CLASS TEST

Sl. : 01_JP_EC_05072023

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ELECTRONICS ENGINEERING

NETWORK THEORY

Duration : 1:00 hr. **Maximum Marks : 50**

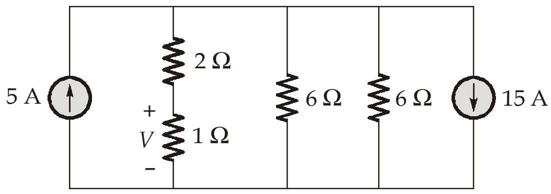
Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

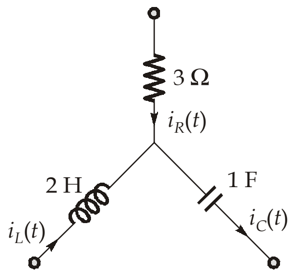
Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 Consider the circuit shown in the figure below:



The voltage 'V' across the 1 Ω resistor is
(a) –5 V
(b) –20 V
(c) –6.67 V
(d) 10 V

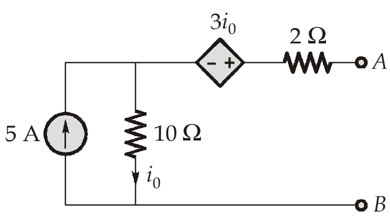
Q.2 Consider a circuit shown below,



At steady state, the current through resistor is given by 15cos$t$ and the voltage across the inductor is 2sin$t$. The RMS value of the current through the capacitor is
(a) $\frac{15}{\sqrt{2}}$ A
(b) $12\sqrt{2}$ A
(c) $7\sqrt{2}$ A
(d) $8\sqrt{2}$ A

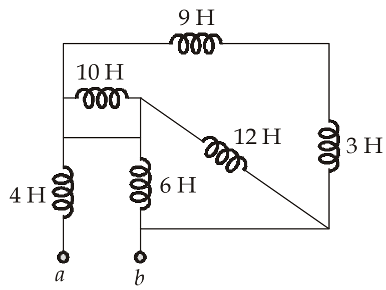
Q.3 A DC voltage source is connected across a series R-C circuit, when steady state reaches, the ratio of energy stored in the capacitor to the total energy supplied by the voltage source is given by
(Assume that the circuit is initially relaxed)
(a) $\frac{1}{2}$
(b) $\frac{1}{4}$
(c) 0.632
(d) 1

Q.4 Consider the circuit shown in the figure below:



The Thevenin's equivalent resistance seen across the terminal A and B is
(a) 2 Ω
(b) 10 Ω
(c) 12 Ω
(d) 15 Ω

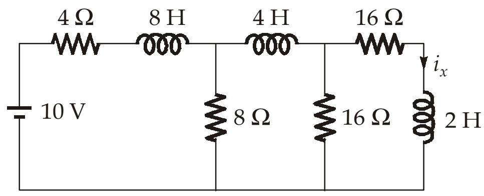
Q.5 For the circuit shown in the figure below,



The equivalent inductance seen across the terminals a and b is
(a) 5 H
(b) 7 H
(c) 9 H
(d) 11 H

Q.6 A series RLC circuit consists of a 10 Ω resistor in series with L = 20 μH and C = 100 μF. The new value of L, for which the resonant frequency is one half the original value.
(a) 10 μH
(b) 40 μH
(c) 80 μH
(d) 400 μH

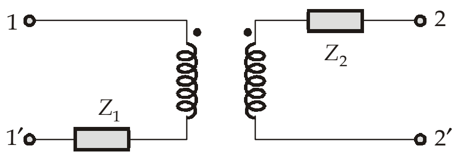
Q.7 If the circuit shown in the figure below has been connected for a very long time, then the current i_x is



(a) $\frac{5}{8}$ A
(b) $\frac{5}{16}$ A
(c) $\frac{4}{5}$ A
(d) $\frac{5}{32}$ A

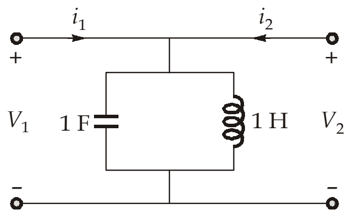
Q.8 If the Laplace transform of the voltage across $\frac{1}{2}$F capacitor is $V_C(s)$ = $\frac{s+1}{s^3+s^2+s+1}$, then the value of current through capacitor at t = 0^+ is
(a) 0 A
(b) 1 A
(c) $\frac{1}{2}$ A
(d) 2 A

