ACE
Engineering Academy

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ESE- 2018 (Prelims) - Offline Test Series Test- 9

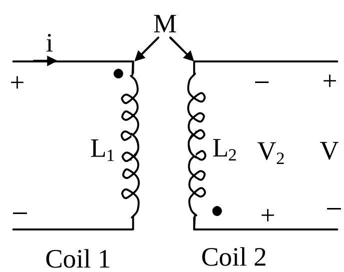
ELECTRONICS & TELECOMMUNICATION ENGINEERING

SUBJECT: MATERIAL SCIENCE + NETWORK THEORY SOLUTIONS

01. Ans: (a)

Sol: The dots indicate that when current entering the dotted terminal of one coil, voltage induced is positive at the dotted terminal of other coil.

Given circuit,



Here current entering the dotted terminal of coil 1.

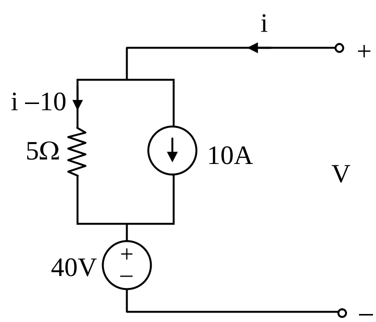
⇒ induced voltage is positive at the dotted terminal of coil2.

$\therefore V_2 = M\frac{di}{dt}$

But, $V = -V_2 = -M\frac{di}{dt}$

02. Ans: (c)

Sol: Given circuit,



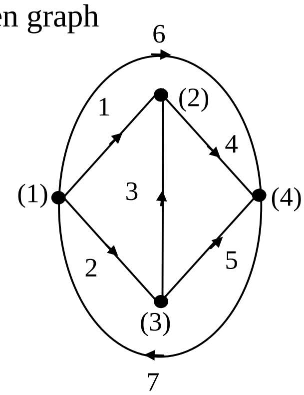
Applying KVL,

$\Rightarrow -V + 5(I - 10) + 40 = 0$

$\Rightarrow V = 5i - 10$

03. Ans: (c)

Sol: Given graph



Number of possible trees = $|[A_r][A_r]^T|$

Where,

$[A_r]$ is the reduced incidence matrix

Incidence matrix, for the given graph is

$$A = \begin{array}{c} \\ (1) \\ (2) \\ (3) \\ (4) \end{array}\begin{array}{c} \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \end{matrix} \\ \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 & -1 \\ -1 & 0 & -1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 & -1 & -1 & 1 \end{bmatrix} \end{array}$$

By taking the (4) node as reference,

Reduced incidence matrix,

$$[A_r] = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 & -1 \\ -1 & 0 & -1 & 1 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$[A_r][A_r]^T$

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

$$= \begin{bmatrix} 4 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 3 \end{bmatrix}$$

$$\therefore\ |[A_r][A_r]^T| = \begin{vmatrix} 4 & -1 & -1 \\ -1 & 3 & -1 \\ -1 & -1 & 3 \end{vmatrix}$$

$= 4(9 - 1) + 1(-3-1) - 1(1+3)$

$= 32 - 4 - 4 = 24$

$\therefore$ Number of possible trees = 24

04. Ans: (a)

Sol: Given networks,

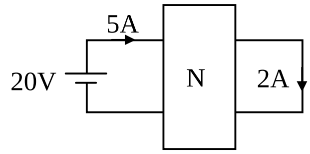


Fig.1

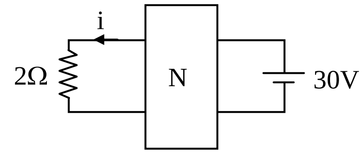
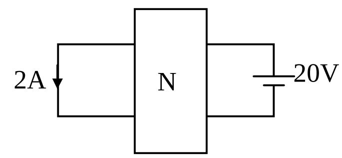


Fig.2

Applying reciprocity theorem to Fig (1)



By using linearity principle,

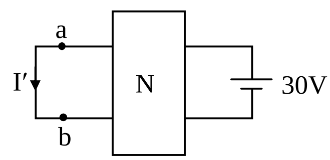


Fig.3

$$I' = \frac{30}{20} \times 2 = 3\text{ A}$$

With respect to the terminals a and b the short circuit current $I_{SC} = I' = 3$ A

Similarly with respect to the terminals a and b the Norton's equivalent resistance R_N is

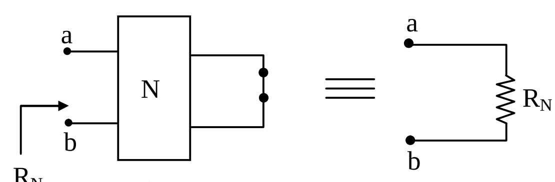
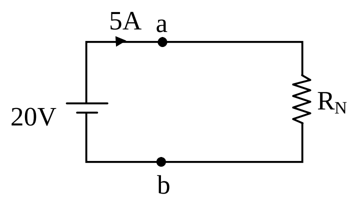


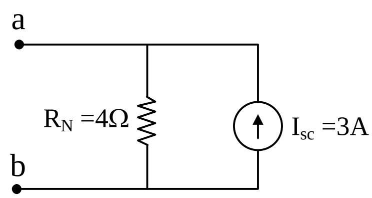
Fig.4

Fig (1) is the energized version of Fig. (4)

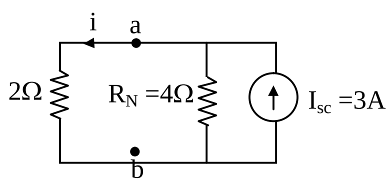


$\Rightarrow R_N = \dfrac{20}{5} = 4\ \Omega$

The Notron's equivalent of Fig. (3) with respect to terminals a and b is



Then the Fig. (2) becomes

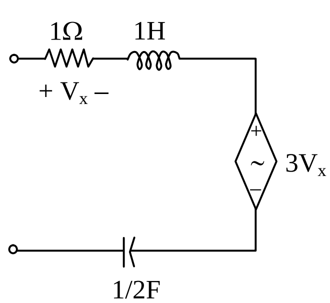


$\Rightarrow i = I_{SC} \times \dfrac{4}{2+4}$

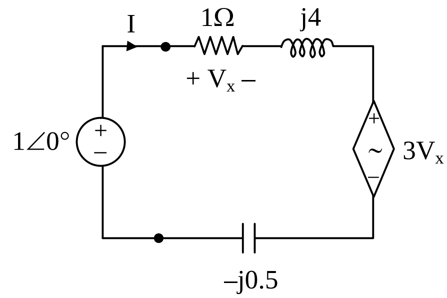
$\Rightarrow i = 3 \times \dfrac{4}{6} = 2\ A$

