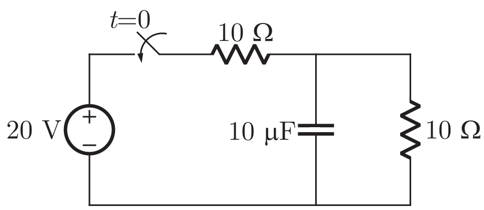
(A) $\begin{bmatrix} Z_1 & Z_1+Z_2 \\ Z_1+Z_2 & Z_2 \end{bmatrix}$ (B) $\begin{bmatrix} Z_1 & Z_1 \\ Z_1+Z_2 & Z_2 \end{bmatrix}$

(C) $\begin{bmatrix} Z_1 & Z_2 \\ Z_2 & Z_1+Z_2 \end{bmatrix}$ (D) $\begin{bmatrix} Z_1 & Z_1 \\ Z_1 & Z_1+Z_2 \end{bmatrix}$

MCQ 2.64 In the figure given, for the initial capacitor voltage is zero. The switch is closed at $t=0$. The final steady-state voltage across the capacitor is



(A) 20 V (B) 10 V

(C) 5 V (D) 0 V

MCQ 2.65 If $\vec{E}$ is the electric intensity, $\nabla(\nabla\times\vec{E})$ is equal to

(A) $\vec{E}$ (B) $|\vec{E}|$

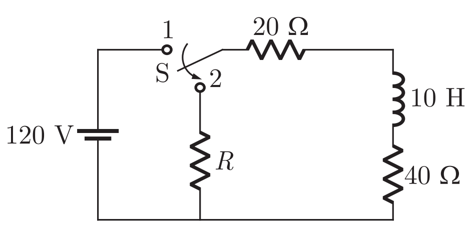
(C) null vector (D) Zero

YEAR 2005 TWO MARKS

Statement for Linked Answer Question 66 and 67.

A coil of inductance 10 H and resistance 40 Ω is connected as shown in the figure. After the switch S has been in contact with point 1 for a very long time, it is moved to point 2 at, $t=0$.

MCQ 2.66 If, at t $=0^+$, the voltage across the coil is 120 V, the value of resistance R is



(A) 0 Ω (B) 20 Ω

(C) 40 Ω (D) 60 Ω

MCQ 2.67 For the value as obtained in (a), the time taken for 95% of the stored energy to be dissipated is close to

(A) 0.10 sec (B) 0.15 sec

(C) 0.50 sec (D) 1.0 sec

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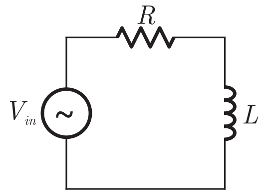
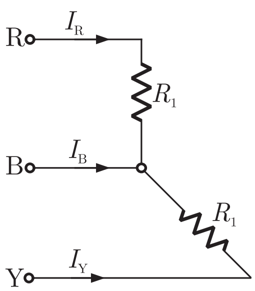
MCQ 2.68 The RL circuit of the figure is fed from a constant magnitude, variable frequency sinusoidal voltage source V_{in}. At 100 Hz, the $R$and L elements each have a voltage drop μ_{RMS}.If the frequency of the source is changed to 50 Hz, then new voltage drop across R is



(A) $\sqrt{\frac{5}{8}}$ uRMS (B) $\sqrt{\frac{2}{3}}$ uRMS

(C) $\sqrt{\frac{8}{5}}$ uRMS (D) $\sqrt{\frac{3}{2}}$ uRMS

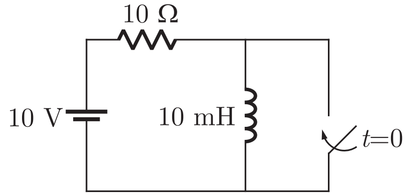
MCQ 2.69 For the three-phase circuit shown in the figure the ratio of the currents I_R: I_Y: I_B is given by



(A) $1:1:\sqrt{3}$ (B) $1:1:2$

(C) $1:1:0$ (D) $1:1:\sqrt{3/2}$

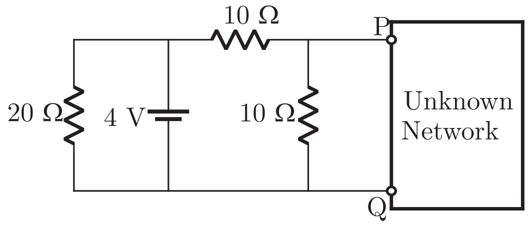
MCQ 2.70 The circuit shown in the figure is in steady state, when the switch is closed at $t=0$.Assuming that the inductance is ideal, the current through the inductor at $t=0^+$ equals



(A) 0 A (B) 0.5 A

(C) 1 A (D) 2 A

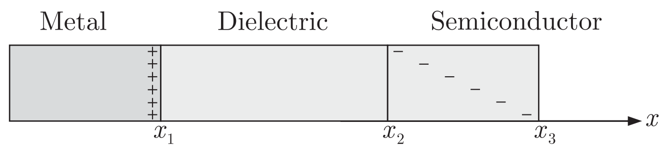
MCQ 2.71 In the given figure, the Thevenin's equivalent pair (voltage, impedance), as seen at the terminals P-Q, is given by

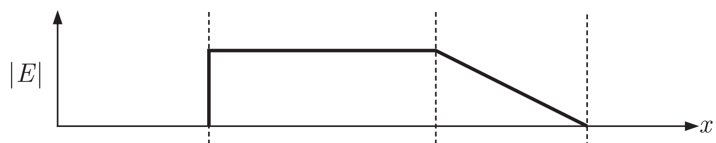


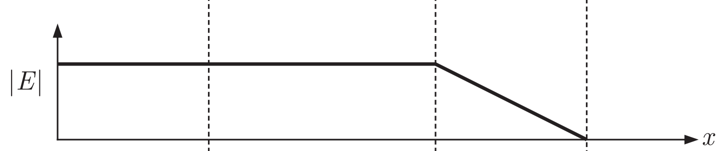
(A) (2 V, 5 Ω) (B) (2 V, 7.5 Ω)

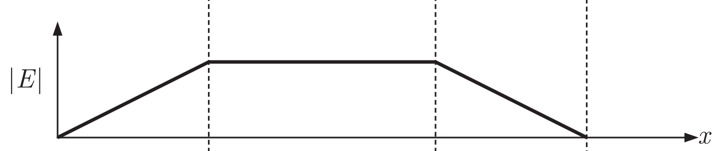
(C) (4 V, 5 Ω) (D) (4 V, 7.5 Ω)

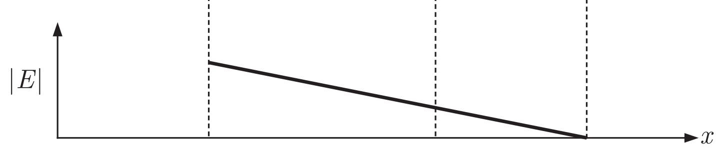
MCQ 2.72 The charge distribution in a metal-dielectric-semiconductor specimen is shown in the figure. The negative charge density decreases linearly in the semiconductor as shown. The electric field distribution is as shown in



(A)


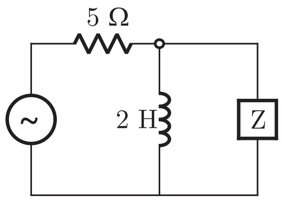
(B)


(C)


(D)


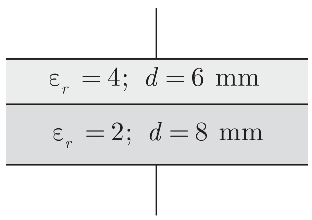
YEAR 2004 ONE MARK

MCQ 2.73 The value of Z in figure which is most appropriate to cause parallel resonance at 500 Hz is



(A) 125.00 mH (B) 304.20 μF
(C) 2.0 μF (D) 0.05 μF

MCQ 2.74 A parallel plate capacitor is shown in figure. It is made two square metal plates of 400 mm side. The 14 mm space between the plates is filled with two layers of dielectrics of $\varepsilon_r = 4$, 6 mm thick and $\varepsilon_r = 2$, 8 mm thick. Neglecting fringing of fields at the edge the capacitance is

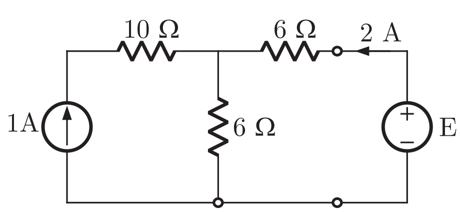


(A) 1298 pF (B) 944 pF
(C) 354 pF (D) 257 pF

MCQ 2.75 The inductance of a long solenoid of length 1000 mm wound uniformly with 3000 turns on a cylindrical paper tube of 60 mm diameter is
(A) 3.2 μH (B) 3.2 mH
(C) 32.0 mH (D) 3.2 H

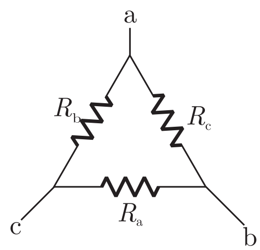
YEAR 2004 **TWO MARKS**

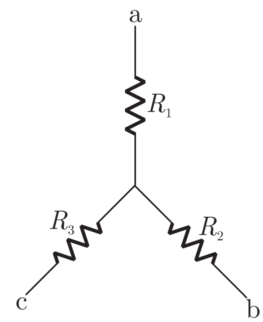
MCQ 2.76 In figure, the value of the source voltage is



(A) 12 V (B) 24 V
(C) 30 V (D) 44 V

MCQ 2.77 In figure, R_a, R_b and R_c are 20 Ω, 20 Ω and 10 Ω respectively. The resistances R_1, R_2 and R_3 in Ω of an equivalent star-connection are

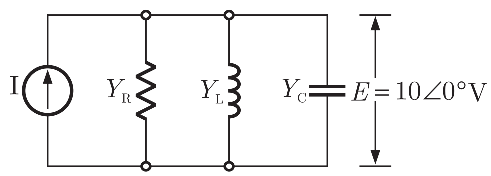




(A) 2.5, 5, 5 (B) 5, 2.5, 5

(C) 5, 5, 2.5 (D) 2.5, 5, 2.5

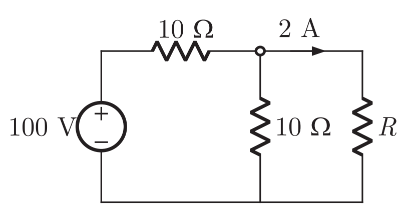
MCQ 2.78 In figure, the admittance values of the elements in Siemens are $Y_R = 0.5 + j0$, $Y_L = 0 - j1.5$, $Y_C = 0 + j0.3$ respectively. The value of I as a phasor when the voltage E across the elements is $10\angle 0^\circ$ V



(A) $1.5 + j0.5$ (B) $5 - j18$

(C) $0.5 + j1.8$ (D) $5 - j12$

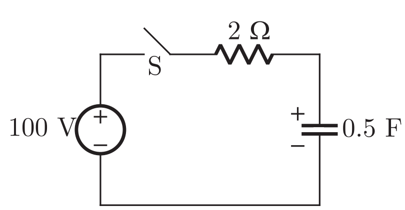
MCQ 2.79 In figure, the value of resistance R in Ω is



(A) 10 (B) 20

(C) 30 (D) 40

MCQ 2.80 In figure, the capacitor initially has a charge of 10 Coulomb. The current in the circuit one second after the switch S is closed will be



(A) 14.7 A (B) 18.5 A

(C) 40.0 A (D) 50.0 A

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MCQ 2.81 The rms value of the current in a wire which carries a d.c. current of 10 A and a sinusoidal alternating current of peak value 20 A is

(A) 10 A (B) 14.14 A

(C) 15 A (D) 17.32 A

MCQ 2.82 The Z-matrix of a 2-port network as given by $\begin{bmatrix} 0.9 & 0.2 \\ 0.2 & 0.6 \end{bmatrix}$

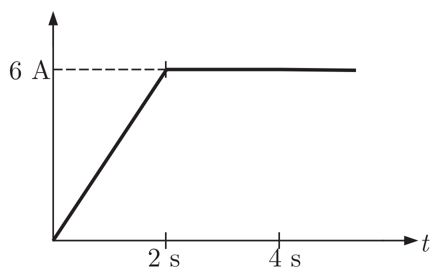
The element Y_{22} of the corresponding Y-matrix of the same network is given by

(A) 1.2 (B) 0.4

(C) -0.4 (D) 1.8

YEAR 2003 **ONE MARK**

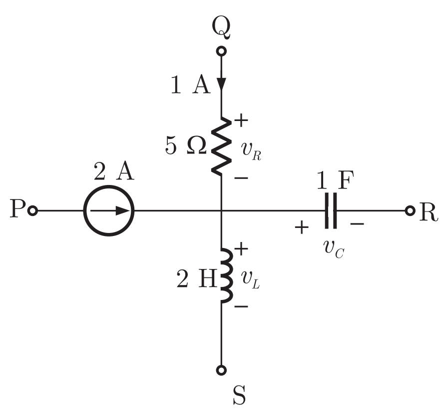
MCQ 2.83 Figure Shows the waveform of the current passing through an inductor of resistance $1\,\Omega$ and inductance 2 H. The energy absorbed by the inductor in the first four seconds is



(A) 144 J (B) 98 J

(C) 132 J (D) 168 J

MCQ 2.84 A segment of a circuit is shown in figure $v_R = 5\,V$, $v_c = 4\sin 2t$.The voltage v_L is given by



(A) $3 - 8\cos 2t$ (B) $32\sin 2t$

(C) $16\sin 2t$ (D) $16\cos 2t$

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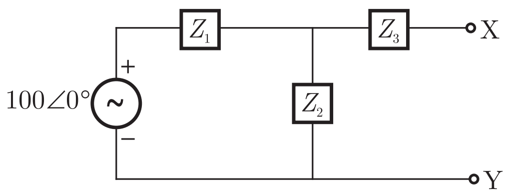
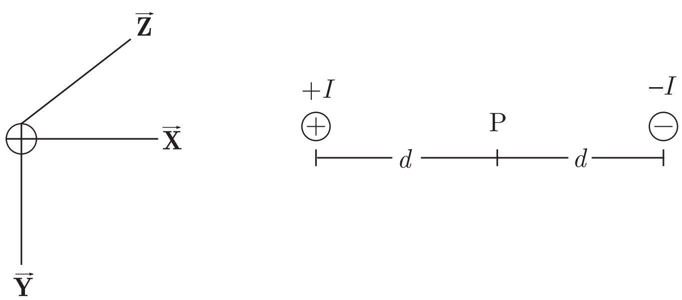
MCQ 2.85 In the figure, $Z_1 = 10\angle -60^\circ, Z_2 = 10\angle 60^\circ, Z_3 = 50\angle 53.13^\circ$.
Thevenin impedance seen form X-Y is



(A) $56.66\angle 45^\circ$ (B) $60\angle 30^\circ$

(C) $70\angle 30^\circ$ (D) $34.4\angle 65^\circ$

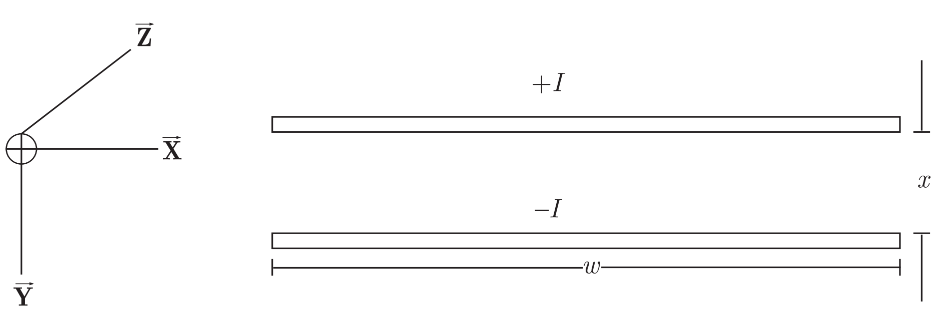
MCQ 2.86 Two conductors are carrying forward and return current of +I and $-I$ as shown in figure. The magnetic field intensity $\vec{\mathbf{H}}$ at point P is



(A) $\frac{I}{\pi d}\vec{\mathbf{Y}}$ (B) $\frac{I}{\pi d}\vec{\mathbf{X}}$

(C) $\frac{I}{2\pi d}\vec{\mathbf{Y}}$ (D) $\frac{I}{2\pi d}\vec{\mathbf{X}}$

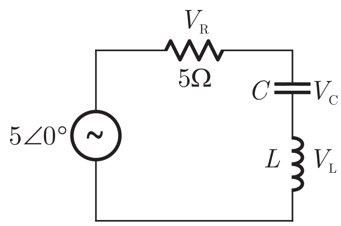
MCQ 2.87 Two infinite strips of width w m in x-direction as shown in figure, are carrying forward and return currents of +I and $-I$ in the z- direction. The strips are separated by distance of x m. The inductance per unit length of the configuration is measured to be L H/m. If the distance of separation between the strips in snow reduced to x/2 m, the inductance per unit length of the configuration is



(A) $2L$ H/m (B) $L/4$ H/m
(C) $L/2$ H/m (D) $4L$ H/m

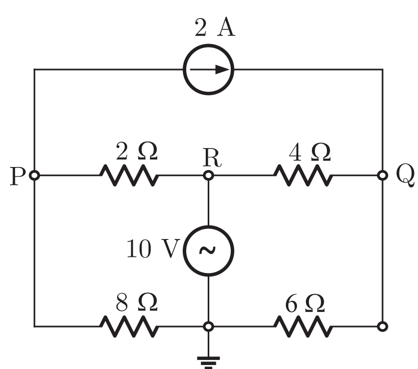
YEAR 2003 TWO MARKS

MCQ 2.88 In the circuit of figure, the magnitudes of V_L and V_C are twice that of V_R. Given that $f = 50$ Hz, the inductance of the coil is