Q.9 Two impedances Z_1 and Z_2 are connected in series with the primary and secondary winding of an ideal transformer as shown in the figure below, where the primary coil has $j6\ \Omega$ and secondary coil has $j9\ \Omega$ reactance. The mutual inductance if $\omega = 1000$ rad/sec is



(a) 7.35 mH (b) 9.45 mH
(c) 10.42 mH (d) 12.25 mH

Q.10 For a parallel LC circuit shown in the figure below, the transmission line parameter $C(s)$ will be equal to

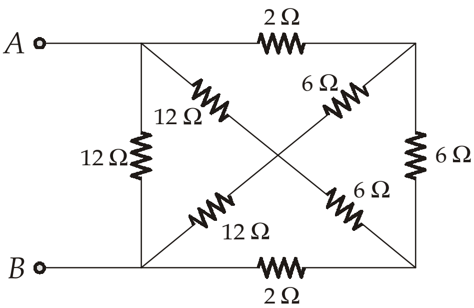


(a) $\dfrac{1}{1+s}$ (b) $s+\dfrac{1}{s}$

(c) $\dfrac{s}{1}+s^2$ (d) $\dfrac{s^2}{s^2+1}$

Q. No. 11 to Q. No. 30 carry 2 marks each

Q.11 The equivalent resistance seen across the terminal 'A' and 'B' in the figure given below is

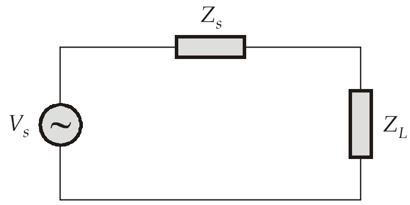


(a) 2 Ω (b) 4 Ω
(c) 6 Ω (d) 8 Ω

Q.12 In a series RLC circuit, L = 40 mH is given. If the instantaneous voltage and current 100cos(314t – 5°) V and 10cos(314t – 50°) A, respectively, the value of R and C will be

(a) R = 10 Ω and C = 580 μF
(b) R = 7.07 Ω and C = 580 μF
(c) R = 7.07 Ω and C = 5.49 mF
(d) R = 14.14 Ω and C = 5.49 mF

Q.13 Consider the circuit shown in the figure below,



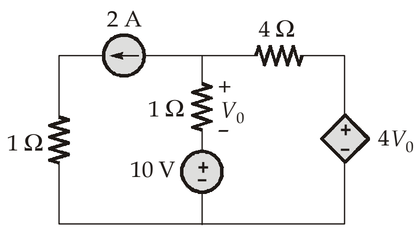
Assume V_s = 250sin500t V and Z_s = (100 + j200) Ω. If Z_L to be a parallel combination of R and C, then the value of R and C such that the maximum power transfer takes from source to load are respectively.

(a) R = 8 Ω and C = 500 μF
(b) R = 100 Ω and C = 10 μF
(c) R = 250 Ω and C = 250 μF
(d) R = 500 Ω and C = 8 μF

Q.14 Four resistors of equal value when connected in parallel across a supply dissipates 150 W. If the same resistors are now connected in series across the same supply, the power dissipated will be

(a) 9.375 W (b) 10.425 W
(c) 11.475 W (d) 15.225 W

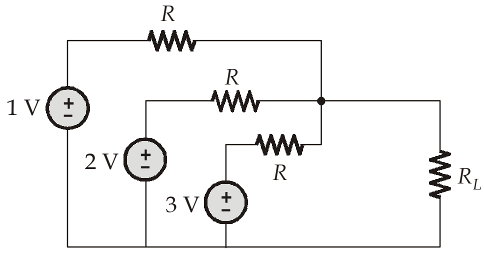
Q.15 Consider the circuit shown in the figure below:



The total power delivered by the dependent source is

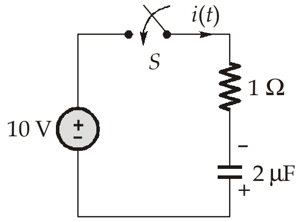
(a) 1024 W (b) 1100 W
(c) 1152 W (d) 1252 W