05. Ans: (a)

Sol: Given network,



Assume a voltage source of value $1\ \angle 0^o$ having a frequency of 4 rad/sec is applied across the circuit then



$\dfrac{V_x}{1} = I \Rightarrow I = V_x$

Applying KVL in the loop,

$\Rightarrow -1\angle 0^o + V_x + j3.5I + 3V_x = 0$

$\Rightarrow -1\angle 0^o + I + j3.5I + 3I = 0$

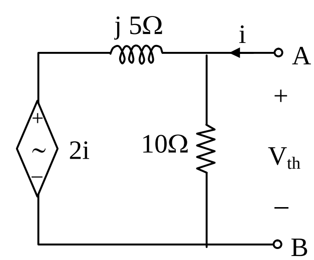
$\Rightarrow I = \dfrac{1\angle 0^o}{4 + j3.5} = 0.1881\angle -41.185^o\ A$

$\therefore$ Circuit power factor = cos(41.185)

= 0.7525 lagging

06. Ans: (a)

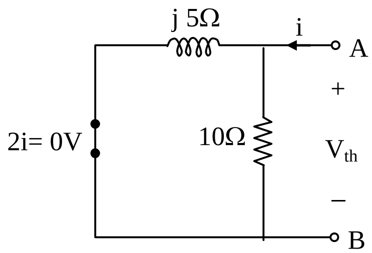
Sol: Given network,



When A and B terminals are open circuited

$\Rightarrow i = 0$

Then the equivalent network becomes

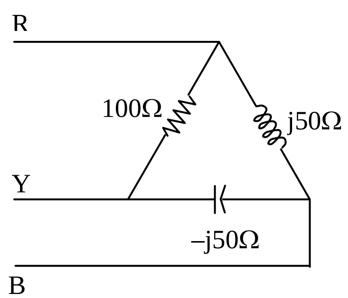


As there is no source to drive the above circuit

$\Rightarrow V_{th} = 0V$

07. Ans: (b)

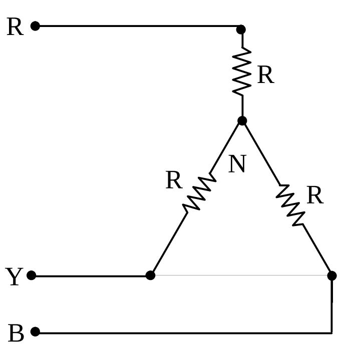
Sol: Given network,



Here the power is consumed only in the 100Ω resistor and its value is

$$P_D = \frac{V_{RY}^2}{100} \text{ …….. (1)}$$

Now connect a balanced star load, each of resistance value R as shown below



Power consumed $P_s = 3\frac{V_{RN}^2}{R}$

$$P_s = \frac{\left(\sqrt{3}V_{RN}\right)^2}{R} = \frac{V_{RY}^2}{R} \text{ ……. (2)}$$

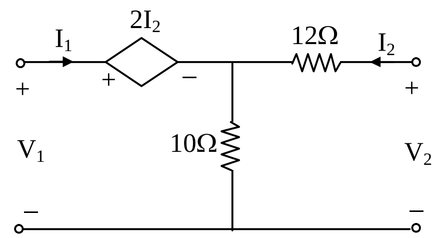
As (1) = (2)

$$\Rightarrow \frac{V_{RY}^2}{100} = \frac{V_{RY}^2}{R}$$

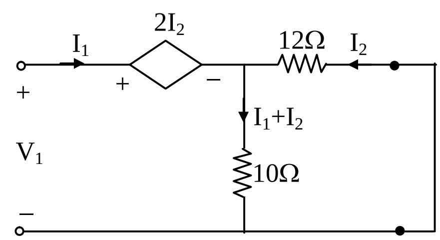
$\Rightarrow R = 100\Omega$

08. Ans: (d)

Sol: Given network,



$$D = \left.\frac{I_1}{-I_2}\right|_{V_2=0}$$



Applying KVL,

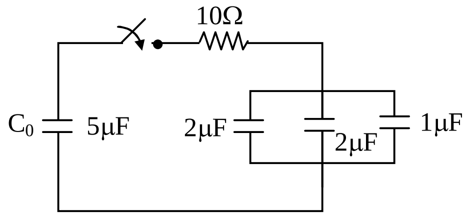
$\Rightarrow -10\ (I_1+I_2) - 12I_2 = 0 \Rightarrow -10\ I_1 = 22I_2$

$$\Rightarrow \frac{I_1}{-I_2} = 2.2$$

$\therefore\ D = 2.2$

09. Ans: (a)

Sol: Given network,

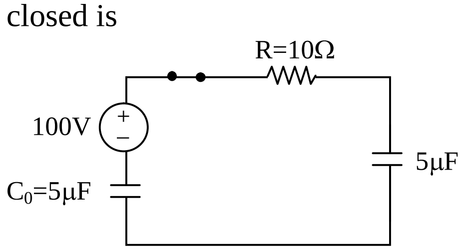


Initial charge in C_0 = 500μC

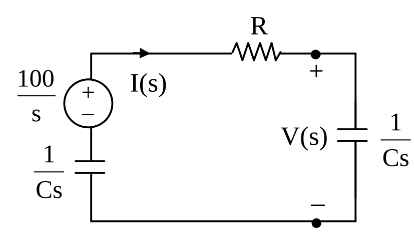
⇒ Initial voltage across capacitor C_0 is