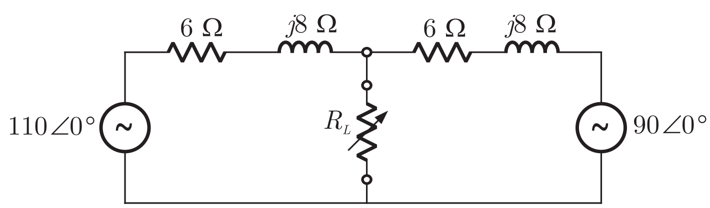
(A) 2.14 mH (B) 5.30 H
(C) 31.8 mH (D) 1.32 H

MCQ 2.89 In figure, the potential difference between points P and Q is



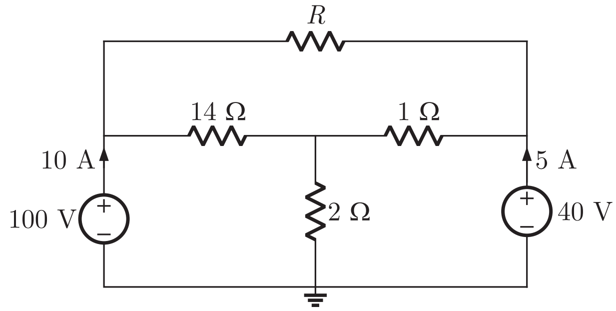
(A) 12 V (B) 10 V
(C) -6 V (D) 8 V

MCQ 2.90 Two ac sources feed a common variable resistive load as shown in figure. Under the maximum power transfer condition, the power absorbed by the load resistance R_L is



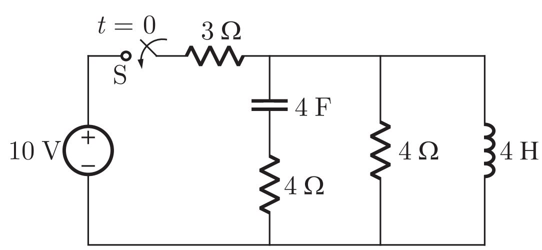
(A) 2200 W (B) 1250 W
(C) 1000 W (D) 625 W

MCQ 2.91 In figure, the value of R is



(A) $10\,\Omega$ (B) $18\,\Omega$
(C) $24\,\Omega$ (D) $12\,\Omega$

MCQ 2.92 In the circuit shown in figure, the switch S is closed at time (t = 0). The voltage across the inductance at $t = 0^+$, is

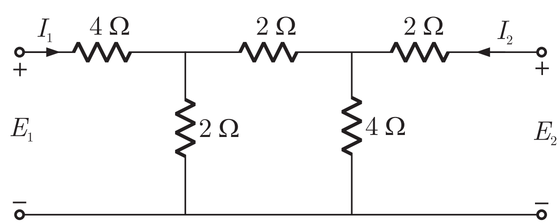


(A) 2 V (B) 4 V
(C) -6 V (D) 8 V

MCQ 2.93 The h-parameters for a two-port network are defined by

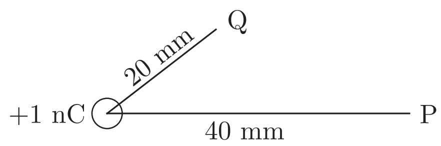
$$\begin{bmatrix} E_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ E_2 \end{bmatrix}$$

For the two-port network shown in figure, the value of h_{12} is given by



(A) 0.125 (B) 0.167
(C) 0.625 (D) 0.25

MCQ 2.94 A point charge of +I nC is placed in a space with permittivity of 8.85×10^{-12} F/m as shown in figure. The potential difference V_{PQ} between two points P and Q at distance of 40 mm and 20 mm respectively fr0m the point charge is



(A) 0.22 kV (B) -225 V

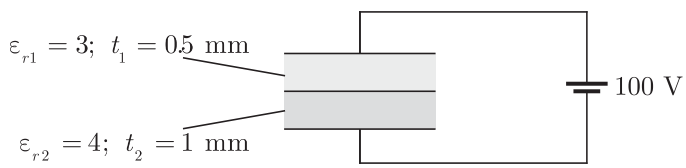
(C) -2.24 kV (D) 15 V

MCQ 2.95 A parallel plate capacitor has an electrode area of 100 mm^2, with spacing of 0.1 mm between the electrodes. The dielectric between the plates is air with a permittivity of 8.85×10^{-12} F/m. The charge on the capacitor is 100 V. The stored energy in the capacitor is

(A) 8.85 pJ (B) 440 pJ

(C) 22.1 nJ (D) 44.3 nJ

MCQ 2.96 A composite parallel plate capacitor is made up of two different dielectric material with different thickness (t_1 and t_2) as shown in figure. The two different dielectric materials are separated by a conducting foil F. The voltage of the conducting foil is



(A) 52 V (B) 60 V

(C) 67 V (D) 33 V

YEAR 2002 **ONE MARK**

MCQ 2.97 A current impulse, $5\delta(t)$, is forced through a capacitor C. The voltage , $v_c(t)$, across the capacitor is given by

(A) $5t$ (B) $5u(t)-C$

(C) $\frac{5}{C}t$ (D) $\frac{5u(t)}{C}$

MCQ 2.98 The graph of an electrical network has N nodes and B branches. The number of links L, with respect to the choice of a tree, is given by

(A) $B-N+1$ (B) $B+N$

(C) $N-B+1$ (D) $N-2B-1$

MCQ 2.99 Given a vector field $\vec{\mathbf{F}}$, the divergence theorem states that

(A) $\int_S \vec{\mathbf{F}}\cdot d\vec{\mathbf{S}}=\int_V \vec{\nabla}\cdot\vec{\mathbf{F}}\,dV$

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(B) $\int_S \vec{\mathbf{F}} \cdot d\vec{\mathbf{S}} = \int_V \vec{\nabla} \times \vec{\mathbf{F}} dV$

(C) $\int_S \vec{\mathbf{F}} \times d\vec{\mathbf{S}} = \int_V \vec{\nabla} \cdot \vec{\mathbf{F}} dV$

(D) $\int_S \vec{\mathbf{F}} \times d\vec{\mathbf{S}} = \int_V \vec{\nabla} \cdot \vec{\mathbf{F}} dV$

MCQ 2.100 Consider a long, two-wire line composed of solid round conductors. The radius of both conductors. The radius of both conductors is 0.25 cm and the distance between their centres is 1 m. If this distance is doubled, then the inductance per unit length

(A) doubles

(B) halves

(C) increases but does not double

(D) decreases but does not halve

MCQ 2.101 A long wire composed of a smooth round conductor runs above and parallel to the ground (assumed to be a large conducting plane). A high voltage exists between the conductor and the ground. The maximum electric stress occurs at

(A) The upper surface of the conductor

(B) The lower surface of the conductor.

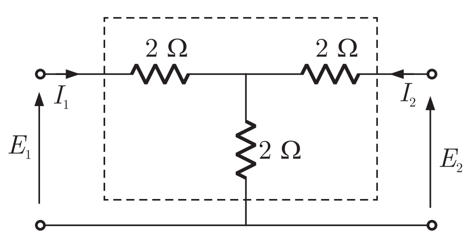
(C) The ground surface.

(D) midway between the conductor and ground.

YEAR 2002 **TWO MARKS**

MCQ 2.102 A two port network shown in Figure, is described by the following equations

$$I_1 = Y_{11} E_1 + Y_{12} E_2$$
$$I_1 = Y_{21} E_1 + Y_{22} E_2$$



The admittance parameters, Y_{11}, Y_{12}, Y_{21} and Y_{22} for the network shown are

(A) 0.5 mho, 1 mho, 2 mho and 1 mho respectively

(B) $\frac{1}{3}$ mho, $-\frac{1}{6}$ mho, $-\frac{1}{6}$ mho and $\frac{1}{3}$ mho respectively

(C) 0.5 mho, 0.5 mho, 1.5 mho and 2 mho respectively

(D) $-\frac{2}{5}$ mho, $-\frac{3}{7}$ mho, $\frac{3}{7}$ mho and $\frac{2}{5}$ mho respectively

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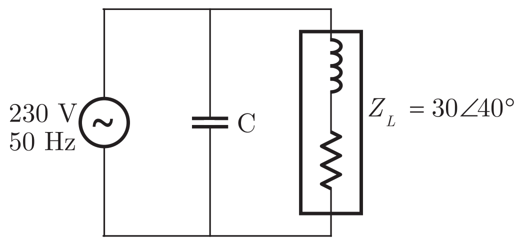
MCQ 2.103 In the circuit shown in Figure, what value of C will cause a unity power factor at the ac source ?



(A) 68.1 μF (B) 165 μF

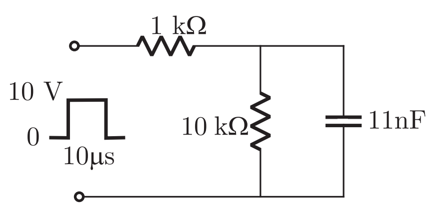
(C) 0.681 μF (D) 6.81 μF

MCQ 2.104 A series R-L-C circuit has $R = 50\,\Omega$; $L = 100\ \mu$H and $C = 1\ \mu$F. The lower half power frequency of the circuit is

(A) 30.55 kHz (B) 3.055 kHz

(C) 51.92 kHz (D) 1.92 kHz

MCQ 2.105 A 10 V pulse of 10 μs duration is applied to the circuit shown in Figure, assuming that the capacitor is completely discharged prior to applying the pulse, the peak value of the capacitor voltage is

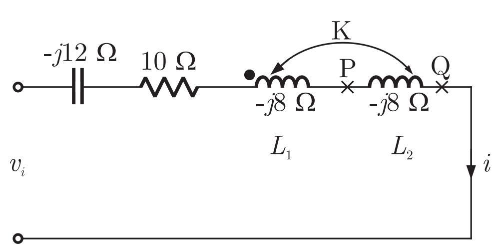


(A) 11 V (B) 5.5 V

(C) 6.32 V (D) 0.96 V

MCQ 2.106 In the circuit shown in Figure, it is found that the input voltage (v_i) and current i are in phase. The coupling coefficient is $K = \frac{M}{\sqrt{L_1 L_2}}$, where M is the mutual inductance between the two coils.

The value of K and the dot polarity of the coil P-Q are



(A) $K = 0.25$ and dot at P (B) $K = 0.5$ and dot at P

(C) $K = 0.25$ and dot at Q (C) $K = 0.5$ and dot at Q

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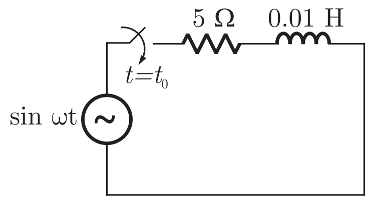
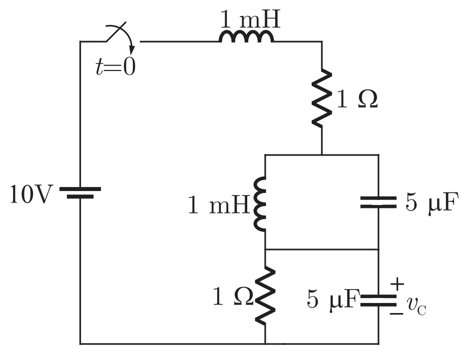
MCQ 2.107 Consider the circuit shown in Figure If the frequency of the source is 50 Hz, then a value of t_0 which results in a transient free response is



(A) 0 ms (B) 1.78 ms
(C) 2.71 ms (D) 2.91 ms

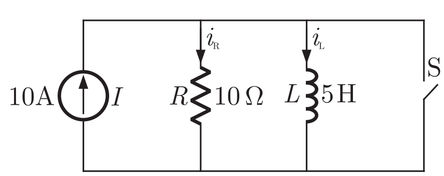
MCQ 2.108 In the circuit shown in figure, the switch is closed at time $t = 0$. The steady state value of the voltage v_c is



(A) 0 V (B) 10 V
(C) 5 V (D) 2.5 V

Common data Question for Q. 109-110* :

A constant current source is supplying 10 A current to a circuit shown in figure. The switch is initially closed for a sufficiently long time, is suddenly opened at $t = 0$



MCQ 2.109 The inductor current $i_L(t)$ will be
(A) 10 A (B) 0 A
(C) $10e^{-2t}$ A (D) $10(1 - e^{-2t})$ A

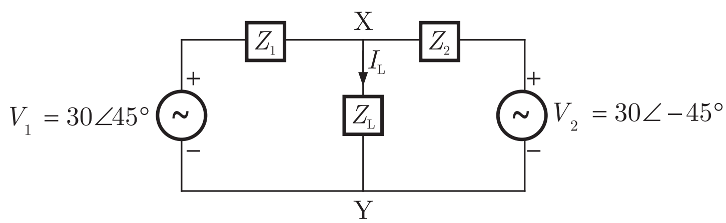
MCQ 2.110 What is the energy stored in L, a long time after the switch is opened

(A) Zero (B) 250 J

(C) 225 J (D) 2.5 J

Common Data Question for Q. 111-112* :

An electrical network is fed by two ac sources, as shown in figure, Given that $Z_1 = (1 - j)\,\Omega$, $Z_2 = (1 + j)\,\Omega$ and $Z_L = (1 + j0)\,\Omega$.



MCQ 2.111 *Thevenin voltage and impedance across terminals X and Y respectively are

(A) 0 V, $(2 + 2j)\,\Omega$ (B) 60 V, $1\,\Omega$

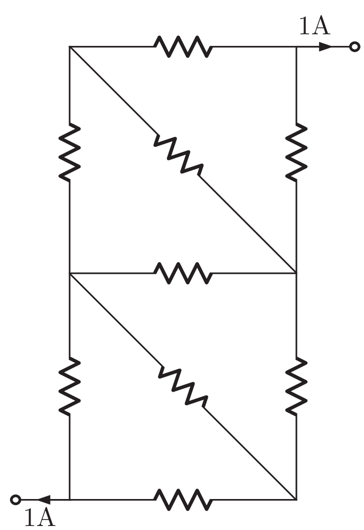
(C) 0 V, $1\,\Omega$ (D) 30 V, $(1 + j)\,\Omega$

MCQ 2.112 *Current i_L through load is

(A) 0 A (B) 1 A

(C) 0.5 A (D) 2 A

MCQ 2.113 *In the resistor network shown in figure, all resistor values are $1\,\Omega$. A current of 1 A passes from terminal a to terminal b as shown in figure, Voltage between terminal a and b is



(A) 1.4 Volt (B) 1.5 Volt

(C) 0 Volt (D) 3 Volt

YEAR 2001 **ONE MARK**

MCQ 2.114 In a series RLC circuit at resonance, the magnitude of the voltage developed across the capacitor

(A) is always zero

(B) can never be greater than the input voltage

(C) can be greater than the input voltage, however it is 90° out of phase with the input voltage

(D) can be greater than the input voltage, and is in phase with the input voltage.

MCQ 2.115 Two incandescent light bulbs of 40 W and 60 W rating are connected in series across the mains. Then

(A) the bulbs together consume 100 W

(B) the bulbs together consume 50 W

(C) the 60 W bulb glows brighter

(D) the 40 bulb glows brighter

MCQ 2.116 A unit step voltage is applied at $t = 0$ to a series RL circuit with zero initial conditions.

(A) It is possible for the current to be oscillatory.

(B) The voltage across the resistor at $t = 0^+$ is zero.

(C) The energy stored in the inductor in the steady state is zero.

(D) The resistor current eventually falls to zero.

MCQ 2.117 Given two coupled inductors L_1 and L_2, their mutual inductance M satisfies

(A) $M = \sqrt{L_1^2 + L_2^2}$ (B) $M > \frac{(L_1 + L_2)}{2}$

(C) $M > \sqrt{L_1 L_2}$ (D) $M \leq \sqrt{L_1 L_2}$

MCQ 2.118 A passive 2-port network is in a steady-state. Compared to its input, the steady state output can never offer

(A) higher voltage (B) lower impedance

(C) greater power (D) better regulation

YEAR 2001 **TWO MARKS**

MCQ 2.119 Consider the star network shown in Figure The resistance between terminals A and B with C open is 6 Ω, between terminals B and C with A open is 11 Ω, and between terminals C and A with B open is 9 Ω. Then

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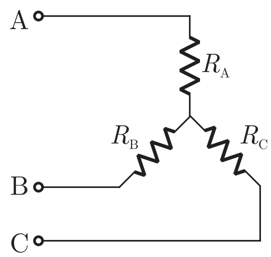


(A) $R_A = 4\,\Omega, R_B = 2\,\Omega, R_C = 5\,\Omega$

(B) $R_A = 2\,\Omega, R_B = 4\,\Omega, R_C = 7\,\Omega$

(C) $R_A = 3\,\Omega, R_B = 3\,\Omega, R_C = 4\,\Omega$

(D) $R_A = 5\,\Omega, R_B = 1\,\Omega, R_C = 10\,\Omega$

MCQ 2.120 A connected network of $N > 2$ nodes has at most one branch directly connecting any pair of nodes. The graph of the network

(A) Must have at least N branches for one or more closed paths to exist

(B) Can have an unlimited number of branches

(C) can only have at most N branches

(D) Can have a minimum number of branches not decided by N

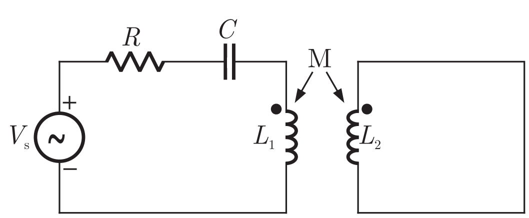
MCQ 2.121 A 240 V single-phase ac source is connected to a load with an impedance of $10\angle 60^\circ\,\Omega$. A capacitor is connected in parallel with the load. If the capacitor suplies 1250 VAR, the real power supplied by the source is

(A) 3600 W (B) 2880 W

(C) 240 W (D) 1200 W

Common Data Questions Q.122-123*:

For the circuit shown in figure given values are
$R = 10\,\Omega$, $C = 3\,\mu$F, $L_1 = 40$ mH, $L_2 = 10$ mH and $M = 10$ mH



MCQ 2.122 The resonant frequency of the circuit is

A) $\frac{1}{3} \times 10^5$ rad/sec (B) $\frac{1}{2} \times 10^5$ rad/sec

(C) $\frac{1}{\sqrt{21}} \times 10^5$ rad/sec (D) $\frac{1}{9} \times 10^5$ rad/sec

MCQ 2.123 The Q-factor of the circuit in Q.82 is

(A) 10 (B) 350

(C) 101 (D) 15

MCQ 2.124 Given the potential function in free space to be $V(x) = (50x^2 + 50y^2 + 50z^2)$ volts, the magnitude (in volts/metre) and the direction of the electric field at a point (1,-1,1), where the dimensions are in metres, are

(A) $100; (\hat{i} + \hat{j} + \hat{k})$ (B) $100/\sqrt{3}; (\hat{i} - \hat{j} + \hat{k})$

(C) $100\sqrt{3}; [(-\hat{i} + \hat{j} - \hat{k})/\sqrt{3}]$ (D) $100\sqrt{3}; [(-\hat{i} - \hat{j} - \hat{k})/\sqrt{3}]$

MCQ 2.125 The hysteresis loop of a magnetic material has an area of 5 cm^2 with the scales given as 1 cm = 2 AT and 1 cm = 50 mWb. At 50 Hz, the total hysteresis loss is.