$$V_0 = \frac{q}{C_0} = \frac{500\mu}{5\mu} = 100\text{V}$$

The equivalent, circuit after the switch is closed is



Convert into Laplace domain



$$\Rightarrow I(s) = \frac{100/s}{R + \frac{2}{Cs}}$$

$$I(s) = \frac{100}{R\left(s + \frac{2}{RC}\right)}$$

$$\text{and } V(s) = \frac{1}{Cs} I(s)$$

$$= \frac{1}{Cs} \cdot \frac{100}{R\left(s + \frac{2}{RC}\right)}$$

Steady state value of v(t) is = $\underset{s\to 0}{\text{Lt}}\ sV(s)$

$$= \underset{s\to 0}{\text{Lt}}\ s.\frac{100}{s(RCs+2)}$$

$$= 50V$$

∴ Steady state voltage across 1μF capacitor = 50V

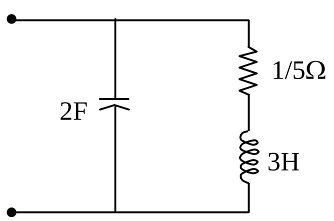
∴ Charge in the 1μF capacitor q = CV

$$= 1\mu\times 50$$

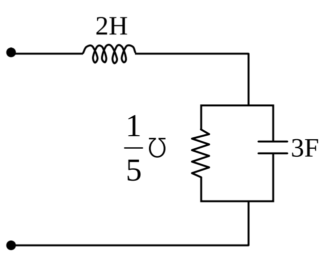
$$= 50\ \mu C$$

10. Ans: (c)

Sol: Given network

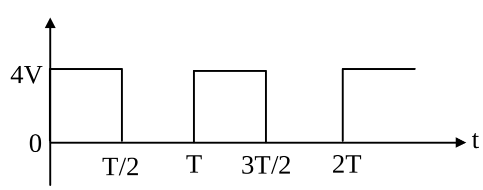


The dual of the above network is



11. Ans: (b)

Sol: The wave form is as shown below



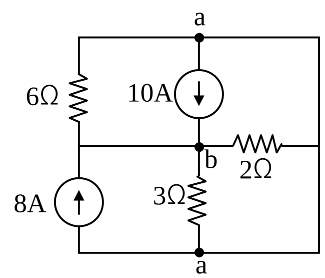
$$V_{rms}^2 = \frac{1}{T}\int_0^{T/2}(4)^2 dt$$

$$\Rightarrow V_{rms}^2 = \frac{1}{T}\times 16\times T/2 = 8$$

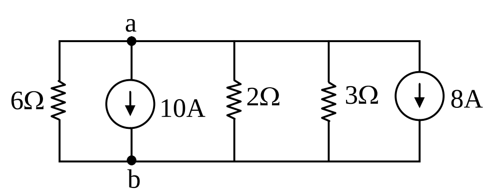
$$\Rightarrow V_{rms} = 2\sqrt{2}V$$

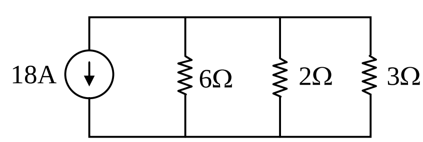
12. Ans: (b)

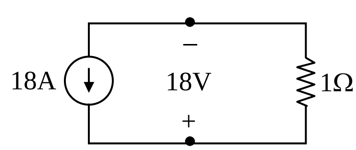
Sol: Given circuit



The above circuit can be redrawn as







⇒ Total power delivered by the sources

= 18 × 18 = 324W

13. Ans: (d)

Sol: At the cut off frequency $I = \frac{I_m}{\sqrt{2}}$

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

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

At the lower cut off frequency ω_1,

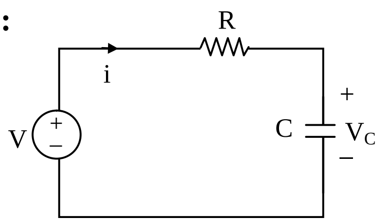
$$\omega_1 L < \frac{1}{\omega_1 C}$$

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

$\Rightarrow$ Net reactance = –R

14. Ans: (a)

Sol:



Under steady state condition $V_c = V = 100V$

And $i(t) = \frac{V}{R} e^{-t/RC}$

Energy dissipated by the resistor

$$E_R = \int_0^\infty i^2 R \, dt$$

$$E_R = \int_0^\infty \frac{V^2}{R^2} e^{-2t/RC}.R \, dt$$

$$= \frac{V^2}{R}\left[\frac{e^{-2t/RC}}{-2/RC}\right]_0^\infty$$

$$= \frac{-1}{2}CV^2[0-1] = \frac{1}{2}CV^2$$

$$\Rightarrow E_R = \frac{1}{2}CV^2$$

$$= \frac{1}{2} \times 1 \times 10^{-6} \times (100)^2 = 5mJ$$

15. Ans: (a)

Sol: We know, when two, 2-port networks are connected in parallel, their individual Y-parameters gets added.

$\therefore$ First, we need to convert given ABCD parameters to Y-parameters.

For 2-port network

Y-parameters are

$$\left.\begin{aligned} I_1 &= Y_{11}V_1 + Y_{12}V_2 \\ I_2 &= Y_{21}V_1 + Y_{22}V_2 \end{aligned}\right\} (1)$$

ABCD parameters

$$\left.\begin{aligned} V_1 &= AV_2 - BI_2 \\ I_1 &= CV_2 - DI_2 \end{aligned}\right\} (2)$$

Make $V_2 = 0$ to find Y_{11} & Y_{21}

Equation (2) becomes $V_1 = -BI_2$

$I_1 = -DI_2$

$$\therefore Y_{11} = \left.\frac{I_1}{V_1}\right|_{V_2=0} = \frac{D}{B} \qquad Y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0} = \frac{-1}{B}$$

Similarly, $V_1 = 0$, to find Y_{12} & Y_{22}

$\therefore$ From equation (2) $AV_2 = BI_2$

$$\Rightarrow V_2 = \frac{B}{A} I_2$$

$$I_1 = CV_2 - DI_2$$

$$I_1 = C\frac{B}{A} I_2 - DI_2 = \frac{CB - DA}{A} I_2$$

$$I_1 = \frac{BC - AD}{A} I_2$$

But $I_2 = \frac{A}{B} V_2$

$$\Rightarrow I_1 = \frac{BC - AD}{A} \frac{A}{B} V_2$$

$$\Rightarrow I_1 = \left(\frac{BC - AD}{B}\right) V_2 \quad \ldots\ldots(3)$$

$$\therefore Y_{12} = \left.\frac{I_1}{V_2}\right|_{V_1=0} = \frac{BC - AD}{B}$$

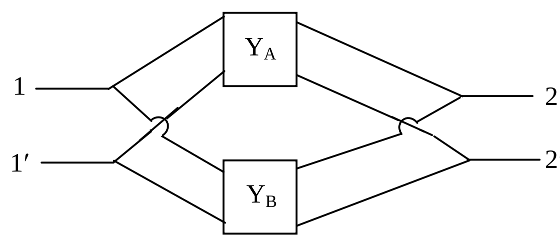
And $I_1 = \frac{BC - AD}{B} I_2$ put this value in equation (3)

$$\frac{BC - AD}{A} I_2 = \frac{BC - AD}{B} V_2$$

$$I_2 = \frac{A}{B} V_2 \Rightarrow Y_{22} = \left.\frac{I_2}{V_2}\right|_{V_1=0} = \frac{A}{B}$$

Y-parameter matrix in terms of ABCD parameter is

$$Y_T = \begin{bmatrix} \frac{D}{B} & \frac{BC - AD}{B} \\ \frac{-1}{B} & \frac{A}{B} \end{bmatrix}$$



Y_T or $Y_{eq} = Y_A + Y_B$

$$= \begin{bmatrix} \frac{D}{B} & \frac{BC - AD}{B} \\ \frac{-1}{B} & \frac{A}{B} \end{bmatrix} + \begin{bmatrix} \frac{D}{B} & \frac{BC - AD}{B} \\ \frac{-1}{B} & \frac{A}{B} \end{bmatrix}$$

$$Y_T \text{ or } Y_{eq} = \begin{bmatrix} 2\frac{D}{B} & 2\frac{(BC - AD)}{B} \\ \frac{-2}{B} & \frac{2A}{B} \end{bmatrix}$$

Now, again connect back to ABCD parameters

$$\left.\begin{aligned} I_1 &= \frac{2D}{B} V_1 + 2\frac{(BC - AD)}{B} V_2 \\ I_2 &= -\frac{2}{B} V_1 + \frac{2A}{B} V_2 \end{aligned}\right\} (4)$$

Make $V_2 = 0$ $\quad I_1 = \frac{2D}{B} V_1$

$$I_2 = -\frac{2}{B} V_1$$

$$B_T = -\left.\frac{V_1}{I_2}\right|_{V_2=0} = \frac{B}{2} = 0.5B$$

$$D_T = -\left.\frac{I_1}{I_2}\right|_{V_2=0} = \frac{2D/B}{2/B} = D$$

Make $I_2 = 0$, equation (4) becomes

$$V_1 = AV_2 \ \& \ I_1 = \frac{2D}{B}V_1 + 2\frac{(BC - AD)}{B}V_2$$

$$= \frac{2D}{B}AV_2 + \frac{(2BC - 2AD)}{B}V_2$$

$$= \left(\frac{2AD + 2BC - 2AD}{B}\right)V_2$$

$I_1 = 2CV_2$

$$\therefore A_T = \frac{V_1}{V_2} = A$$

$$C_T = \frac{I_1}{V_2} = 2C$$

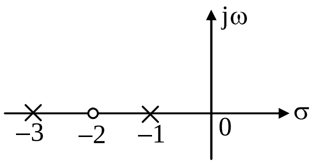
$$[T] = \begin{bmatrix} A_T & B_T \\ C_T & D_T \end{bmatrix} = \begin{bmatrix} A & 0.5B \\ 2C & D \end{bmatrix}$$

16. Ans: (c)

Sol: Given network function

$$F(s) = \frac{(s+2)}{(s+1)(s+3)}$$

The pole zero pattern for the above network function is as shown below



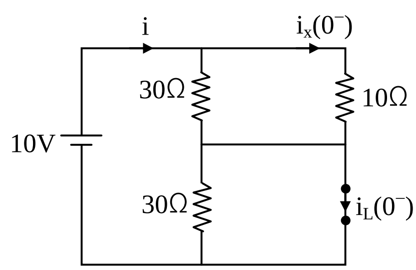
As we can see from above pole zero plot poles and zeros alternate on negative real axis and nearest to the origin is a pole.

∴ It can be realized as RC impedance function or RL admittance function.

17. Ans: (a)

Sol: Assume the circuit is in steady state before the switch opens.

⇒ The inductor will acts as short circuit. Then the circuit at t= 0^- is



Equivalent resistance seen by the 10V voltage source is = 30 || 10

$$= \frac{30\times10}{40} = 7.5\ \Omega$$

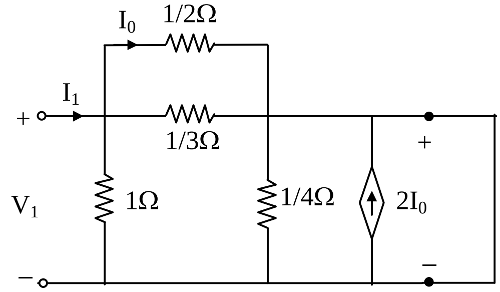
$$\Rightarrow i = \frac{10}{7.5} = \frac{4}{3}\text{ A}$$

$$\therefore\ i_x(0^-) = i\times\frac{30}{40}$$

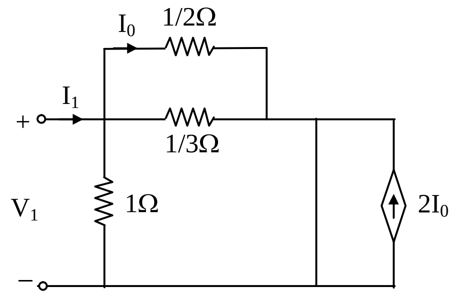
$$= \frac{4}{3}\times\frac{3}{4} = 1\text{ A}$$