(A) 15 W (B) 20 W

(C) 25 W (D) 50 W

MCQ 2.126 The conductors of a 10 km long, single phase, two wire line are separated by a distance of 1.5 m. The diameter of each conductor is 1 cm. If the conductors are of copper, the inductance of the circuit is

(A) 50.0 mH (B) 45.3 mH

(C) 23.8 mH (D) 19.6 mH

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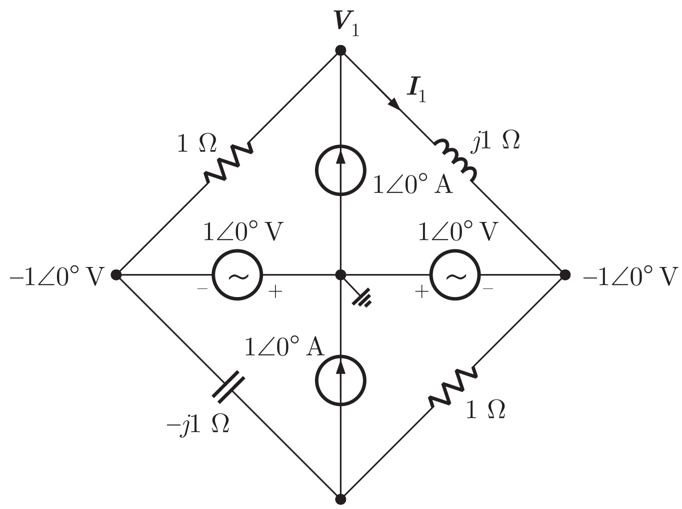
SOLUTION

SOL 2.1 Option (C) is correct.



Applying nodal analysis at top node.

$$\frac{V_1 + 1\angle 0^\circ}{1} + \frac{V_1 + 1\angle 0^\circ}{j1} = 1\angle 0^\circ$$

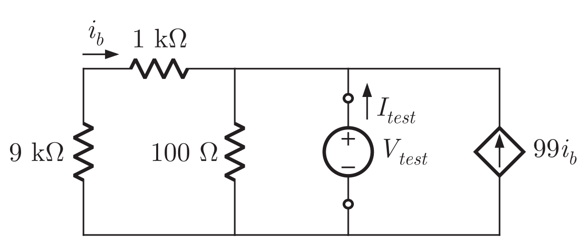
$$V_1(j1+1) + j1 + 1\angle 0^\circ = j1$$

$$V_1 = \frac{-1}{1+j1}$$

Current $$I_1 = \frac{V_1 + 1\angle 0^\circ}{j1} = \frac{-\frac{1}{1+j}+1}{j1} = \frac{j}{(1+j)j} = \frac{1}{1+j}\text{ A}$$

SOL 2.2 Option (A) is correct.

We put a test source between terminal 1, 2 to obtain equivalent impedance



$$Z_{Th} = \frac{V_{test}}{I_{test}}$$

By applying KCL at top right node

$$\frac{V_{test}}{9\text{k}+1\text{k}} + \frac{V_{test}}{100} - 99I_b = I_{test}$$

$$\frac{V_{test}}{10\text{k}} + \frac{V_{test}}{100} - 99I_b = I_{test} \qquad \text{...(i)}$$

But $$I_b = -\frac{V_{test}}{9k+1k} = -\frac{V_{test}}{10\text{k}}$$

Substituting I_b into equation (i), we have

$$\frac{V_{test}}{10\text{k}} + \frac{V_{test}}{100} + \frac{99\,V_{test}}{10\text{k}} = I_{test}$$

$$\frac{100\,V_{test}}{10\times 10^3} + \frac{V_{test}}{100} = I_{test}$$

$$\frac{2\,V_{test}}{100} = I_{test}$$

$$Z_{Th} = \frac{V_{test}}{I_{test}} = 50\,\Omega$$

SOL 2.3 Option (C) is correct.

$$G(s) = \frac{(s^2+9)(s+2)}{(s+1)(s+3)(s+4)}$$

$$G(j\omega) = \frac{(-\omega^2+9)(j\omega+2)}{(j\omega+1)(j\omega+3)(j\omega+4)}$$

The steady state output will be zero if

$$|G(j\omega)| = 0$$

$$-\omega^2 + 9 = 0$$

$$\omega = 3\text{ rad/s}$$

SOL 2.4 Option (B) is correct.

In phasor form

$$Z = 4 - j3$$

$$Z = 5\angle{-36.86^\circ}\,\Omega$$

$$\boldsymbol{I} = 5\angle{100^\circ}\text{ A}$$

Average power delivered.

$$P_{avg.} = \frac{1}{2}|\boldsymbol{I}|^2 Z\cos\theta = \frac{1}{2}\times 25\times 5\cos 36.86^\circ = 50\text{ W}$$

Alternate method:

$$Z = (4-j3)\,\Omega$$

$$I = 5\cos(100\pi t + 100)\text{ A}$$

$$P_{avg} = \frac{1}{2}\text{Re}\{|I|^2 Z\} = \frac{1}{2}\times\text{Re}\{(5)^2\times(4-j3)\} = \frac{1}{2}\times 100 = 50\text{ W}$$

SOL 2.5 Option (D) is correct.

The s-domain equivalent circuit is shown as below.

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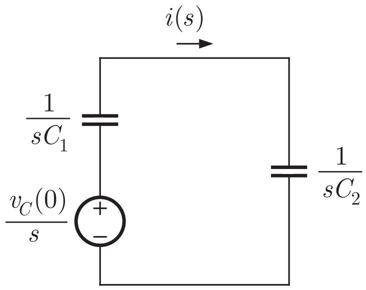


$$I(s) = \frac{v_c(0)/s}{\frac{1}{C_1 s} + \frac{1}{C_2 s}} = \frac{v_c(0)}{\frac{1}{C_1} + \frac{1}{C_2}}$$

$$I(s) = \left(\frac{C_1 C_2}{C_1 + C_2}\right)(12\text{ V}) \qquad v_C(0) = 12\text{ V}$$

$$I(s) = 12 C_{eq}$$

Taking inverse Laplace transform for the current in time domain,

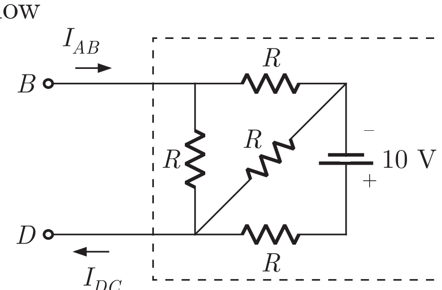
$$i(t) = 12 C_{eq}\delta(t) \qquad \text{(Impulse)}$$

SOL 2.6 Option (A) is correct.

In the given circuit, $V_A - V_B = 6\text{ V}$

So current in the branch, $I_{AB} = \frac{6}{2} = 3\text{ A}$

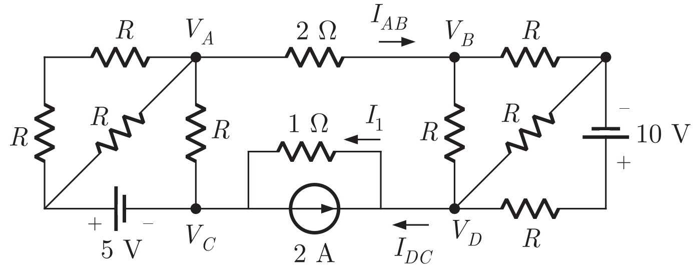
We can see, that the circuit is a one port circuit looking from terminal BD as shown below



One port network

For a one port network current entering one terminal, equals the current leaving the second terminal. Thus the outgoing current from A to B will be equal to the incoming current from D to C as shown

i.e. $I_{DC} = I_{AB} = 3\text{ A}$



The total current in the resistor $1\,\Omega$ will be

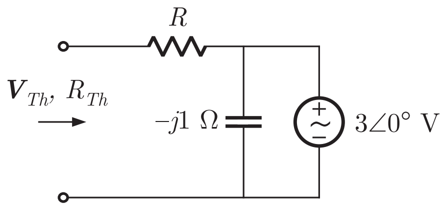
$$I_1 = 2 + I_{DC} \qquad \text{(By writing KCL at node } D\text{)}$$

$$= 2 + 3 = 5\text{ A}$$

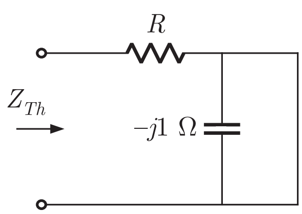
So, $$V_{CD} = 1 \times (-I_1) = -5\text{ V}$$

SOL 2.7 Option (A) is correct.

We obtain Thevenin equivalent of circuit B.



Thevenin Impedance :

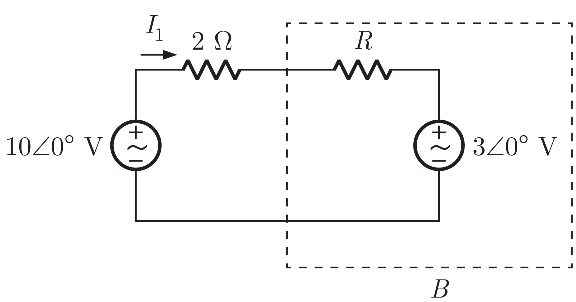


$$Z_{Th} = R$$

Thevenin Voltage :

$$\mathbf{V}_{Th} = 3\angle 0^\circ\text{ V}$$

Now, circuit becomes as



Current in the circuit, $I_1 = \dfrac{10-3}{2+R}$

Power transfer from circuit A to B

$$P = (I_1^2)^2 R + 3I_1$$

$$= \left[\frac{10-3}{2+R}\right]^2 R + 3\left[\frac{10-3}{2+R}\right] = \frac{49R}{(2+R)^2} + \frac{21}{(2+R)}$$

$$= \frac{49R + 21(2+R)}{(2+R)^2} = \frac{42+70R}{(2+R)^2}$$

$$\frac{dP}{dR} = \frac{(2+R)^2 70 - (42+70R)\,2\,(2+R)}{(2+R)^4} = 0$$

$$(2+R)\,[(2+R)\,70 - (42+70R)\,2] = 0$$

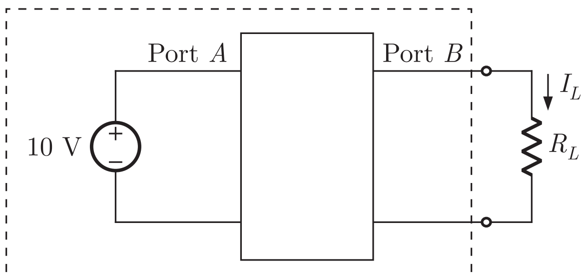
$$140 + 70R - 84 - 140R = 0$$

$$56 = 70R$$

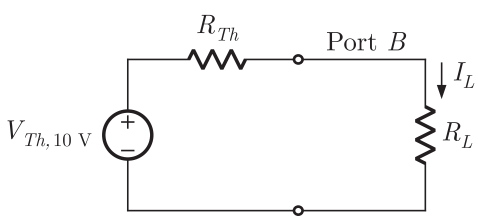
$$R = 0.8\,\Omega$$

SOL 2.8 Option (C) is correct.

When 10 V is connected at port A the network is



Now, we obtain Thevenin equivalent for the circuit seen at load terminal, let Thevenin voltage is $V_{Th,10\,V}$ with 10 V applied at port A and Thevenin resistance is R_{Th}.



$$I_L = \frac{V_{Th,10\,V}}{R_{Th} + R_L}$$

For $R_L = 1\,\Omega$, $I_L = 3$ A

$$3 = \frac{V_{Th,10\,V}}{R_{Th} + 1} \qquad \text{...(i)}$$

For $R_L = 2.5\,\Omega$, $I_L = 2$ A

$$2 = \frac{V_{Th,10\,V}}{R_{Th} + 2.5} \qquad \text{...(ii)}$$

Dividing above two

$$\frac{3}{2} = \frac{R_{Th} + 2.5}{R_{Th} + 1}$$

$$3R_{Th} + 3 = 2R_{Th} + 5$$

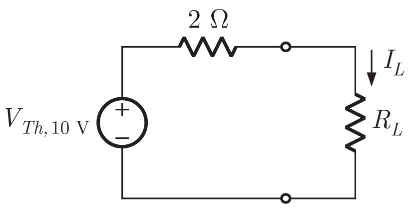
$$R_{Th} = 2\,\Omega$$

Substituting R_{Th} into equation (i)

$$V_{Th,10\,V} = 3(2+1) = 9\,V$$

Note that it is a non reciprocal two port network. Thevenin voltage seen at port B depends on the voltage connected at port A. Therefore we took subscript $V_{Th,10\,V}$. This is Thevenin voltage only when $10\,V$ source is connected at input port A. If the voltage connected to port A is different, then Thevenin voltage will be different. However, Thevenin's resistance remains same.

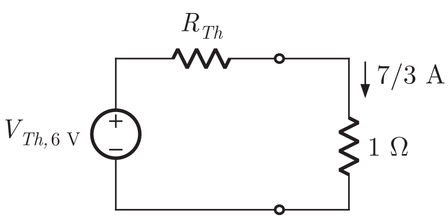
Now, the circuit is



For $R_L = 7\,\Omega$, $\quad I_L = \frac{V_{Th,10\,V}}{2+R_L} = \frac{9}{2+7} = 1\,A$

SOL 2.9 Option (B) is correct.

Now, when $6\,V$ connected at port A let Thevenin voltage seen at port B is $V_{Th,6\,V}$. Here $R_L = 1\,\Omega$ and $I_L = \frac{7}{3}\,A$



$$V_{Th,6\,V} = R_{Th} \times \frac{7}{3} + 1 \times \frac{7}{3} = 2 \times \frac{7}{3} + \frac{7}{3} = 7\,V$$

This is a linear network, so V_{Th} at port B can be written as

$$V_{Th} = V_1\alpha + \beta$$

where V_1 is the input applied at port A.

We have $V_1 = 10\,V$, $V_{Th,10\,V} = 9\,V$

$$9 = 10\alpha + \beta \qquad ...(i)$$

When $V_1 = 6\,V$, $V_{Th,\,6\,V} = 9\,V$

$$7 = 6\alpha + \beta \qquad ...(ii)$$

Solving (i) and (ii)

$$\alpha = 0.5,\ \beta = 4$$

Thus, with any voltage V_1 applied at port A, Thevenin voltage or open circuit voltage at port B will be

So, $\quad V_{Th,\,V_1} = 0.5\,V_1 + 4$

For $V_1 = 8\text{ V}$

$$V_{Th,8\text{ V}} = 0.5 \times 8 + 4 = 8 = V_{oc} \qquad \text{(open circuit voltage)}$$

SOL 2.10 Option (A) is correct.

By taking $\boldsymbol{V}_1$, $\boldsymbol{V}_2$ and $\boldsymbol{V}_3$ all are phasor voltages.

$$\boldsymbol{V}_1 = \boldsymbol{V}_2 + \boldsymbol{V}_3$$

Magnitude of $\boldsymbol{V}_1$, $\boldsymbol{V}_2$ and $\boldsymbol{V}_3$ are given as

$$V_1 = 220\text{ V},\ V_2 = 122\text{ V},\ V_3 = 136\text{ V}$$

Since voltage across R is in same phase with $\boldsymbol{V}_1$ and the voltage V_3 has a phase difference of θ with voltage $\boldsymbol{V}_1$, we write in polar form

$$\boldsymbol{V}_1 = V_2\angle 0^\circ + V_3\angle\theta$$

$$\boldsymbol{V}_1 = V_2 + V_3\cos\theta + jV_3\sin\theta$$

$$\boldsymbol{V}_1 = (V_2 + V_3\cos\theta) + jV_3\sin\theta$$

$$|\boldsymbol{V}_1| = \sqrt{(V_2 + V_3\cos\theta)^2 + (V_2\sin\theta)^2}$$

$$220 = \sqrt{(122 + 136\cos\theta)^2 + (136\sin\theta)^2}$$

By solving, power factor

$$\cos\theta = 0.45$$

SOL 2.11 Option (B) is correct.

Voltage across load resistance

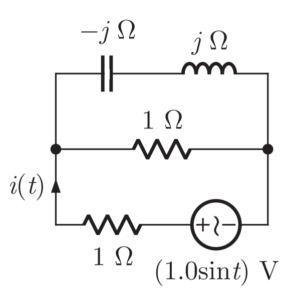
$$V_{RL} = V_3\cos\theta = 136 \times 0.45 = 61.2\text{ V}$$

Power absorbed in R_L

$$P_L = \frac{V_{RL}^2}{R_L} = \frac{(61.2)^2}{5} \simeq 750\text{ W}$$

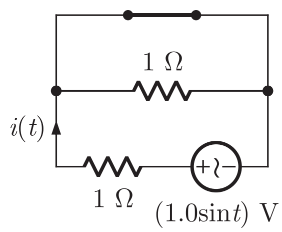
SOL 2.12 Option (B) is correct.