18. Ans: (a)

Sol: $Y_{11} = \left.\frac{I_1}{V_1}\right|_{V_2=0}$



The equivalent network becomes



Equivalent resistance seen by the port 1 is

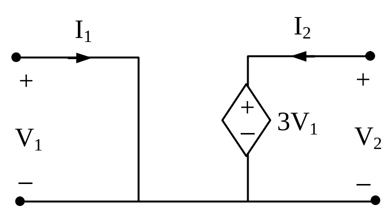
$$= 1 \parallel \frac{1}{2} \parallel \frac{1}{3} = \frac{1}{6}\ \Omega$$

$$\Rightarrow V_1 = \frac{1}{6}\ I_1 \Rightarrow \frac{I_1}{V_1} = 6\mho$$

$$\Rightarrow Y_{11} = 6\mho$$

19. Ans: (d)

Sol: Given network



As we are unable to write I_1 interms of V_1 and V_2 therefore Y parameters doesn't exist.

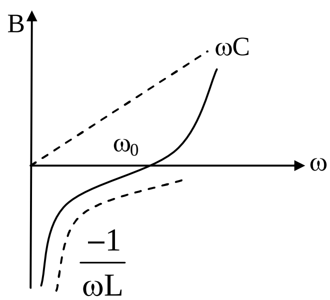
20. Ans: (a)

Sol: For parallel resonant circuit,

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

Susceptance $B = \omega C - \frac{1}{\omega L}$

The plot of susceptance is as shown below

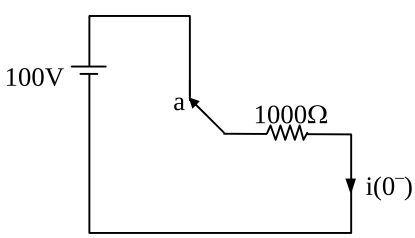


21. Ans: (c)

Sol: Assume the circuit is in steady state before the switch is changed from a to b

$\Rightarrow$ inductor will acts as short circuit.

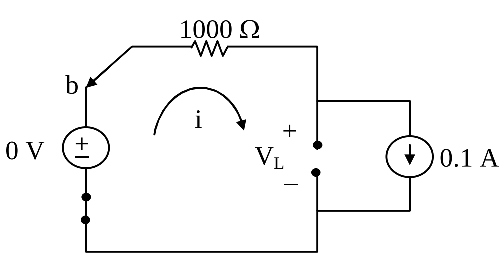
Then the circuit is



$\Rightarrow i(0^-) = \frac{100}{1000} = 0.1\,A$

And initial voltage across the capacitor is $V_C(0^-) = 0$ V

At $t = 0^+$ the equivalent circuit is



$\Rightarrow V_L$ at $t = 0^+$ is $= -100$

$\Rightarrow L\frac{di}{dt} = -100 \Rightarrow \frac{di}{dt} = -100$

$\therefore \frac{di}{dt}$ at $t = 0^+$ is $= -100$ A/sec.

22. Ans: (b)

Sol: For

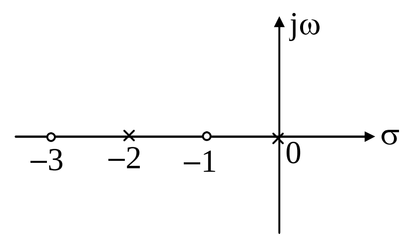
RC driving point impedance function
RC driving point admittance function
RL driving point impedance function
RL driving point admittance function

→ Poles and zeros should alternate only on negative real axis

23. Ans: (b)

Sol: Given $Z(S) = \frac{(s+1)(s+3)}{s(s+2)}$

The pole zero pattern is as shown below

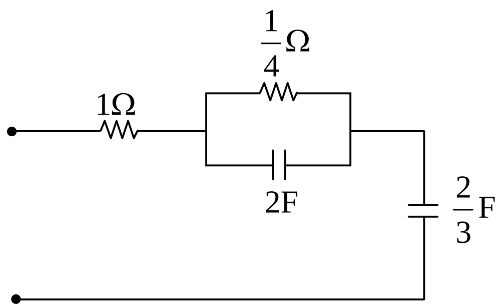


As we can see the poles and zeros alternate on negative real axis and nearest to the origin is a pole.

$\therefore$ It can be realized as RC driving point impedance

$Z(S) = 1 + \frac{2s+3}{s(s+2)} = 1 + \frac{3/2}{s} + \frac{1/2}{s+2}$

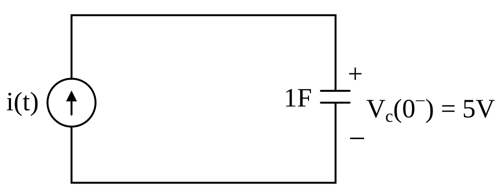
The network for the above impedance function is as shown below



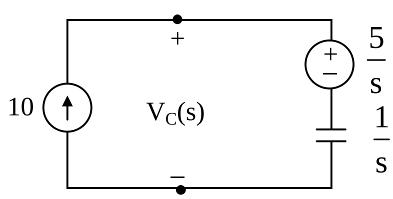
∴ Two energy storage elements are present.