The frequency domains equivalent circuit at $\omega = 1\text{ rad/sec}$.



Since the capacitor and inductive reactances are equal in magnitude, the net impedance of that branch will become zero.

Equivalent circuit



Current $$i(t) = \frac{\sin t}{1\,\Omega} = (1\sin t)\,\text{A}$$

rms value of current

$$i_{\text{rms}} = \frac{1}{\sqrt{2}}\,\text{A}$$

SOL 2.13 Option (D) is correct.

Voltage in time domain

$$v(t) = 100\sqrt{2}\cos(100\pi t)$$

Current in time domain

$$i(t) = 10\sqrt{2}\sin(100\pi t + \pi/4)$$

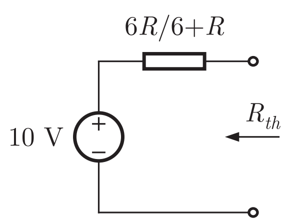
Applying the following trigonometric identity

$$\sin(\phi) = \cos(\phi - 90^\circ)$$

So, $$i(t) = 10\sqrt{2}\cos(100\pi t + \pi/4 - \pi/2)$$
$$= 10\sqrt{2}\cos(100\pi t - \pi/4)$$

In phasor form, $$\boldsymbol{I} = \frac{10\sqrt{2}}{\sqrt{2}}\angle{-\pi/4}$$

SOL 2.14 Option (A) is correct.



Power transferred to the load

$$P = I^2 R_L = \left(\frac{10}{R_{th} + R_L}\right)^2 R_L$$

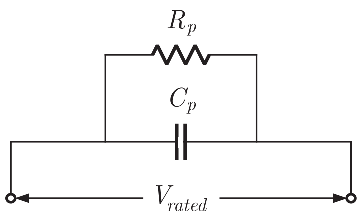
For maximum power transfer R_{th}, should be minimum.

$$R_{th} = \frac{6R}{6+R} = 0$$

$$R = 0$$

Note: Since load resistance is constant so we choose a minimum value of R_{th}

SOL 2.15 Option (C) is correct.



$$\text{Power loss} = \frac{V_{rated}^2}{R_p} = \frac{(5\times 10^3)^2}{1.25\times 10^6} = 20\text{ W}$$

For an parallel combination of resistance and capacitor

$$\tan\delta = \frac{1}{\omega C_p R_p} = \frac{1}{2\pi\times 50\times 1.25\times 0.102} = \frac{1}{40} = 0.025$$

SOL 2.16 Option (C) is correct.

Charge

$$Q = CV = \frac{\varepsilon_0\varepsilon_r A}{d}V = (\varepsilon_0\varepsilon_r A)\frac{V}{d} \qquad C = \frac{\varepsilon_0\varepsilon_r A}{d}$$

$$Q = Q_{\max}$$

We have $\varepsilon_0 = 8.85\times 10^{-14}\text{ F/cm}$, $\varepsilon_r = 2.26$, $A = 20\times 40\text{ cm}^2$

$$\frac{V}{d} = 50\times 10^3\text{ kV/cm}$$

Maximum electrical charge on the capacitor

when $$\frac{V}{d} = \left(\frac{V}{d}\right)_{\max} = 50\text{ kV/cm}$$

Thus, $$Q = 8.85\times 10^{-14}\times 2.26\times 20\times 40\times 50\times 10^3 = 8\,\mu\text{C}$$

SOL 2.17 Option (C) is correct.

$$v_i = 100\sqrt{2}\sin(100\pi t)\text{ V}$$

Fundamental component of current

$$i_{i_1} = 10\sqrt{2}\sin(100\pi t - \pi/3)\text{ A}$$

Input power factor

$$pf = \frac{I_{1(rms)}}{I_{rms}}\cos\phi_1$$

$I_{1(rms)}$ is rms values of fundamental component of current and I_{rms} is the rms value of converter current.

$$pf = \frac{10}{\sqrt{10^2+5^2+2^2}}\cos\pi/3 = 0.44$$

SOL 2.18 Option (B) is correct.

Only the fundamental component of current contributes to the mean ac input power. The power due to the harmonic components of current is zero.

So, $$P_{\text{in}} = V_{rms} I_{1rms} \cos\phi_1 = 100 \times 10 \cos\pi/3 = 500 \text{ W}$$

SOL 2.19 Option (B) is correct.

Power delivered by the source will be equal to power dissipated by the resistor.

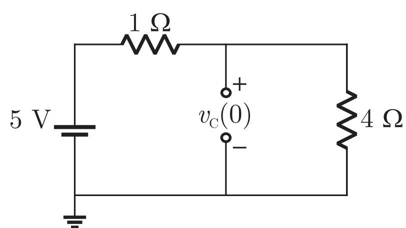
$$P = V_s I_s \cos\pi/4 = 1 \times \sqrt{2} \cos\pi/4 = 1 \text{ W}$$

SOL 2.20 Option (D) is correct.

$$\overline{I_C} = \overline{I_s} - \overline{I_{RL}} = \sqrt{2}\angle\pi/4 - \sqrt{2}\angle-\pi/4$$
$$= \sqrt{2}\{(\cos\pi/4 + j\sin\pi/4) - (\cos\pi/4 - j\sin\pi/4)\}$$
$$= 2\sqrt{2}\, j\sin\pi/4 = 2j$$

SOL 2.21 Option (B) is correct.

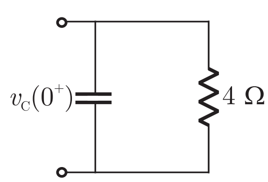
For $t < 0$, the switch was closed for a long time so equivalent circuit is



Voltage across capacitor at $t = 0$

$$v_c(0) = \frac{5}{4 \times 1} = 4 \text{ V}$$

Now switch is opened, so equivalent circuit is



For capacitor at $t = 0^+$

$$v_c(0^+) = v_c(0) = 4 \text{ V}$$

current in 4 Ω resistor at $t = 0^+$, $i_1 = \dfrac{v_c(0^+)}{4} = 1$ A

so current in capacitor at $t = 0^+$, $i_c(0^+) = i_1 = 1$ A

SOL 2.22 Option (B) is correct.

Thevenin equivalent across 1 Ω resistor can be obtain as following

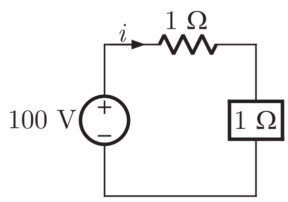
Open circuit voltage $\quad v_{th} = 100$ V $\quad (i = 0)$

Short circuit current $\quad i_{sc} = 100 \text{ A} \quad (v_{th} = 0)$

So,

$$R_{th} = \frac{v_{th}}{i_{sc}} = \frac{100}{100} = 1\,\Omega$$

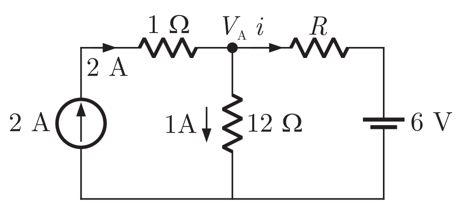
Equivalent circuit is



$$i = \frac{100}{1+1} = 50 \text{ A}$$

SOL 2.23 Option (B) is correct.

The circuit is



Current in $R\,\Omega$ resistor is

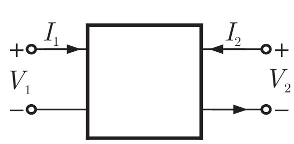
$$i = 2 - 1 = 1 \text{ A}$$

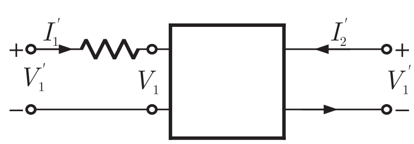
Voltage across $12\,\Omega$ resistor is

$$V_A = 1 \times 12 = 12 \text{ V}$$

So, $$i = \frac{V_A - 6}{R} = \frac{12-6}{1} = 6\,\Omega$$

SOL 2.24 Option (C) is correct.





$V_1 = Z_{11}I_1 + Z_{12}I_2 \qquad V'_1 = Z'_{11}I'_1 + Z'_{12}I'_2$

$V_2 = Z_{21}I_1 + Z_{22}I_2 \qquad V'_2 = Z'_{21}I'_1 + Z'_{22}I'_2$

Here, $I_1 = I'_1,\ I_2 = I'_2$

When $R = 1\,\Omega$ is connected

$$V'_1 = V_1 + I'_1 \times 1 = V_1 + I_1$$

$$V'_1 = Z_{11}I_1 + Z_{12}I_2 + I_1$$

$$V'_1 = (Z_{11}+1)I_1 + Z_{12}I_2$$

So, $$Z'_{11} = Z_{11} + 1$$

$$Z'_{12} = Z_{12}$$

Similarly for output port

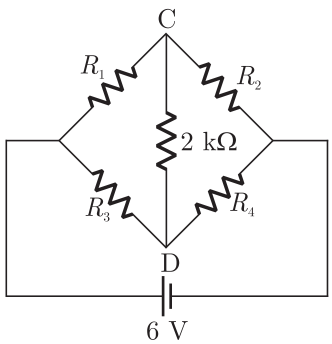
$$V'_2 = Z'_{21}I'_1 + Z'_{22}I'_2$$

$$= Z'_{21}I_1 + Z'_{22}I_2$$

So, $Z'_{21} = Z_{21}$, $Z'_{22} = Z_{22}$

Z-matrix is $$Z = \begin{bmatrix} Z_{11}+1 & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}$$

SOL 2.25 Option (A) is correct.



In the bridge

$$R_1R_4 = R_2R_3 = 1$$

So it is a balanced bridge

$$I = 0 \text{ mA}$$

SOL 2.26 Option (D) is correct.

Resistance of the bulb rated 200 W/220 V is

$$R_1 = \frac{V^2}{P_1} = \frac{(220)^2}{200} = 242\,\Omega$$

Resistance of 100 W/220 V lamp is

$$R_T = \frac{V^2}{P_2} = \frac{(220)^2}{100} = 484\,\Omega$$

To connect in series

$$R_T = n \times R_1$$

$$484 = n \times 242$$

$$n = 2$$

SOL 2.27 Option (D) is correct.

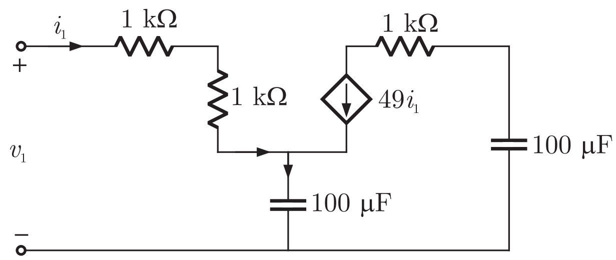
For $t < 0$, S_1 is closed and S_2 is opened so the capacitor C_1 will charged upto 3 volt.

$$V_{C1}(0) = 3 \text{ Volt}$$

Now when switch positions are changed, by applying charge conservation

$$C_{eq}V_{C_1}(0^+) = C_1V_{C_1}(0^+) + C_2V_{C_2}(0^+)$$
$$(2+1)\times 3 = 1\times 3 + 2\times V_{C_2}(0^+)$$
$$9 = 3 + 2V_{C_2}(0^+)$$
$$V_{C_2}(0^+) = 3 \text{ Volt}$$

SOL 2.28 Option (A) is correct.



Applying KVL in the input loop

$$v_1 - i_1(1+1)\times 10^3 - \frac{1}{j\omega C}(i_1 + 49i_1) = 0$$
$$v_1 = 2\times 10^3 i_1 + \frac{1}{j\omega C}50i_1$$

Input impedance, $Z_1 = \frac{v_1}{i_1} = 2\times 10^3 + \frac{1}{j\omega(C/50)}$

Equivalent capacitance, $C_{eq} = \frac{C}{50} = \frac{100\ \mu\text{F}}{50} = 2\ \mu\text{F}$

SOL 2.29 Option (B) is correct.

Voltage across 2 Ω resistor, $V_S = 2$ V

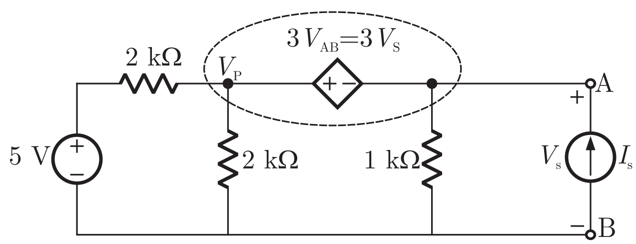
Current, $I_{2\Omega} = \frac{V_S}{2} = \frac{4}{2} = 2$ A

To make the current double we have to take

$$V_S = 8 \text{ V}$$

SOL 2.30 Option (B) is correct.

To obtain equivalent Thevenin circuit, put a test source between terminals AB



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Applying KCL at super node

$$\frac{V_P - 5}{2} + \frac{V_P}{2} + \frac{V_S}{1} = I_S$$

$$V_P - 5 + V_P + 2V_S = 2I_S$$

$$2V_P + 2V_S = 2I_s + 5$$

$$V_P + V_S = I_S + 2.5 \quad ...(1)$$

$$V_P - V_S = 3V_S$$

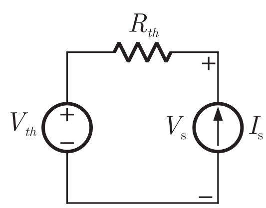
$\Rightarrow$ $$V_P = 4V_S$$

So, $$4V_S + V_S = I_S + 2.5$$

$$5V_S = I_S + 2.5$$

$$V_S = 0.2I_S + 0.5 \quad ...(2)$$

For Thevenin equivalent circuit



$$V_S = I_S R_{th} + V_{th} \quad ...(3)$$

By comparing (2) and (3),

Thevenin resistance $R_{th} = 0.2\,\text{k}\Omega$

SOL 2.31 Option (D) is correct.

From above $V_{th} = 0.5$ V

SOL 2.32 Option (A) is correct.

No. of chords is given as

$$l = b - n + 1$$

$b \rightarrow$ no. of branches

$n \rightarrow$ no. of nodes

$l \rightarrow$ no. of chords

$b = 6, \quad n = 4$

$$l = 6 - 4 + 1 = 3$$

SOL 2.33 Option (A) is correct.

Impedance $Z_o = 2.38 - j0.667\ \Omega$

Constant term in impedance indicates that there is a resistance in the circuit. Assume that only a resistance and capacitor are in the circuit, phase difference in Thevenin voltage is given as

$$\theta = -\tan^{-1}(\omega CR) \qquad \text{(Due to capacitor)}$$

$$Z_o = R - \frac{j}{\omega C}$$

So, $$\frac{1}{\omega C} = 0.667$$

and $$R = 2.38\,\Omega$$

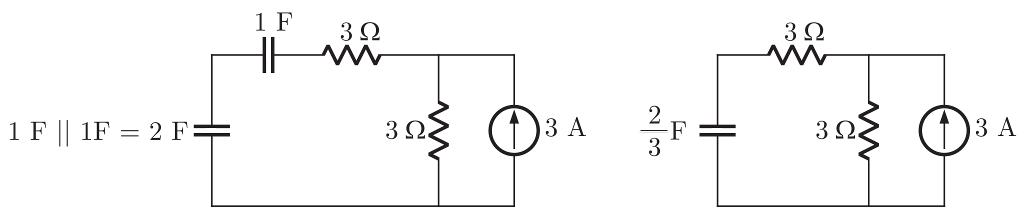
$$\theta = -\tan^{-1}\left(\frac{1 \times 2.38}{0.667}\right) = -74.34^\circ \neq -15.9^\circ$$

given $$V_{oc} = 3.71\angle -15.9^\circ$$

So, there is an inductor also connected in the circuit

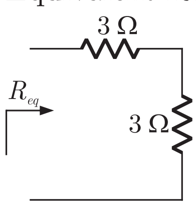
SOL 2.34 Option (C) is correct.

Time constant of the circuit can be calculated by simplifying the circuit as follows



$$C_{eq} = \frac{2}{3}\text{ F}$$

Equivalent Resistance



$$R_{eq} = 3 + 3 = 6\,\Omega$$

Time constant $$\tau = R_{eq}C_{eq} = 6 \times \frac{2}{3} = 4\text{ sec}$$

SOL 2.35 Option (C) is correct.

Impedance of the circuit is

$$Z = j\omega L + \frac{\frac{1}{j\omega C}R}{\frac{1}{j\omega C} + R} = j\omega L + \frac{R}{1 + j\omega CR} \times \frac{1 - j\omega CR}{1 - j\omega CR}$$

$$= j\omega L + \frac{R(1 - j\omega CR)}{1 + \omega^2 C^2 R^2} = \frac{j\omega L(1 + \omega^2 C^2 R^2) + R - j\omega CR^2}{1 + \omega^2 C^2 R^2}$$

$$= \frac{R}{1 + \omega^2 C^2 R^2} + \frac{j[\omega L(1 + \omega^2 C^2 R^2) - \omega CR^2]}{1 + \omega^2 C^2 R^2}$$

For resonance $\text{Im}(Z) = 0$

So, $\omega L(1+\omega^2 C^2 R^2) = \omega CR^2$

$L = 0.1$ H, $C = 1$ F, $R = 1\,\Omega$

So, $\omega \times 0.1[1+\omega^2(1)(1)] = \omega(1)(1)^2$

$$1+\omega^2 = 10$$

$$\Rightarrow \qquad \omega = \sqrt{9} = 3 \text{ rad/sec}$$

SOL 2.36 Option (A) is correct.