24. Ans: (d)

Sol: At t= 0^+ the circuit is



Convert into Laplace domain



$$\Rightarrow V_C(s) = \frac{5}{s} + \frac{1}{s} \times 10$$

$$= \frac{15}{s}$$

$$\Rightarrow v_C(t) = 15\,u(t)$$

At t= 0^+ $\Rightarrow u(t=0^+) = 1$

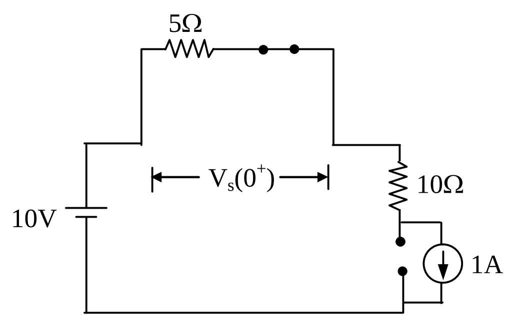
$$\Rightarrow v_C(0^+) = 15\text{ V}$$

25. Ans: (b)

Sol: The equivalent network at t=0^- is

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

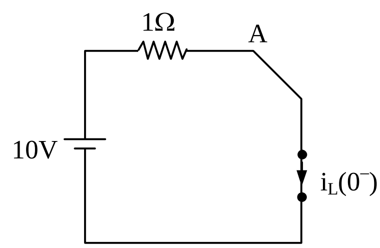
At t= 0^+ the network is



$$\Rightarrow V_S\,(t = 0^+) = 5 \times 1 = 5V$$

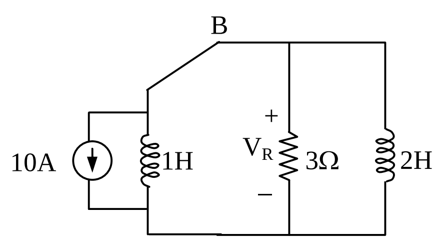
26. Ans: (d)

Sol: At t = 0^- the network is

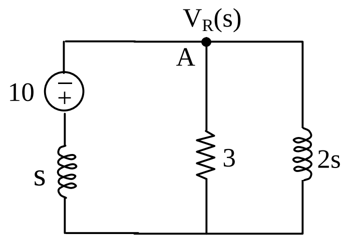


$$\Rightarrow i_L(0^-) = \frac{10}{1} = 10A$$

At t= 0^+ the network is



Convert the above circuit into Laplace domain



Applying KCL at node 'A'

$$\Rightarrow \frac{V_R(s)+10}{s}+\frac{V_R(s)}{3}+\frac{V_R(s)}{2s}=0$$

$$\Rightarrow V_R(s)\left[\frac{3}{2s}+\frac{1}{3}\right]=-\frac{10}{s}$$

$$\Rightarrow V_R(s)=\frac{-30}{s+\frac{9}{2}} \Rightarrow v_R(t)=-30\,e^{-4.5\,t}$$

As $t\to\infty \Rightarrow V_R(t) = 0V$

27. Ans: (b)

Sol: The equivalent capacitance across a, b is calculated by simplifying the bridge circuit as shown in Fig. 1 to Fig. 5.

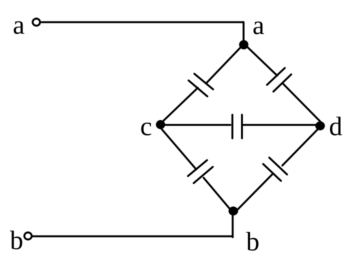


Fig. 1

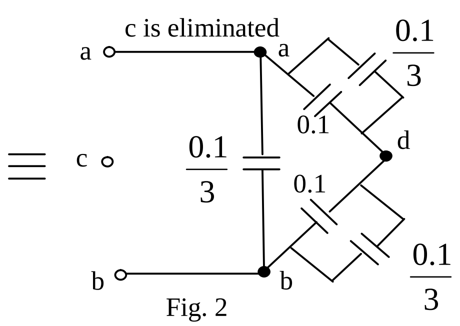


Fig. 2

Note: The bridge is balanced and the answer is easy to get.

28. Ans: (d)

Sol:

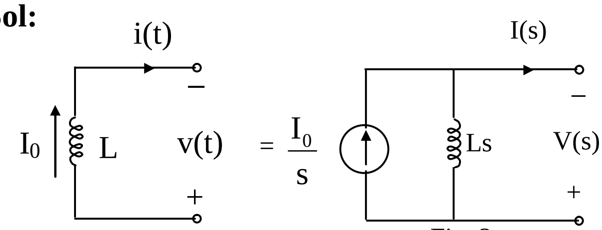


Fig. 1 Fig. 2

$$i(t)=\frac{1}{L}\int_{-\infty}^{t} v(t)\,dt,\quad I(s)=\frac{I_0}{s}+\frac{1}{Ls}V(s)$$

The inductor in time domain and transform domain are shown in Fig.1 and Fig. 2.

29. Ans: (c)

Sol: $L = 3\times10^{-3}$ H,

$$i(t)=\frac{10t}{2\times10^{-3}}=5\times10^{3}\,t\ A$$

$$\frac{d\,i(t)}{dt}=5\times10^{3}\ A/s,$$

$$v(t)=L\frac{d\,i(t)}{dt}=15\,V$$

$p(t) = v(t)\,i(t) = 15\times5\times10^{3}\,t$ W = 75000t

30. Ans: (a)

Sol: sub-network N_1 can be replaced by its Thevenin equivalent even if the sub-network N_2 contains a two-terminal element which is non-linear.

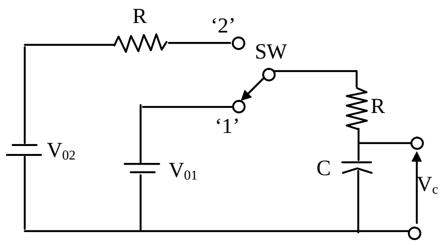
31. Ans: (c)

Sol: If a network has all linear elements except for a few non – linear ones, then superposition theorem may hold on careful selection of element values, source waveform and response.

Note: The reader may see this important statement and an example in comment (3), page 661, of Text Book “Basic Circuit Theory” by Desoer & Kuh.

32. Ans: (d)

Sol: The figure accompanying the question specifies voltage across C as in fig.1.



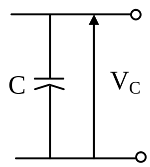


Fig: 1

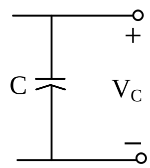
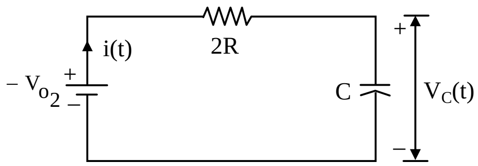


Fig: 2

Polarity of V_c is therefore specified as in fig.2.

At $t = 0^-$, V_c would have acquired a value of V_{01} volts.

For $t \geq 0^+$, the circuit can be redrawn as in fig.3.



$V_C(t=0^-)=V_C(t=0^+)=V_{01}$

Fig: 3

KVL: $2Ri + \frac{1}{C}\int_0^t i\,dt + V_{01} = -V_{02} \quad t \geq 0^+$

Solving, $i(t) = Ae^{-t/2RC}$.

At t = 0, $2R\,A + V_{01} = -V_{02}$

or $A = -\frac{V_{01}+V_{02}}{2R}$

thus $i(t) = -\frac{(V_{01}+V_{02})}{2R}e^{-t/2RC}$

$$V_c(t) = \frac{1}{C}\int_0^t i\,dt + V_{01} = (V_{01}+V_{02})\left[e^{-(t/2RC)} - 1\right] + V_{01}.$$

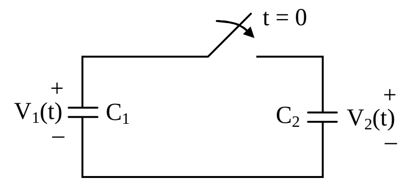
Check: At t = 0; $V_c(t)$ must equal V_{01}, which if does.

At $t = \infty$, $V_c(t)$ must equal $-V_{02}$, which again it does.

Note: In the question if the polarity given for V_{02} is reversed, then (d) would be the answer.

33. Ans: (d)

Sol: In the circuit given below,



At $t = 0^-$; $V_1(t) = 12$ V and $V_2(t) = 0$V.

At $t = 0^+$ (immediately after the switch is closed) the two capacitances must acquire some common voltage. Since this means voltages across capacitances changing instantaneously, there must be an impulse current through the loop.

34. Ans: (b)

Sol:

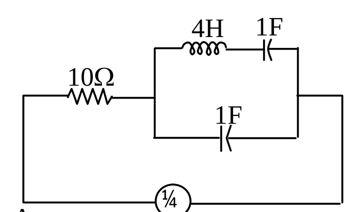


Fig.

The given circuit is shown in Fig.

$Z_{AB} = 10 + Z_1$

where, $Z_1 = \left(\frac{-j}{\omega}\right) \| \left(j4\omega - \frac{j}{\omega}\right)$

$$= \frac{\left(\frac{-j}{\omega}\right)\left(j4\omega - \frac{j}{\omega}\right)}{\frac{-j}{\omega} + j4\omega - \frac{j}{\omega}}$$

$$= \frac{4 - \frac{1}{\omega^2}}{j4\omega - \frac{j2}{\omega}}$$

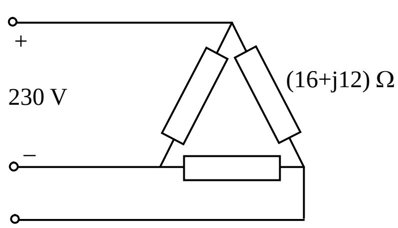
For circuit to be resonant i.e., $\omega^2 = \frac{1}{4}$

$\omega = \frac{1}{2} = 0.5$ rad/ sec

$\therefore\ \omega_{resonance} = 0.5$ rad/sec

35. Ans: (b)

Sol:



$P = \sqrt{3} V_L I_L \cos\phi$

$I_{ph} = \frac{230}{\sqrt{16^2 + 12^2}} = \frac{230}{20} = 11.5\,A$

$I_L = \sqrt{3} I_{Ph} = 11.5(\sqrt{3}) = 19.91$ A

$\cos\phi = \frac{R}{|Z|} = \frac{16}{\sqrt{16^2+12^2}} = \frac{16}{20} = \frac{4}{5} = 0.8$

$P = \sqrt{3}(230)(19.91)(0.8) = 6348$

$= 6.34$ kW

36. Ans: (a)

Sol: Output voltage $= t \times g \times p$

$= 2\times10^{-3}\times0.055\times1.25\times10^{6}$

$= 137.5$ V

37. Ans: (a)

Sol: Ionic polarization takes place by displacement of cations and anions. It is independent of temperature

$\alpha_i = \frac{e^2}{\omega^2 m}$

Ionic Polarizability is inversely proportional to the square of natural frequency (ω)

38. Ans: (b)

Sol: Polarization (P) = $\varepsilon_0(\varepsilon_r - 1)E$

$= 8.854 \times 10^{-12} \times (8-1) \times 10 \times 10^3$

$= 6.2 \times 10^{-7}$

39. Ans: (c)

40. Ans: (a)

41. Ans: (b)

Sol: $\rho = \frac{1}{ne\mu} \Rightarrow \mu = \frac{1}{ne\rho}$

$= \frac{1}{6\times10^{28}\times1.6\times10^{-19}\times1.54\times10^{-8}}$

$= 6.76 \times 10^{-3}$ m^2/V-s

42. Ans: (c)

Sol: $H_C = H_0\left[1-\left(\frac{T}{T_C}\right)^2\right]$

$$1\times10^5 = 2\times10^5\left[1-\left(\frac{8}{T_C}\right)^2\right]$$

$$\frac{1\times10^5}{2\times10^5} = 1-\left(\frac{8}{T_c}\right)^2$$

$$\frac{1\times10^5}{2\times10^5}+\left(\frac{8}{T_c}\right)^2 = 1$$

$$\frac{64}{T_c^2}+0.5=1 \Rightarrow T_c^2=\frac{64}{0.5}$$

$T_C = 11.31$ K

43. Ans: (b)

Sol: $J_c = \frac{i_C}{A} = \frac{H_C\times2\pi R}{\pi R^2} = \frac{2H_C}{R}$

44. Ans: (a)

Sol: Based on F.London and H.London research, magnetic flux density is allowed by super conductor up to some layers from the surface.