By applying KVL in the circuit

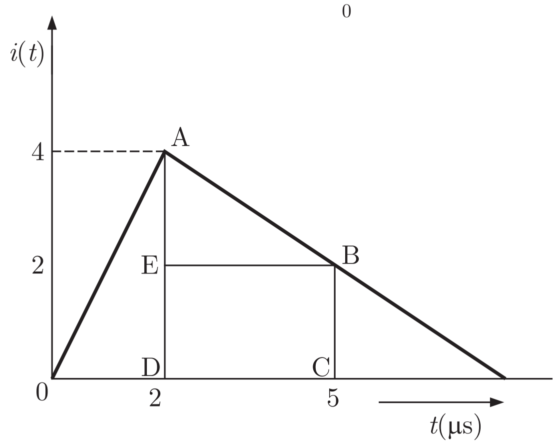
$$V_{ab} - 2i + 5 = 0$$

$i = 1$ A, $\qquad V_{ab} = 2\times 1 - 5 = -3$ Volt

SOL 2.37 Option (C) is correct.

Charge stored at $t = 5\,\mu$ sec

$$Q = \int_0^5 i(t)\,dt = \text{area under the curve}$$



$$Q = \text{Area OABCDO}$$

$$= \text{Area (OAD)} + \text{Area(AEB)} + \text{Area(EBCD)}$$

$$= \frac{1}{2}\times 2\times 4 + \frac{1}{2}\times 2\times 3 + 3\times 2$$

$$= 4+3+6 = 13 \text{ nC}$$

SOL 2.38 Option (D) is correct.

Initial voltage across capacitor

$$V_0 = \frac{Q_o}{C} = \frac{13\text{ nC}}{0.3\text{ nF}} = 43.33 \text{ Volt}$$

When capacitor is connected across an inductor it will give sinusoidal esponse as

$$v_c(t) = V_o \cos\omega_o t$$

where $\omega_o = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.3\times10^{-9}\times0.6\times10^{-3}}}$

$$= 2.35\times10^6 \text{ rad/sec}$$

At $t = 1\,\mu\text{sec}$, $v_c(t) = 43.33\cos(2.35\times10^6\times1\times10^{-6})$

$$= 43.33\times(-0.70) = -30.44 \text{ V}$$

SOL 2.39 Option (B) is correct.

By writing node equations at node A and B

$$\frac{V_a-5}{1} + \frac{V_a-0}{1} = 0$$

$$2V_a - 5 = 0$$

$$V_a = 2.5 \text{ V}$$

Similarly

$$\frac{V_b - 4V_{ab}}{3} + + \frac{V_b-0}{1} = 0$$

$$\frac{V_b - 4(V_a - V_b)}{3} + V_b = 0$$

$$V_b - 4(2.5 - V_b) + 3V_b = 0$$

$$8V_b - 10 = 0$$

$$V_b = 1.25 \text{ V}$$

Current $i = \frac{V_b}{1} = 1.25 \text{ A}$

SOL 2.40 Option ( ) is correct.

SOL 2.41 Option (B) is correct.

Here two capacitance C_1 and C_2 are connected in series, so equivalent capacitance is

$$C_{eq} = \frac{C_1C_2}{C_1+C_2}$$

C_1	Glass	$\varepsilon_{r1} = 8;\ d_1 = 4$ mm
C_2	Paper	$\varepsilon_{r2} = 2;\ d_2 = 2$ mm

$$C_1 = \frac{\varepsilon_0\varepsilon_{r1}A}{d_1} = \frac{8.85\times10^{-12}\times8\times500\times500\times10^{-6}}{4\times10^{-3}}$$

$$= 442.5\times10^{-11} \text{ F}$$

$$C_2 = \frac{\varepsilon_0\varepsilon_{r2}A}{d_2} = \frac{8.85\times10^{-12}\times2\times500\times500\times10^{-6}}{2\times10^{-3}}$$

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$$= 221.25 \times 10^{-11} \text{ F}$$

$$C_{eq} = \frac{442.5 \times 10^{-11} \times 221.25 \times 10^{-11}}{442.5 \times 10^{-11} + 221.25 \times 10^{-11}} = 147.6 \times 10^{-11}$$

$$\simeq 1476 \text{ pF}$$

SOL 2.42 Option (B) is correct.

Circumference $l = 300$ mm

no. of turns $n = 300$

Cross sectional area $A = 300 \text{ mm}^2$

Inductance of coil $L = \frac{\mu_0 n^2 A}{l} = \frac{4\pi \times 10^{-7} \times (300)^2 \times 300 \times 10^{-6}}{(300 \times 10^{-3})}$

$$= 113.04 \text{ } \mu\text{H}$$

SOL 2.43 Option (A) is correct.

Divergence of a vector field is given as

Divergence $= \nabla \cdot V$

In cartesian coordinates

$$\nabla = \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}$$

So $$\nabla \cdot V = \frac{\partial}{\partial x}[-(x\cos xy + y)] + \frac{\partial}{\partial y}[(y\cos xy)] + \frac{\partial}{\partial z}[(\sin z^2 + x^2 + y^2)]$$

$$= -x(-\sin xy)\, y + y(-\sin xy)\, x + 2z\cos z^2 = 2z\cos z^2$$

SOL 2.44 Option (A) is correct.

Writing KVL for both the loops

$$V - 3(I_1 + I_2) - V_x - 0.5\frac{dI_1}{dt} = 0$$

$$V - 3I_1 - 3I_2 - V_x - 0.5\frac{dI_1}{dt} = 0 \quad ...(1)$$

In second loop

$$-5I_2 + 0.2V_x + 0.5\frac{dI_1}{dt} = 0$$

$$I_2 = 0.04V_x + 0.1\frac{dI_1}{dt} \quad ...(2)$$

Put I_2 from eq(2) into eq(2)

$$V - 3I_1 - 3\left[0.04V_x + 0.1\frac{dI_1}{dt}\right] - V_x - 0.5\frac{dI_1}{dt} = 0$$

$$0.8\frac{dI_1}{dt} = -1.12V_x - 3I_1 + V$$

$$\frac{dI_1}{dt} = -1.4V_x - 3.75I_1 + \frac{5}{4}V$$

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SOL 2.45 Option (A) is correct.

Impedance of the given network is

$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

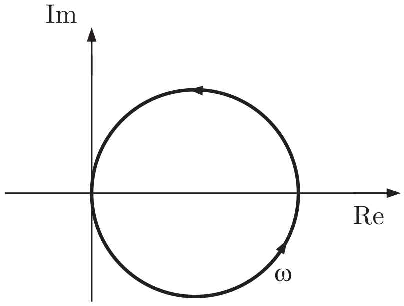
$$\text{Admittance}Y = \frac{1}{Z} = \frac{1}{R + j\left(\omega L - \frac{1}{\omega C}\right)}$$

$$= \frac{1}{R + j\left(\omega L - \frac{1}{\omega C}\right)} \times \frac{R - j\left(\omega L - \frac{1}{\omega C}\right)}{R - j\left(\omega L - \frac{1}{\omega C}\right)} = \frac{R - j\left(\omega L - \frac{1}{\omega C}\right)}{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$= \frac{R}{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} - \frac{j\left(\omega L - \frac{1}{\omega C}\right)}{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

$$= \mathrm{Re}(Y) + \mathrm{Im}(Y)$$

Varying frequency for $\mathrm{Re}(Y)$ and $\mathrm{Im}(Y)$ we can obtain the admittance-locus.



SOL 2.46 Option (D) is correct.

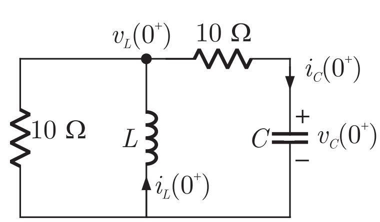
At $t = 0^+$, when switch positions are changed inductor current and capacitor voltage does not change simultaneously

So at $t = 0^+$

$$v_c(0^+) = v_c(0^-) = 10 \text{ V}$$

$$i_L(0^+) = i_L(0^-) = 10 \text{ A}$$

The equivalent circuit is



Applying KCL

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$$\frac{v_L(0^+)}{10} + \frac{v_L(0^+) - v_c(0^+)}{10} = i_L(0^+) = 10$$

$$2v_L(0^+) - 10 = 100$$

Voltage across inductor at $t = 0^+$

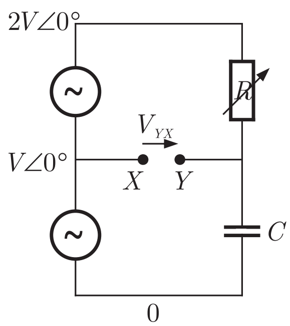
$$v_L(0^+) = \frac{100 + 10}{2} = 55 \text{ V}$$

So, current in capacitor at $t = 0^+$

$$i_C(0^+) = \frac{v_L(0^+) - v_c(0^+)}{10} = \frac{55 - 10}{10} = 4.5 \text{ A}$$

SOL 2.47 Option (B) is correct.

In the circuit



$$V_X = V\angle 0^\circ$$

$$\frac{V_y - 2V\angle 0^\circ}{R} + (V_y) j\omega C = 0$$

$$V_y(1 + j\omega CR) = 2V\angle 0^\circ$$

$$V_y = \frac{2V\angle 0^\circ}{1 + j\omega CR}$$

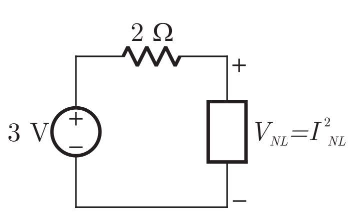
$$V_{YX} = V_X - V_Y = V - \frac{2V}{1 + j\omega CR}$$

$R \to 0$, $\quad V_{YX} = V - 2V = -V$

$R \to \infty$, $\quad V_{YX} = V - 0 = V$

SOL 2.48 Option (A) is correct.

The circuit is



Applying KVL

$$3 - 2 \times I_{NL}^2 = V_{NL}$$
$$3 - 2I_{NL}^2 = I_{NL}^2$$
$$3I_{NL}^2 = 3 \Rightarrow I_{NL} = 1 \text{ A}$$
$$V_{NL} = (1)^2 = 1 \text{ V}$$

So power dissipated in the non-linear resistance

$$P = V_{NL} I_{NL} = 1 \times 1 = 1 \text{ W}$$

SOL 2.49 Option (C) is correct.

In node incidence matrix

$$\begin{array}{c} \\ n_1 \\ n_2 \\ n_3 \\ n_4 \end{array} \begin{array}{c} \begin{matrix} b_1 & b_2 & b_3 & b_4 & b_5 & b_6 \end{matrix} \\ \begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & -1 & 1 & 0 \\ -1 & 0 & 0 & 0 & -1 & -1 \\ 0 & 0 & -1 & 1 & 0 & 1 \end{bmatrix} \end{array}$$

In option (C)

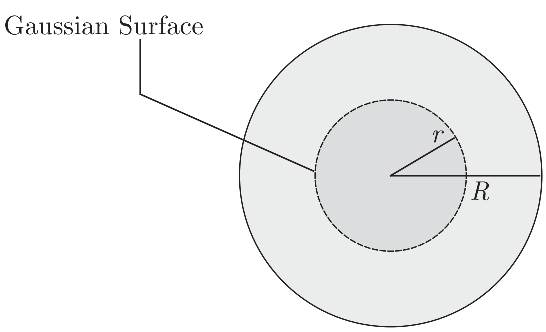
$$E = AV$$

$$\begin{bmatrix} e_1 & e_2 & e_3 & e_4 \end{bmatrix}^T = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & -1 & 1 & 0 \\ -1 & 0 & 0 & 0 & -1 & -1 \\ 0 & 0 & -1 & 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} V_1 & V_2 & -- & V_6 \end{bmatrix}^T$$

$$\begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ e_4 \end{bmatrix} = \begin{bmatrix} V_1 + V_2 + V_3 \\ -V_2 - V_4 + V_5 \\ -V_1 - V_5 - V_6 \\ -V_3 + V_4 + V_6 \end{bmatrix} \text{ which is true.}$$

SOL 2.50 Option (A) is correct.

Assume a Gaussian surface inside the sphere $(x < R)$



From gauss law

$$\psi = Q_{\text{enclosed}}$$
$$= \oint D \cdot ds = Q_{\text{enclosed}}$$

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$$Q_{enclosed} = \frac{Q}{\frac{4}{3}\pi R^3} \times \frac{4}{3}\pi r^3 = \frac{Qr^3}{R^3}$$

So, $$\oint D \cdot ds = \frac{Qr^3}{R^3}$$

or $$D \times 4\pi r^2 = \frac{Qr^3}{R^3} = \frac{Q}{4\pi\varepsilon_0}\frac{r}{R^3} \qquad \because D = \varepsilon_0 E$$

SOL 2.51 Option (D) is correct.

Inductance is given as

$$L = \frac{\mu_0 N^2 A}{l} = \frac{4\pi \times 10^{-7} \times (400)^2 \times (16 \times 10^{-4})}{(1 \times 10^{-3})} = 321.6 \text{ mH}$$

$$V = IX_L = \frac{230}{2\pi f L} \qquad \therefore X_L = 2\pi f L$$

$$= \frac{230}{2 \times 3.14 \times 50 \times 321.6 \times 10^{-3}} = 2.28 \text{ A}$$

SOL 2.52 Option (A) is correct.

Energy stored is inductor

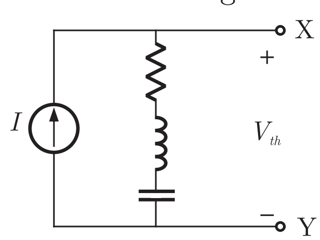
$$E = \frac{1}{2}LI^2 = \frac{1}{2} \times 321.6 \times 10^{-3} \times (2.28)^2$$

Force required to reduce the air gap of length 1 mm is

$$F = \frac{E}{l} = \frac{0.835}{1 \times 10^{-3}} = 835 \text{ N}$$

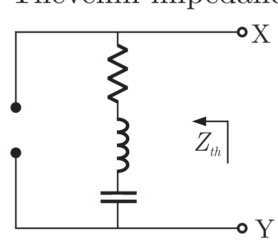
SOL 2.53 Option (D) is correct.

Thevenin voltage:



$$V_{th} = I(R + Z_L + Z_C) = 1\angle 0^\circ [1 + 2j - j]$$
$$= 1(1 + j) = \sqrt{2}\angle 45^\circ \text{ V}$$

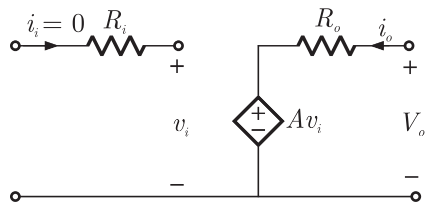
Thevenin impedance:



$$Z_{th} = R + Z_L + Z_C = 1 + 2j - j = (1 + j)\,\Omega$$

SOL 2.54 Option (A) is correct.

In the given circuit



Output voltage

$$v_o = Av_i = 10^6 \times 1\,\mu\text{V} = 1 \text{ V}$$

Input impedance

$$Z_i = \frac{v_i}{i_i} = \frac{v_i}{0} = \infty$$

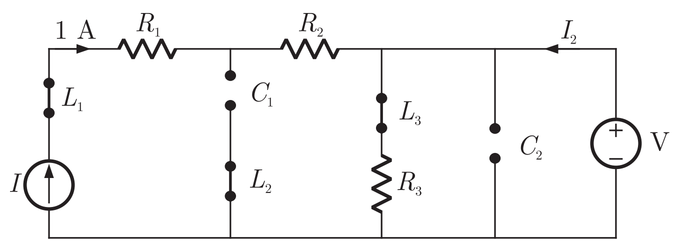
Output impedance

$$Z_o = \frac{v_o}{i_o} = \frac{Av_i}{i_o} = R_o = 10\,\Omega$$

SOL 2.55 Option (D) is correct.

All sources present in the circuit are DC sources, so all inductors behaves as short circuit and all capacitors as open circuit

Equivalent circuit is



Voltage across R_3 is

$$5 = I_1 R_3$$
$$5 = I_1(1)$$
$$I_1 = 5 \text{ A} \qquad \text{(current through } R_3\text{)}$$

By applying KCL, current through voltage source

$$1 + I_2 = I_1$$
$$I_2 = 5 - 1 = 4 \text{ A}$$

SOL 2.56 Option () is correct.

Given Two port network can be described in terms of h-parametrs only.

SOL 2.57 Option (A) is correct.

At resonance reactance of the circuit would be zero and voltage across inductor and capacitor would be equal

$$V_L = V_C$$

At resonance impedance of the circuit

$$Z_R = R_1 + R_2$$

Current $\quad I_R = \dfrac{V_1\angle 0^\circ}{R_1 + R_2}$

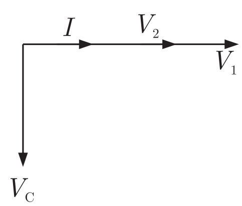
Voltage $\quad V_2 = I_R R_2 + j(V_L - V_C)$

$$V_2 = \frac{V_1\angle 0^\circ}{R_1 + R_2} R_2$$

Voltage across capacitor

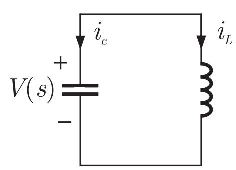
$$V_C = \frac{1}{j\omega C} \times I_R = \frac{1}{j\omega C} \times \frac{V_R\angle 0^\circ}{R_1 + R_2} = \frac{V_R\angle -90^\circ}{\omega C(R_1 + R_2)}$$

So phasor diagram is



SOL 2.58 Option (B) is correct.

This is a second order LC circuit shown below



Capacitor current is given as

$$i_C(t) = C\frac{dv_c(t)}{dt}$$

Taking Laplace transform

$$I_C(s) = CsV(s) - V(0),\ V(0) \rightarrow \text{initial voltage}$$

Current in inductor

$$i_L(t) = \frac{1}{L}\int v_c(t)\,dt$$

$$I_L(s) = \frac{1}{L}\frac{V(s)}{s}$$

for $t > 0$, applying KCL(in s-domain)

$$I_C(s) + I_L(s) = 0$$

$$CsV(s) - V(0) + \frac{1}{L}\frac{V(s)}{s} = 0$$

$$\left[s^2 + \frac{1}{LCs}\right]V(s) = V_o$$

$$V(s) = V_o\frac{s}{s^2+\omega_0^2}, \qquad \because \omega_0^2 = \frac{1}{LC}$$

Taking inverse Laplace transformation

$$v(t) = V_o\cos\omega_o t, \quad t > 0$$

SOL 2.59 Option (B) is correct.

Power dissipated in heater when AC source is connected

$$P = 2.3\,\text{kW} = \frac{V_{rms}^2}{R}$$

$$2.3\times10^3 = \frac{(230)^2}{R}$$

$$R = 23\,\Omega \text{ (Resistance of heater)}$$

Now it is connected with a square wave source of 400 V peak to peak

Power dissipated is

$$P = \frac{V_{rms}^2}{R}, \qquad V_{p-p} = 400\text{ V} \Rightarrow V_p = 200\text{ V}$$

$$= \frac{(200)^2}{23} = 1.739\text{ kW} \qquad V_{rms} = V_p = 200 \text{ (for square wave)}$$

SOL 2.60 Option (D) is correct.

From maxwell's first equation

$$\nabla\cdot D = \rho_v$$

$$\nabla\cdot E = \frac{\rho_v}{\varepsilon}$$

(Divergence of electric field intensity is non-Zero)

Maxwell's fourth equation

$$\nabla\cdot B = 0$$

(Divergence of magnetic field intensity is zero)

SOL 2.61 Option (C) is correct.

Current in the circuit

$$I = \frac{100}{R+(10\,||\,10)} = 8\text{ A} \qquad \text{(given)}$$

$$\frac{100}{R+5} = 8$$

Or $$R = \frac{60}{8} = 7.5\,\Omega$$

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SOL 2.62 Option (A) is correct.

Rms value is given as

$$\mu_{rms} = \sqrt{3^2 + \frac{(4)^2}{2}} = \sqrt{9+8} = \sqrt{17} \text{ V}$$

SOL 2.63 Option (D) is correct.

Writing KVL in input and output loops

$V_1 - (i_1 + i_2) Z_1 = 0$

$$V_1 = Z_1 i_1 + Z_1 i_2 \qquad ...(1)$$

Similarly

$V_2 - i_2 Z_2 - (i_1 + i_2) Z_1 = 0$

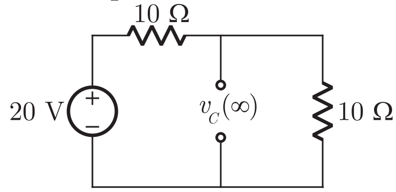
$$V_2 = Z_1 i_1 + (Z_1 + Z_2) i_2 \qquad ...(2)$$

From equation (1) and (2) Z-matrix is given as

$$Z = \begin{bmatrix} Z_1 & Z_1 \\ Z_1 & Z_1 + Z_2 \end{bmatrix}$$

SOL 2.64 Option (B) is correct.

In final steady state the capacitor will be completely charged and behaves as an open circuit



Steady state voltage across capacitor

$$v_c(\infty) = \frac{20}{10+10}(10) = 10 \text{ V}$$

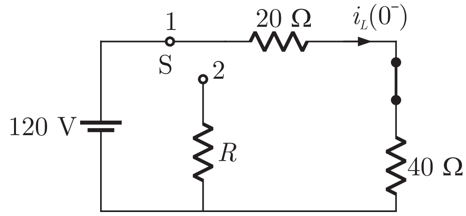
SOL 2.65 Option (D) is correct.

We know that divergence of the curl of any vector field is zero

$$\nabla (\nabla \times \vec{\mathbf{E}}) = 0$$

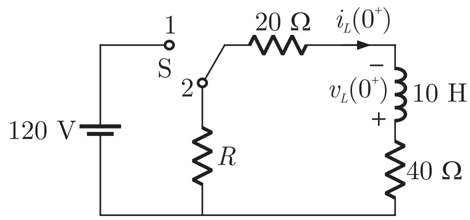
SOL 2.66 Option (A) is correct.

When the switch is at position 1, current in inductor is given as



$$i_L(0^-) = \frac{120}{20+40} = 2 \text{ A}$$

At $t=0$, when switch is moved to position 1,inductor current does not change simultaneously so



$$i_L(0^+) = i_L(0^-) = 2\text{ A}$$

Voltage across inductor at $t=0^+$

$$v_L(0^+) = 120\text{ V}$$

By applying KVL in loop

$$120 = 2(40+R+20)$$
$$120 = 120+R$$
$$R = 0\,\Omega$$

SOL 2.67 Option (C) is correct.

Let stored energy and dissipated energy are E_1 and E_2 respectively. Then Current

$$\frac{i_2^2}{i_1^2} = \frac{E_2}{E_1} = 0.95$$
$$i_2 = \sqrt{0.95}\,i_1 = 0.97 i_1$$

Current at any time t, when the switch is in position (2) is given by

$$i(t) = i_1 e^{-\frac{R}{L}t} = 2e^{-\frac{60}{10}t} = 2e^{-6t}$$

After 95% of energy dissipated current remaining in the circuit is

$$i = 2 - 2\times 0.97 = 0.05\text{ A}$$

So,
$$0.05 = 2e^{-6t}$$
$$t \approx 0.50\text{ sec}$$

SOL 2.68 Option (C) is correct.

At $f_1 = 100$ Hz, voltage drop across R and L is μ_{RMS}

$$\mu_{\text{RMS}} = \left|\frac{V_{in}.R}{R+j\omega_1 L}\right| = \left|\frac{V_{in}(j\omega_1 L)}{R+j\omega_1 L}\right|$$

So,
$$R = \omega_1 L$$

At $f_2 = 50$ Hz, voltage drop across R

$$\mu'_{\text{RMS}} = \left|\frac{V_{in}.R}{R+j\omega_2 L}\right|$$

$$\frac{\mu_{RMS}}{\mu'_{RMS}} = \left|\frac{R + j\omega_2 L}{R + j\omega_1 L}\right| = \sqrt{\frac{R^2 + \omega_2^2 L^2}{R^2 + \omega_1^2 L^2}}$$

$$= \sqrt{\frac{\omega_1^2 L^2 + \omega_2^2 L^2}{\omega_1^2 L^2 + \omega_1^2 L^2}}, \quad R = \omega_1 L$$

$$= \sqrt{\frac{\omega_1^2 + \omega_2^2}{2\omega_1^2}} = \sqrt{\frac{f_1^2 + f_2^2}{2f_1^2}} = \sqrt{\frac{(100)^2 + (50)^2}{2(100)^2}} = \sqrt{\frac{5}{8}}$$

$$\mu'_{RMS} = \sqrt{\frac{8}{5}}\mu_{RMS}$$

SOL 2.69 Option (A) is correct.

In the circuit

$$\overline{I}_B = I_R\angle 0° + I_y\angle 120°$$

$$I_B^2 = I_R^2 + I_y^2 + 2I_R I_y \cos\left(\frac{120°}{2}\right) = I_R^2 + I_y^2 + I_R I_y$$

Since $\quad I_R = I_y$

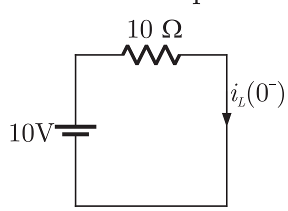
so, $\quad I_B^2 = I_R^2 + I_R^2 + I_R^2 = 3I_R^2$

$$I_B = \sqrt{3}\, I_R = \sqrt{3}\, I_y$$

$$I_R : I_y : I_B = 1:1:\sqrt{3}$$

SOL 2.70 Option (C) is correct.

Switch was opened before $t = 0$, so current in inductor for $t < 0$



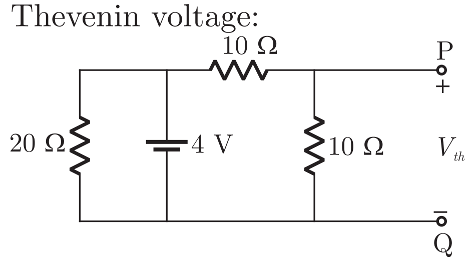
$$i_L(0^-) = \frac{10}{10} = 1 \text{ A}$$

Inductor current does not change simultaneously so at $t = 0$ when switch is closed current remains same

$$i_L(0^+) = i_L(0^-) = 1 \text{ A}$$

SOL 2.71 Option (A) is correct.

Thevenin voltage:



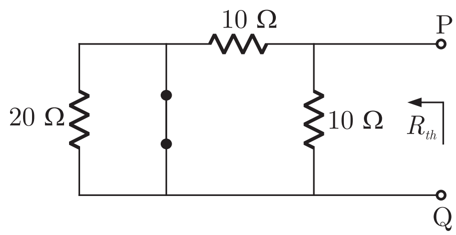
Nodal analysis at P

$$\frac{V_{th}-4}{10}+\frac{V_{th}}{10}=0$$

$$2V_{th}-4=0$$

$$V_{th}=2\text{ V}$$

Thevenin resistance:



$$R_{th}=10\,\Omega\,||\,10\,\Omega=5\,\Omega$$

SOL 2.72 Option (A) is correct.

Electric field inside a conductor (metal) is zero. In dielectric charge distribution os constant so electric field remains constant from x_1 to x_2. In semiconductor electric field varies linearly with charge density.

SOL 2.73 Option (D) is correct.

Resonance will occur only when Z is capacitive, in parallel resonance condition, suseptance of circuit should be zero.

$$\frac{1}{j\omega L}+j\omega C=0$$

$$1-\omega^2LC=0$$

$$\omega=\frac{1}{\sqrt{LC}}\quad\text{(resonant frequency)}$$

$$C=\frac{1}{\omega^2L}=\frac{1}{4\times\pi^2\times(500)^2\times2}=0.05\,\mu\text{F}$$

SOL 2.74 Option (D) is correct.

Here two capacitor C_1 and C_2 are connected in series so equivalent Capacitance is

$$C_{eq}=\frac{C_1C_2}{C_1+C_2}$$

$$C_1=\frac{\varepsilon_0\varepsilon_{r1}A}{d_1}=\frac{8.85\times10^{-12}\times4(400\times10^{-3})^2}{6\times10^{-3}}$$

$$=\frac{8.85\times10^{-12}\times4\times16\times10^{-2}}{6\times10^{-3}}=94.4\times10^{-11}\text{ F}$$

Similarly

$$C_2=\frac{\varepsilon_0\varepsilon_{r2}A}{d_2}=\frac{8.85\times10^{-12}\times2\times(400\times10^{-3})^2}{8\times10^{-3}}$$

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$$= \frac{8.85 \times 10^{-12} \times 2 \times 16 \times 10^{-12}}{8 \times 10^{-3}} = 35.4 \times 10^{-11}\ \text{F}$$

$$C_{eq} = \frac{94.4 \times 10^{-11} \times 35.4 \times 10^{-11}}{(94.4 + 35.4) \times 10^{-11}} = 25.74 \times 10^{-11} \simeq 257\ \text{pF}$$

SOL 2.75 Option (C) is correct.

Inductance of the Solenoid is given as

$$L = \frac{\mu_0 N^2 A}{l}$$

Where $A \rightarrow$ are of Solenoid

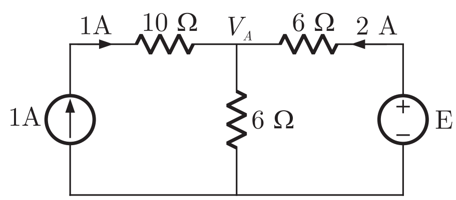
$l \rightarrow$ length

$$L = \frac{4\pi \times 10^{-7} \times (3000)^2 \times \pi (30 \times 10^{-3})^2}{(1000 \times 10^{-3})} = 31.94 \times 10^{-3}\ \text{H}$$

$$\simeq 32\ \text{mH}$$

SOL 2.76 Option (C) is correct.

In the circuit



Voltage $V_A = (2 + 1) \times 6 = 18\ \text{Volt}$

So,

$$2 = \frac{E - V_A}{6}$$

$$2 = \frac{E - 18}{6}$$

$$E = 12 + 18 = 30\ \text{V}$$

SOL 2.77 Option (A) is correct.

Delta to star ($\Delta - Y$) conversions is given as

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c} = \frac{10 \times 10}{20 + 10 + 10} = 2.5\,\Omega$$

$$R_2 = \frac{R_a R_c}{R_a + R_b + R_c} = \frac{20 \times 10}{20 + 10 + 10} = 5\,\Omega$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c} = \frac{20 \times 10}{20 + 10 + 10} = 5\,\Omega$$

SOL 2.78 Option (D) is correct.

For parallel circuit

$$I = \frac{E}{Z_{eq}} = EY_{eq}$$

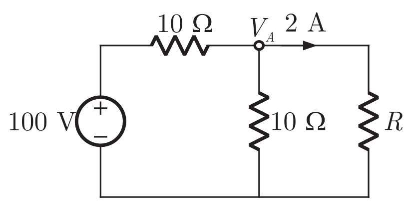
$Y_{eq} \rightarrow$ Equivalent admittance of the circuit

$$Y_{eq} = Y_R + Y_L + Y_C = (0.5 + j0) + (0 - j1.5) + (0 + j0.3)$$
$$= 0.5 - j1.2$$

So, current $I = 10(0.5 - j1.2) = (5 - j12)\text{ A}$

SOL 2.79 Option (B) is correct.

In the circuit



Voltage $V_A = \frac{100}{10 + (10\,||\,R)} \times (10\,||\,R) = \left(\frac{100}{10 + \frac{10R}{10+R}}\right)\left(\frac{10R}{10+R}\right)$

$$= \frac{1000R}{100 + 20R} = \frac{50R}{5+R}$$

Current in $R\,\Omega$ resistor

$$2 = \frac{V_A}{R}$$

$$2 = \frac{50R}{R(5+R)}$$

or $R = 20\,\Omega$

SOL 2.80 Option (A) is correct.

Since capacitor initially has a charge of 10 coulomb, therefore

$$Q_0 = Cv_c(0) \qquad v_c(0) \rightarrow \text{initial voltage across capacitor}$$
$$10 = 0.5v_c(0)$$
$$v_c(0) = \frac{10}{0.5} = 20\text{ V}$$

When switch S is closed, in steady state capacitor will be charged completely and capacitor voltage is

$$v_c(\infty) = 100\text{ V}$$

At any time t transient response is

$$v_c(t) = v_c(\infty) + [v_c(0) - v_c(\infty)]\,e^{-\frac{t}{RC}}$$
$$v_c(t) = 100 + (20 - 100)\,e^{-\frac{t}{2\times 0.5}} = 100 - 80e^{-t}$$

Current in the circuit

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$$i(t) = C\frac{dv_c}{dt} = C\frac{d}{dt}[100 - 80e^{-t}]$$

$$= C \times 80e^{-t} = 0.5 \times 80e^{-t} = 40e^{-t}$$

At $t = 1$ sec,

$$i(t) = 40e^{-1} = 14.71 \text{ A}$$

SOL 2.81 Option (D) is correct.

Total current in the wire

$$I = 10 + 20\sin\omega t$$

$$I_{rms} = \sqrt{10^2 + \frac{(20)^2}{2}} = \sqrt{100 + 200} = \sqrt{300} = 17.32 \text{ A}$$

SOL 2.82 Option (D) is correct.

From Z to Y parameter conversion

$$\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}^{-1}$$

So,

$$\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{12} & Y_{22} \end{bmatrix} = \frac{1}{0.50}\begin{bmatrix} 0.6 & -0.2 \\ -0.2 & 0.9 \end{bmatrix}$$

$$Y_{22} = \frac{0.9}{0.50} = 1.8$$

SOL 2.83 Option (C) is correct.

Energy absorbed by the inductor coil is given as

$$E_L = \int_0^t P dt$$

Where power

$$P = VI = I\left(L\frac{dI}{dt}\right)$$

So,

$$E_L = \int_0^t LI\left(\frac{dI}{dt}\right)dt$$

For$0 \le t \le 4$ sec

$$E_L = 2\int_0^4 I\left(\frac{dI}{dt}\right)dt$$

$$= 2\int_0^2 I(3)\,dt + 2\int_2^4 I(0)\,dt \qquad \left\{\because \frac{dI}{dt} = 3, 0 \le t \le 2, \quad = 0, 2 < t < 4\right.$$

$$= 6\int_0^2 I.dt = 6(\text{area under the curve } i(t) - t)$$

$$= 6 \times \frac{1}{2} \times 2 \times 6 = 36 \text{ J}$$

Energy absorbed by $1\,\Omega$ resistor is

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$$E_R = \int_0^t I^2 R dt$$

$$= \int_0^2 (3t)^2 \times 1 dt + \int_2^4 (6)^2 dt \qquad \begin{cases} I = 3t, & 0 \le t \le 2 \\ = 6\text{ A} & 2 \le t \le 4 \end{cases}$$

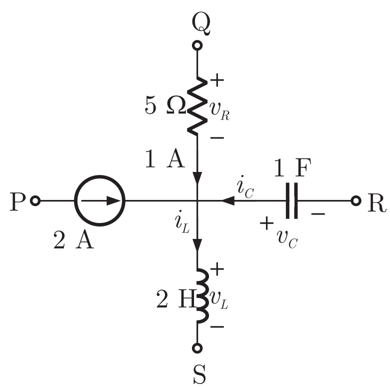
$$= 9 \times \left[\frac{t^3}{3}\right]_0^2 + 36\left[t\right]_2^4 = 24 + 72 = 96 \text{ J}$$

Total energy absorbed in 4 sec

$$E = E_L + E_R = 36 + 96 = 132 \text{ J}$$

SOL 2.84 Option (B) is correct.

Applying KCL at center node



$$i_L = i_C + 1 + 2$$

$$i_L = i_C + 3$$

$$i_C = -C\frac{dv_c}{dt} = -1\frac{d}{dt}[4\sin 2t]$$

$$= -8\cos 2t$$

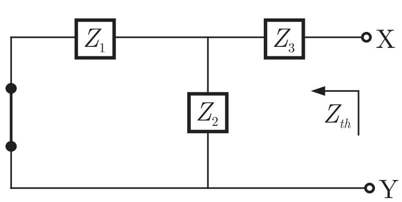
so $\qquad i_L = -8\cos 2t + 3 \qquad$ (current through inductor)

Voltage across inductor

$$v_L = L\frac{di_L}{dt} = 2 \times \frac{d}{dt}[3 - 8\cos 2t] = 32\sin 2t$$

SOL 2.85 Option (A) is correct.