London penetration depth: It is the depth from the surface of super conductor upto which flux density is decreased by 63%.

$B = B_0 e^{\frac{-X}{\lambda_L}}$

B = Flux density at a depth ‘X’

B_0 = flux density at surface of super conductor

λ_L = London penetration depth

45. Ans: (d)

Sol: Hall angle $\tan\theta_H = \mu B = 0.041\times0.1 = 0.0041$

$\theta_H = \tan^{-1}(0.0041)$

$\theta_H = 0.2349$

46. Ans: (a)

47. Ans: (c)

Sol: Total magnetic moment $= N \times i \times A$

$= 500\times 20 \times 10^{-3} \times \pi (2 \times 10^{-2})^2$

$= 500 \times 20 \times 10^{-3} \times 4\pi \times 10^{-4}$

$= 4\pi \times 10^{-3}$ A-m^2

48. Ans: (a)

Sol: Magnetic flux density (b) = 88×10^{-4} Wb/m^2

Field strength (H) = 100 A/m

$$\mu_R = \frac{\mu}{\mu_0} = \frac{B}{H\mu_0} = \frac{88\times10^{-4}}{100\times4\pi\times10^{-7}} = 70$$

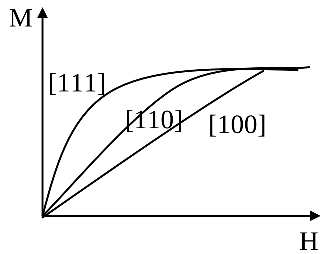
49. Ans: (a)

Sol: The hysteresis loop of ferromagnetic material depends on

1. Temperature
2. Crystallographic imperfection
3. Cold working

50. Ans: (a)

Sol:



51. Ans: (b)

Sol: Magnetorheological materials has the ability to increase viscosity drastically with applied field.

52. Ans: (c)

53. Ans: (d)

54. Ans: (a)

Sol: Wiess-Domain Theory: Based on Wiess Domain theory in a domain all the dipoles are aligned in a particular direction. If the magnetic field is applied Domain growth takes place in the field direction and at higher field, inside domain dipole relation takes place.

55. Ans: (b)

Sol: **Reason**: The no. of atoms per unit cell in BCC Crystal =2

The no.of atoms per unit cell in FCC crystal = 4 So, the difference is 4-2=2

56. Ans: (d)

Sol: Ga-As compound is a zinc blende structure

57. Ans: (b)

Sol: $\sqrt{2}\,a = 4R$

$$a = \frac{4R}{\sqrt{2}}$$

$$d_{111} = \frac{a}{\sqrt{h^2+k^2+\ell^2}}$$

$$= \frac{4\left(0.128\times10^{-9}\right)}{\sqrt{2}\times\sqrt{1^2+1^2+1^2}} = 2\ A^o$$

58. Ans: (d)

Sol: $X \to 1$ $(-1, 2, \infty)$

$Y \to 2$ $\left(\frac{-1}{1}, \frac{1}{2}, \frac{1}{\infty}\right) = \left(\bar{2}10\right)$

$Z \to \infty$

59. Ans: (d)

Sol: The bullet proof jocket is made up of aramid fiber reinforced polymer (AFRB) with reinforcement phase is Aramid and matrix phase is polymer.

60. Ans: (b)

61. Ans: (c)

62. Ans: (c)

63. Ans: (d)

Sol: The bonding in ceramics is predominantly ionic, it consists of anions and cations. The crystal structure of ceramics is influenced by the radius ratios of the ions. The coordination number depends on the radius of the bonding ions. Ceramics are classified according to their crystal structure as AX, AX_2, ABX_3 and AB_2X_4 types.

Examples under each type are given below:

AX : NaCl, CsCl, Zns

AX_2: SiO_2, CaF_2, PuO_2, ThO_2

ABX_3: $BaTiO_3$, $SrZrO_3$, $SrSnO_3$

AB_2X_4: $MgAl_2O_4$, $FeAl_2O_4$

64. Ans: (c)

Sol: If the temperature of metal increases, the lattice vibration in the crystal structure increases. Hence collision frequency increases and relaxation time decreases. Due to that resistivity of metal increases.

65. Ans: (c)

Sol: Ceramics have high melting point and can with stand high temperature.

66. Ans: (b)

Sol: If the radius X = 0.155, a more stable configuration is possible with three anions bonding with cation. This form a stable structure only upto an X value of 0.225 for $0.155 < X < 0.225$ the anions do not touch each other.

67. Ans: (a)

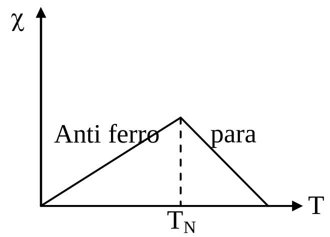
68. Ans: (a)

Sol: $BaTiO_3$ crystal is Ferroelectric material upto 120^oC, due to non-centro symmetric (asymmetric) structure. But above 120°C it become centro-symmetric and hence it looses its ferroelectric character.

69. Ans: (b)

Sol: The antiferro magnetic material depends on Neel's law

$$\chi = \frac{C}{T - T_N}$$



70. Ans: (d)

Sol: Impressed voltage V = (100 – j90) V

Current I = (3 – j4) A

Complex power, $S = V I^*$

$= (100 - j90)(3 + j4)$

$= (660 + j130)$ VA

∴ Real power = 660 W ∴ Statement (I) is false.

71. Ans: (b)

72. Ans: (d)

Sol: Equivalent network obtained from Δ - Y transformation relation is valid for any frequency.

So statement (I) is false.

73. Ans: (b)

74. Ans: (b)

Sol: Conversion to equivalent T – NW and application of Thevenin's Theorem have no relation.

75. Ans: (b)

Sol: Poly crystal materials are stronger than single crystal material because they require more stresses to initiate slip and yielding. Poly crystalline materials there are many preferred planes and direction for different grains due to their random orientation.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