Thevenin impedance can be obtain as following



$$Z_{th} = Z_3 + (Z_1 || Z_2)$$

Given that $Z_1 = 10\angle -60^\circ = 10\left(\frac{1-\sqrt{3}j}{2}\right) = 5(1-\sqrt{3}j)$

$$Z_2 = 10\angle 60^\circ = 10\left(\frac{1+\sqrt{3}j}{2}\right) = 5(1+\sqrt{3}j)$$

$$Z_3 = 50\angle 53.13^\circ = 50\left(\frac{3+4j}{5}\right) = 10(3+4j)$$

So,

$$Z_{th} = 10(3+4j) + \frac{5(1-3j)\,5(1+\sqrt{3}j)}{5(1-\sqrt{3}j)+5(1+\sqrt{3}j)}$$

$$= 10(3+4j) + \frac{25(1+3)}{10} = 30+40j+10 = 40+40j$$

$$Z_{th} = 40\sqrt{2}\angle 45^\circ\,\Omega$$

SOL 2.86 Option (A) is correct.

Due to the first conductor carrying $+I$ current, magnetic field intensity at point P is

$$\vec{\mathbf{H}}_1 = \frac{I}{2\pi d}\vec{\mathbf{Y}} \text{ (Direction is determined using right hand rule)}$$

Similarly due to second conductor carrying $-I$ current, magnetic field intensity is

$$\vec{\mathbf{H}}_2 = \frac{-I}{2\pi d}(-\vec{\mathbf{Y}}) = \frac{I}{2\pi d}\vec{\mathbf{Y}}$$

Total magnetic field intensity at point P.

$$\vec{\mathbf{H}} = \vec{\mathbf{H}}_1 + \vec{\mathbf{H}}_2 = \frac{I}{2\pi d}\vec{\mathbf{Y}} + \frac{I}{2\pi d}\vec{\mathbf{Y}} = \frac{I}{\pi d}\vec{\mathbf{Y}}$$

SOL 2.87 Option ( ) is correct.

SOL 2.88 Option (C) is correct.

Given that magnitudes of V_L and V_C are twice of V_R

$$|V_L| = |V_C| = 2V_R \text{ (Circuit is at resonance)}$$

Voltage across inductor

$$V_L = i_R \times j\omega L$$

Current i_R at resonance

$$i_R = \frac{5\angle 0^\circ}{R} = \frac{5}{5} = 1 \text{ A}$$

so, $|V_L| = \omega L = 2V_R$

$$\omega L = 2\times 5 \qquad V_R = 5 \text{ V, at resonance}$$

$$2\times\pi\times 50\times L = 10$$

$$L = \frac{10}{314} = 31.8 \text{ mH}$$

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SOL 2.89 Option (C) is correct.

Applying nodal analysis in the circuit

At node P

$$2 + \frac{V_P - 10}{2} + \frac{V_P}{8} = 0$$

$$16 + 4V_P - 40 + V_P = 0$$

$$5V_P - 24 = 0$$

$$V_P = \frac{24}{5} \text{ Volt}$$

At node Q

$$2 = \frac{V_Q - 10}{4} + \frac{V_Q - 0}{6}$$

$$24 = 3V_Q - 30 + 2V_Q$$

$$5V_Q - 54 = 0$$

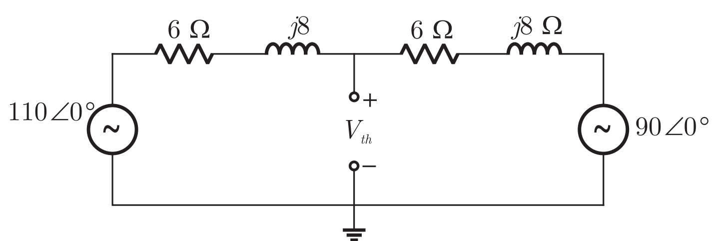
$$V_Q = \frac{54}{5} \text{ V}$$

Potential difference between P-Q

$$V_{PQ} = V_P - V_Q = \frac{24}{5} - \frac{54}{5} = -6 \text{ V}$$

SOL 2.90 Option (D) is correct.

First obtain equivalent Thevenin circuit across load R_L



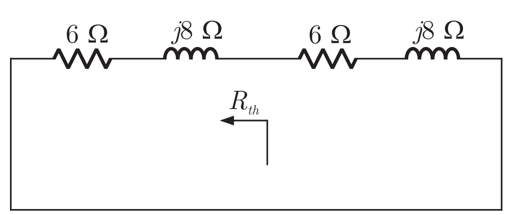
Thevenin voltage

$$\frac{V_{th} - 110\angle 0^\circ}{6 + 8j} + \frac{V_{th} - 90\angle 0^\circ}{6 + 8j} = 0$$

$$2V_{th} - 200\angle 0^\circ = 0$$

$$V_{th} = 100\angle 0^\circ \text{ V}$$

Thevenin impedance

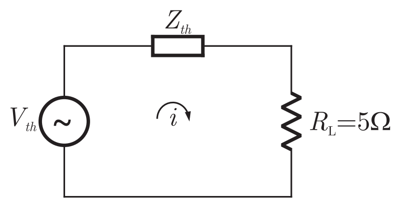


$$Z_{th} = (6 + 8j)\,\Omega \,||\, (6 + 8j)\,\Omega$$

$$= (3+4j)\,\Omega$$

For maximum power transfer

$$R_L = |Z_{th}| = \sqrt{3^2+4^2} = 5\,\Omega$$



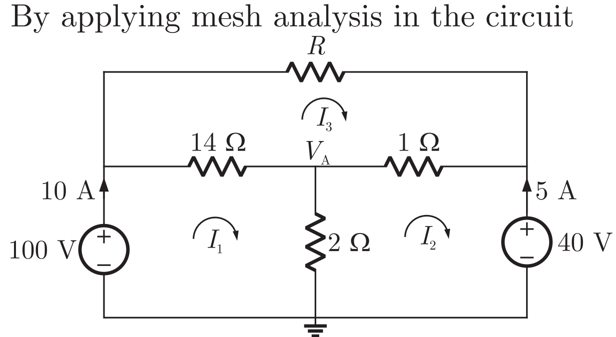
Power in load

$$P = i_{eff}^2 R_L$$

$$P = \left|\frac{100}{3+4j+5}\right|^2 \times 5 = \frac{(100)^2}{80} \times 5 = 625 \text{ Watt}$$

SOL 2.91 Option (D) is correct.

By applying mesh analysis in the circuit



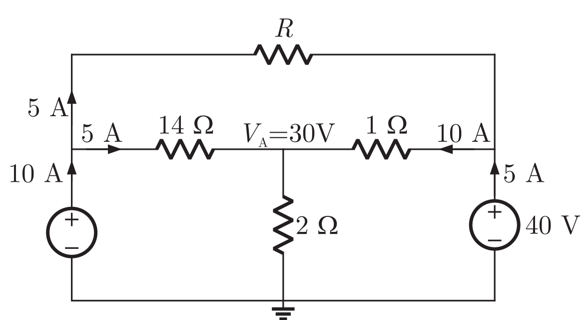
$I_1 = 10$ A, $I_2 = -5$ A

Current in $2\,\Omega$ resistor

$$I_{2\Omega} = I_1 - (-I_2) = 10 - (-5) = 15 \text{ A}$$

So, voltage $V_A = 15 \times 2 = 30$ Volt

Now we can easily find out current in all branches as following



Current in resistor R is 5 A

$$5 = \frac{100-40}{R}$$

$$R = \frac{60}{5} = 12\,\Omega$$

SOL 2.92 Option (B) is correct.

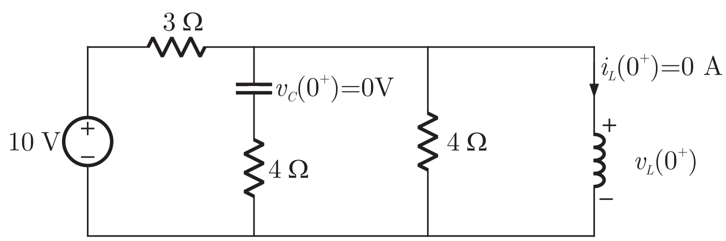
Before $t = 0$, the switch was opened so current in inductor and voltage across capacitor for $t < 0$ is zero

$v_c(0^-) = 0, \quad i_L(0^-) = 0$

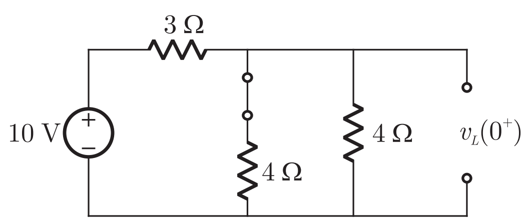
at $t = 0$, when the switch is closed, inductor current and capacitor voltage does not change simultaneously so

$v_c(0^+) = v_c(0^-) = 0, \quad i_L(0^+) = i_L(0^-) = 0$

At $t = 0^+$ the circuit is



Simplified circuit



Voltage across inductor (at $t = 0^+$)

$$v_L(0^+) = \frac{10}{3+2} \times 2 = 4 \text{ Volt}$$

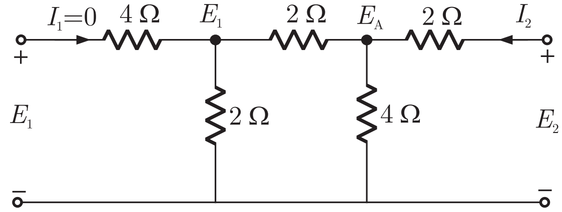
SOL 2.93 Option (D) is correct.

Given that $\quad E_1 = h_{11} I_1 + h_{12} E_2$

and $\quad I_2 = h_{21} I_1 + h_{22} E_2$

Parameter h_{12} is given as

$$h_{12} = \frac{E_1}{E_2}\bigg|_{I_1 = 0 \text{(open circuit)}}$$



At node A

$$\frac{E_A - E_1}{2} + \frac{E_A - E_2}{2} + \frac{E_A}{4} = 0$$

$$5E_A = 2E_1 + 2E_2 \qquad ...(1)$$

Similarly

$$\frac{E_1 - E_A}{2} + \frac{E_1}{2} = 0$$

$$2E_1 = E_A \qquad ...(2)$$

From (1) and (2)

$$5(2E_1) = 2E_1 + 2E_2 4$$

$$8E_1 = 2E_2$$

$$h_{12} = \frac{E_1}{E_2} = \frac{1}{4}$$

SOL 2.94 Option (B) is correct.

$$V_{PQ} = V_P - V_Q = \frac{KQ}{\text{OP}} - \frac{KQ}{\text{OQ}}$$

$$= \frac{9 \times 10^9 \times 1 \times 10^{-9}}{40 \times 10^{-3}} - \frac{9 \times 10^9 \times 1 \times 10^{-9}}{20 \times 10^{-3}}$$

$$= 9 \times 10^3 \left[\frac{1}{40} - \frac{1}{20}\right] = -225 \text{ Volt}$$

SOL 2.95 Option (D) is correct.

Energy stored in Capacitor is

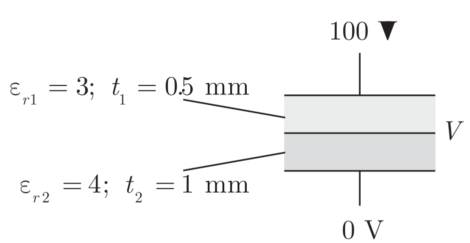
$$E = \frac{1}{2} C V^2$$

$$C = \frac{\varepsilon_0 A}{d} = \frac{8.85 \times 10^{-12} \times 100 \times 10^{-6}}{0.1 \times 10^{-3}} = 8.85 \times 10^{-12} \text{ F}$$

$$E = \frac{1}{2} \times 8.85 \times 10^{-12} \times (100)^2 = 44.3 \text{ nJ}$$

SOL 2.96 Option (B) is correct.

The figure is as shown below



The Capacitor shown in Figure is made up of two capacitor C_1 and C_2

connected in series.

$$C_1 = \frac{\varepsilon_0 \varepsilon_{r1} A}{t_1}, C_2 = \frac{\varepsilon_0 \varepsilon_{r2} A}{t_2}$$

Since C_1 and C_2 are in series charge on both capacitor is same.

$$Q_1 = Q_2$$

$$C_1(100 - V) = C_2 V \text{ (Let V is the voltage of foil)}$$

$$\frac{\varepsilon_0 \varepsilon_{r1} A}{t_1}(100 - V) = \frac{\varepsilon_0 \varepsilon_{r2} A}{t_2} V$$

$$\frac{3}{0.5}(100 - V) = \frac{4}{1} V$$

$$300 - 3V = 2V$$

$$300 = 5V \Rightarrow V = 60 \text{ Volt}$$

SOL 2.97 Option (D) is correct.

Voltage across capacitor is given by

$$v_c(t) = \frac{1}{C}\int_{-\infty}^{\infty} i(t)\,dt = \frac{1}{C}\int_{-\infty}^{\infty} 5\delta(t)\,dt = \frac{5}{C} \times u(t)$$

SOL 2.98 Option (C) is correct.

No. of links is given by

$$L = N - B + 1$$

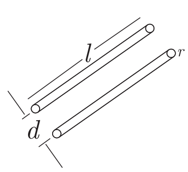
SOL 2.99 Option (A) is correct.

Divergence theorem states that the total outward flux of a vector field F through a closed surface is same as volume integral of the divergence of F

$$\oint_s \vec{\mathbf{F}} \cdot \vec{ds} = \int_V (\vec{\nabla} \cdot \vec{\mathbf{F}})\,dv$$

SOL 2.100 Option (C) is correct.

The figure as shown below



Inductance of parallel wire combination is given as

$$L = \frac{\mu_0 l}{\pi} \ln\left(\frac{d}{r}\right)$$

Where $l \rightarrow$ Length of wires

$d \rightarrow$ Distance between wires

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$r \rightarrow$ Radius

$L \propto \ln d$

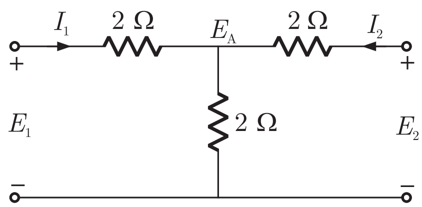
So when d is double, inductance increase but does not double.

SOL 2.101 Option (B) is correct.

Since distance from ground to lower surface is less than from ground to upper surface so electric stress is maximum at lower surface.

SOL 2.102 Option (B) is correct.

Writing node equation for the circuit



$$I_1 = \frac{E_1 - E_A}{2}$$

and $$I_2 = \frac{E_2 - E_A}{2}$$

At node A

$$\frac{E_A - E_1}{2} + \frac{E_A}{2} + \frac{E_A - E_2}{2} = 0$$

$$3E_A = E_1 + E_2 \qquad ...(1)$$

From eqn(1)

$$I_1 = \frac{1}{2}E_1 - \frac{1}{2}\frac{(E_1 + E_2)}{3}$$

$$I_1 = \frac{1}{3}E_1 - \frac{1}{6}E_2 \qquad ...(2)$$

Similarly $$I_2 = \frac{1}{2}E_2 - \frac{1}{2}\frac{(E_1 + E_2)}{3}$$

$$I_2 = -\frac{1}{6}E_1 + \frac{1}{3}E_2 \qquad ...(3)$$

From (2) and (3) admittance parameters are

$$[Y_{11} \quad Y_{12} \quad Y_{21} \quad Y_{22}] = [1/3 \quad -1/6 \quad -1/6 \quad 1/3]$$

SOL 2.103 Option (A) is correct.

Admittance of the given circuit

$$Y(\omega) = j\omega C + \frac{1}{Z_L}$$

$$Z_L = 30\angle 40^\circ = 23.1 + j19.2\,\Omega$$

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So, $$Y(\omega) = j2\pi \times 50 \times C + \frac{1}{23.1 + j19.2} \times \frac{23.1 - j19.2}{23.1 - j19.2}$$

$$= j(100\pi)\,C + \frac{23.1 - j19.2}{902.25}$$

$$= \frac{23.1}{902.25} + j\left[(100\pi)\,C - \frac{19.2}{902.25}\right]$$

For unity power factor

$$I_m[Y(\omega)] = 0$$

$$100 \times 3.14 \times C = \frac{19.2}{902.25}$$

$$C \simeq 68.1\,\mu\text{F}$$

SOL 2.104 Option (B) is correct.

In series RLC circuit lower half power frequency is given by following relations

$$\omega_1 L - \frac{1}{\omega_1 C} = -R$$

$$(2\pi \times f_1 \times 100 \times 10^{-6}) - \frac{1}{2\pi \times f_1(1 \times 10^{-6})} = -50$$

$$f_1 = 3.055 \text{ kHz}$$

SOL 2.105 Option (C) is correct.

Since initial charge across capacitor is zero, voltage across capacitor at any time t is given as

$$v_c(t) = 10(1 - e^{-\frac{t}{\tau}})$$

Time constant $$\tau = R_{eq}C$$

$$= (10\,\text{k}\Omega\,||\,1\,\text{k}\Omega) \times C$$

$$= \left(\frac{10}{11}\right)\text{k}\Omega \times 11\,\text{nF} = 10 \times 10^{-6} \text{ sec} = 10\,\mu\text{sec}$$

So, $$v_c(t) = 10(1 - e^{-\frac{t}{10\,\mu\text{sec}}})$$

Pulse duration is $10\,\mu$sec, so voltage across capacitor will be maximum at $t = 10\,\mu$sec

$$v_c(t = 10\,\mu\text{sec}) = 10(1 - e^{-\frac{10\,\mu\text{sec}}{10\,\mu\text{sec}}}) = 10(1 - e^{-1}) = 6.32 \text{ Volt}$$

SOL 2.106 Option (C) is correct.

Since voltage and current are in phase so equivalent inductance is

$$L_{eq} = 12\,\text{H}$$

$$L_1 + L_2 \pm 2M = 12 \qquad M \rightarrow \text{Mutual Inductance}$$

$$8 + 8 \pm 2M = 12$$

$$16 - 2M = 12 \text{ (Dot is at position } Q)$$

$$M = 2 \text{ H}$$

Coupling Coefficient

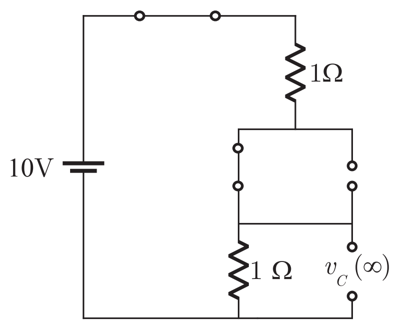
$$K = \frac{2}{\sqrt{8 \times 8}} = 0.25$$

SOL 2.107 Option ( ) is correct.

SOL 2.108 Option (C) is correct.

In steady state there is no voltage drop across inductor (i.e. it is short circuit) and no current flows through capacitors (i.e. it is open circuit)

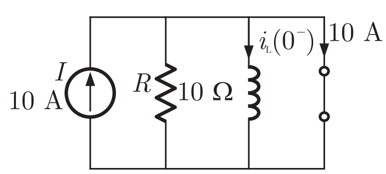
The equivalent circuit is



So, $$v_c(\infty) = \frac{10}{1+1} \times 1 = 5 \text{ Volt}$$

SOL 2.109 Option (C) is correct.

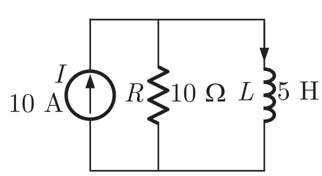
When the switch was closed before $t = 0$, the circuit is



Current in the inductor

$$i_L(0^-) = 0 \text{ A}$$

When the switch was opened at $t = 0$, equivalent circuit is



In steady state, inductor behaves as short circuit and 10 A current flows through it

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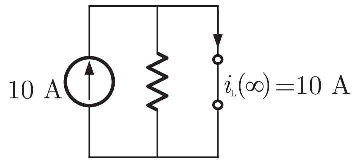


$$i_L(\infty) = 10 \text{ A}$$

Inductor current at any time t is given by

$$i_L(t) = i_L(\infty) + [i_L(0) - i_L(\infty)]e^{-\frac{R}{L}t}$$

$$= 10 + (0 - 10)\,e^{-\frac{5}{10}t} = 10(1 - e^{-2t}) \text{ A}$$

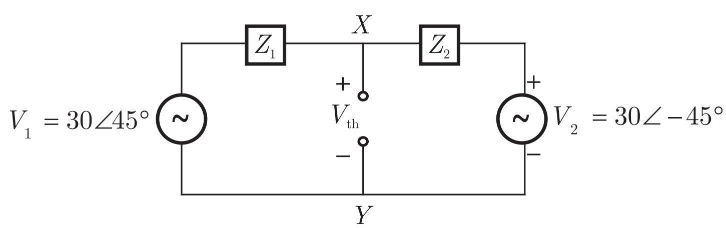
SOL 2.110 Option (B) is correct.

Energy stored in inductor is

$$E = \frac{1}{2}Li^2 = \frac{1}{2} \times 5 \times (10)^2 = 250 \text{ J}$$

SOL 2.111 Option (C) is correct.

To obtain Thevenin's equivalent, open the terminals X and Y as shown below,



By writing node equation at X

$$\frac{V_{th} - V_1}{Z_1} + \frac{V_{th} - V_2}{Z_2} = 0$$

$$V_1 = 30\angle 45° = \frac{30}{\sqrt{2}}(1 + j)$$

$$V_2 = 30\angle -45° = \frac{30}{\sqrt{2}}(1 - j)$$

So,

$$\frac{V_{th} - \frac{30}{\sqrt{2}}(1 + j)}{1 - j} + \frac{V_{th} - \frac{30}{\sqrt{2}}(1 - j)}{1 + j} = 0$$

$$2V_{th} - \frac{30}{\sqrt{2}}(1 + j)^2 - \frac{30}{\sqrt{2}}(1 - j)^2 = 0$$

$$V_{th} = 0 \text{ Volt}$$

Thevenin's impedance

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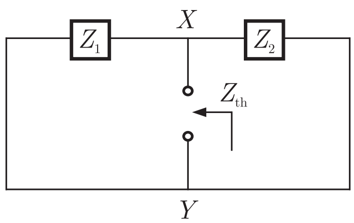
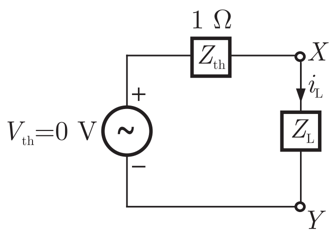


$$Z_{th} = Z_1 \,||\, Z_2 = (1-j)\,||\,(1+j) = \frac{(1-j)(1+j)}{(1-j)+(1+j)} = 1\,\Omega$$

SOL 2.112 Option (A) is correct.

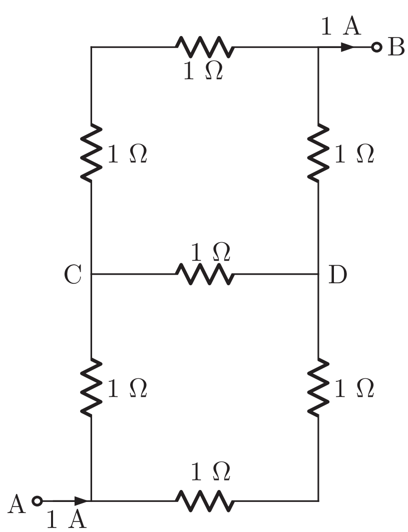
Drawing Thevenin equivalent circuit across load :



So, current $i_L = 0$ A

SOL 2.113 Option (A) is correct.

In the circuit we can observe that there are two wheatstone bridge connected in parallel. Since all resistor values are same, therefore both the bridge are balanced and no current flows through diagonal arm. So the equivalent circuit is



We can draw the circuit as

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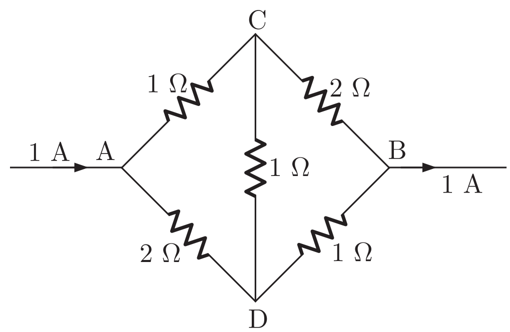
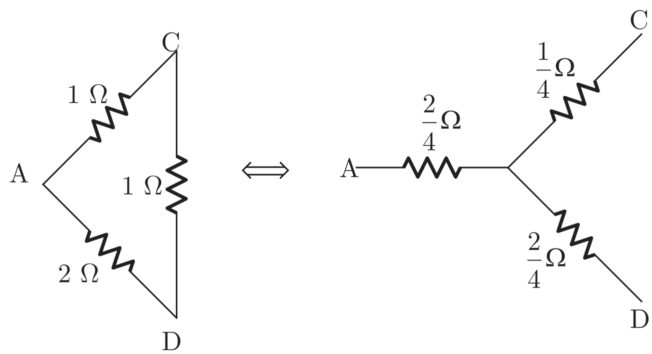
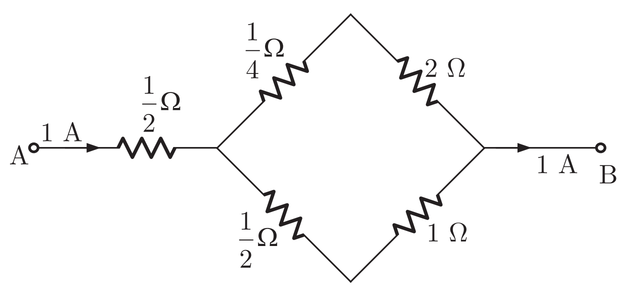
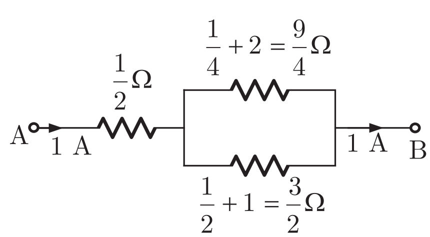


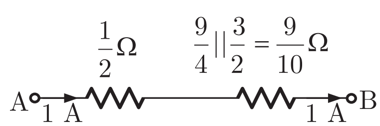
From $\Delta - Y$ conversion

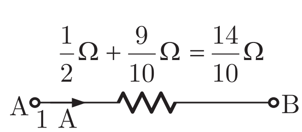


Now the circuit is









$$V_{AB} = 1 \times \frac{14}{10} = 1.4 \text{ Volt}$$

SOL 2.114 Option (C) is correct.

In a series RLC circuit, at resonance, current is given as

$$i = \frac{V_s\angle 0^\circ}{R}, \quad V_S \rightarrow \text{source voltage}$$

So, voltage across capacitor at resonance

$$V_c = \frac{1}{j\omega C} \times \frac{V_s\angle 0^\circ}{R}$$

$$V_c = \frac{V_s}{\omega CR}\angle -90^\circ$$

Voltage across capacitor can be greater than input voltage depending upon values of ω, C and R but it is 90° out of phase with the input

SOL 2.115 Option (D) is correct.

Let resistance of 40 W and 60 W lamps are R_1 and R_2 respectively

$\because$ $$P \propto \frac{1}{R^2}$$

$$\frac{P_1}{P_2} = \frac{R_2}{R_1}$$

$$\frac{R_2}{R_1} = \frac{40}{60}$$

$$R_2 < R_1$$

40 W bulb has high resistance than 60 W bulb, when connected in series power is

$$P_1 = I^2 R_1$$

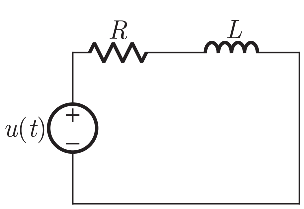
$$P_2 = I^2 R_2$$

$\because$ $R_1 > R_2$, So $P_1 > P_2$

Therefore, 40 W bulb glows brighter

SOL 2.116 Option (B) is correct.

Series RL circuit with unit step input is shown in following figure



$$u(t) = \begin{cases} 1, & t > 0 \\ 0, & \text{otherwise} \end{cases}$$

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Initially inductor current is zero

$$i(0^+) = 0$$

When unit step is applied, inductor current does not change simultaneously and the source voltage would appear across inductor only so voltage across resistor at $t = 0^+$

$$v_R(0^+) = 0$$

SOL 2.117 Option (D) is correct.

For two coupled inductors

$$M = K\sqrt{L_1 L_2}$$

Where $K \rightarrow$ coupling coefficient

$0 < K \leq 1$

So, $$K = \frac{M}{\sqrt{L_1 L_2}} \leq 1$$

$$M \leq \sqrt{L_1 L_2}$$

SOL 2.118 Option (C) is correct.

Since the network contains passive elements only, output can never offer greater power compared to input

SOL 2.119 Option (B) is correct.

Given that

When terminal C is open

$$R_{AB} = R_A + R_B = 6\,\Omega \qquad ...(1)$$

When terminal A is open

$$R_{BC} = R_B + R_C = 11\,\Omega \qquad ...(2)$$

When terminal B is open

$$R_{AC} = R_A + R_C = 9\,\Omega \qquad (3)$$

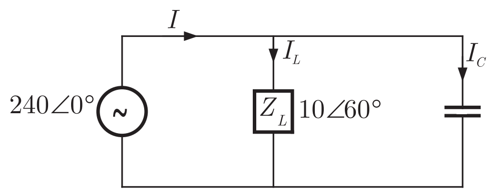
From (1), (2) and (3)

$R_A = 2\,\Omega,\ R_B = 4\,\Omega,\ R_C = 7\,\Omega$

SOL 2.120 Option ( ) is correct.

A graph is connected if there exist at least one path between any two vertices (nodes) of the network. So it should have at least N or more branches for one or more closed paths to exist.

SOL 2.121 Option (B) is correct.



Current $$I_L = \frac{240\angle 0^\circ}{10\angle 60^\circ} = 24\angle -60^\circ = \frac{24(1-\sqrt{3}j)}{2} \text{ A}$$

$$= 12 - j20.784 \text{ A}$$

$$I_c = \frac{P}{V} = \frac{j1250}{240\angle 0^\circ} = j5.20\angle 0^\circ \text{ A}$$

Current $$I = I_C + I_L = 12 - j20.784 + j5.20 = 12 - j15.58$$

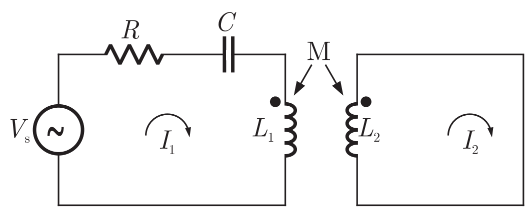
Power supplied by load

$$P = VI = 240(12 - j15.58) = 2880 - 3739j$$

Real power $$P_R = 2880 \text{ W}$$

SOL 2.122 Option (A) is correct.

Let current in primary and secondary loop is I_1 and I_2 respectively, then by writing KVL equation (considering mutual inductance),



In primary loop

$$V_S - I_1 R - I_1\left(\frac{1}{j\omega C}\right) - I_1 j\omega L_1 - I_2 j\omega M = 0$$

$$V_S = I_1\left[R + \frac{1}{j\omega C} + j\omega L_1\right] + j\omega M I_2 \quad \text{...(1)}$$

In secondary loop

$$0 - I_2 j\omega L_2 - I_1 j\omega M = 0$$

$$I_2 L_2 + I_1 M = 0$$

$$I_2 = -\frac{M}{L_2} I_1$$

Put I_2 into equation (1)

$$V_s = I_1\left[R + \frac{1}{j\omega C} + j\omega L_1\right] + j\omega M\left(-\frac{M}{L_2}\right) I_1 = 0$$

$$V_s = I_1\left[R + \frac{1}{j\omega C} + j\omega L_1 - \frac{j\omega M^2}{L_2}\right]$$

$$V_s = I_1\left[R + j\left(\omega L_1 - \frac{\omega M^2}{L_2} - \frac{1}{\omega C}\right)\right]$$

For resonance imaginary part must be zero, so

$$\omega L_1 - \frac{\omega M^2}{L_2} - \frac{1}{\omega C} = 0$$

$$\omega^2\left(L_1 - \frac{M^2}{L_2}\right) - \frac{1}{C} = 0$$

$$\omega^2\left(\frac{L_1L_2 - M^2}{L_2}\right) = \frac{1}{C}$$

$$\omega^2 = \frac{L_2}{C(L_1L_2 - M^2)}$$

Resonant frequency

$$\omega = \sqrt{\frac{L_2}{C(L_1L_2 - M^2)}}$$

$$= \sqrt{\frac{10 \times 10^{-3}}{3 \times 10^{-6}[40 \times 10^{-3} \times 10 \times 10^{-3} - (10 \times 10^{-3})^2]}}$$

$$= \frac{1}{3} \times 10^5 \text{ rad/sec}$$

SOL 2.123 Option (C) is correct.

Quality factor is given as

$$Q = \frac{\omega L_{eq}}{R} + \frac{1}{\omega CR}$$

Where, $\omega = \frac{1}{3} \times 10^5$ rad/sec

$$L_{eq} = L_1 - \frac{M^2}{L_2} = 40 \times 10^{-3} - \frac{(10 \times 10^{-3})^2}{10 \times 10^{-3}}$$

$$= 3 \times 10^{-2} \text{ H}$$

So, $$Q = \frac{10^5}{3} \times \frac{3 \times 10^{-2}}{10} + \frac{3}{10^5 \times 3 \times 10^{-6} \times 10}$$

$$= 100 + 1 = 101$$

SOL 2.124 Option (C) is correct.

Voltage and electric field are related as

$$E = -\nabla V \qquad \text{(Gradient of } V\text{)}$$

$$= -\left[\frac{\partial V_x}{\partial x}\hat{i} + \frac{\partial V_y}{\partial y}\hat{j} + \frac{\partial V_z}{\partial z}\hat{k}\right]$$

$$= -\left[\frac{\partial (50x^2)}{\partial x}\hat{i} + \frac{\partial (50y^2)}{\partial y}\hat{j} + \frac{\partial (50z^2)}{\partial z}\hat{k}\right]$$

$$= -\left[100x\,\hat{i} + 100y\,\hat{j} + 100z\,\hat{k}\right]$$

$$E(1,-1,1) = -\left[100\hat{i} - 100\hat{j} + 100\hat{k}\right] = -100\hat{i} + 100\hat{j} - 100\hat{k}$$

$$E(1,-1,1) = 100\sqrt{3}\left[\frac{-\hat{i} + \hat{j} - \hat{k}}{\sqrt{3}}\right]$$

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SOL 2.125 Option (C) is correct.

Power loss in watt is given as

$$P_h = W_h V f$$

Where $W_h \rightarrow$ Energy Density Loss

$V \rightarrow$ Volume of Material

Here $W_h V =$ Area of hysteresis loop

$= 5 \text{ cm}^2$

So, $P_h = 5 \text{ cm}^2 \times 50$

$= 5 \times 2 \times 50 \times 10^{-3} \times 50 = 25$ Watt

SOL 2.126 Option (C) is correct.

For two parallel wires inductance is

$$L = \frac{\mu_0 l}{\pi} \ln\left(\frac{d}{r}\right)$$

$l \rightarrow$ Length of the wires

$d \rightarrow$ Distance between the wires

$r \rightarrow$ RadiusThus

$$L = \frac{4\pi \times 10^{-7} \times 10 \times 10^3}{\pi} \ln\left(\frac{1.5}{0.5 \times 10^{-2}}\right)$$

$= 4 \times 10^{-3} \ln(300) = 22.81$ mH

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