Q.16 For the circuit shown in the figure below, the value of 'R' such that the maximum power delivered to the load is 5 mW will be



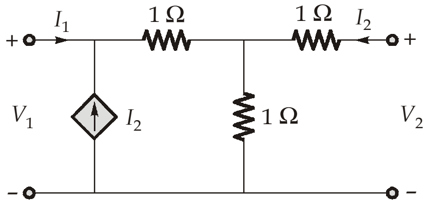
(a) 500 Ω
(b) 550 Ω
(c) 600 Ω
(d) 650 Ω

Q.17 For the circuit shown in the figure below, assume that initial charge on capacitor as 250 μC. The current $i(t)$ following switching at t = 0 will be



(a) $(125e^{-2 \times 10^5 t})$ A
(b) $(135e^{-5 \times 10^5 t})$ A
(c) $(10e^{-2 \times 10^5 t})$ A
(d) $(12.5e^{-5 \times 10^5 t})$ A

Q.18 For the circuit shown in the figure below, The equivalent z-parameter matrix is



(a) $\begin{bmatrix} 2\,\Omega & 3\,\Omega \\ 1\,\Omega & 1\,\Omega \end{bmatrix}$
(b) $\begin{bmatrix} 2\,\Omega & 1\,\Omega \\ 1\,\Omega & 1\,\Omega \end{bmatrix}$
(c) $\begin{bmatrix} 2\,\Omega & 3\,\Omega \\ 1\,\Omega & 3\,\Omega \end{bmatrix}$
(d) $\begin{bmatrix} 2\,\Omega & 3\,\Omega \\ 1\,\Omega & 2\,\Omega \end{bmatrix}$

Q.19 For a series RLC resonant circuit, the resonant frequency is given as 8 MHz and the bandwidth is 7.2 kHz. If the value of effective resistance is 4.5 Ω, then the capacitance C will be equal to

(a) 0.49 pF
(b) 3.98 pF
(c) 12.45 pF
(d) 31.84 pF

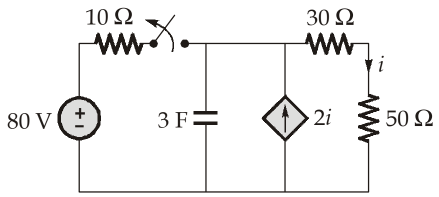
Q.20 A two port network is characterized by the following equations:

$$3V_1 - I_1 + 4I_2 = 0 \text{ and } 4I_1 + 2I_2 - 6V_1 = 5V_2$$

The y-parameter, y_{21} will be

(a) –0.25 ℧
(b) –0.33 ℧
(c) –0.39 ℧
(d) –0.45 ℧

Q.21 Consider the circuit shown in the figure below,



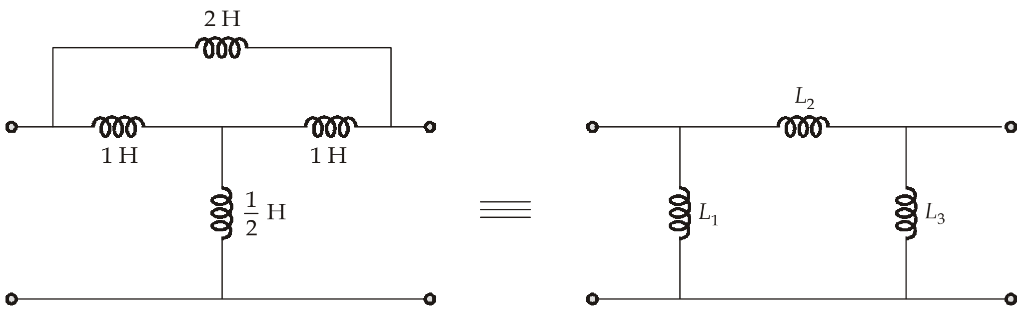
The current i for $t < 0$ is

(a) 0.565 A
(b) 0.942 A
(c) 1 A
(d) 1.142 A

Q.22 For a series RL circuit, the charging time needed for an inductor current to reach 30% of its steady state value is given as 2 sec. If the value of R = 5 Ω, then the value of inductor will be

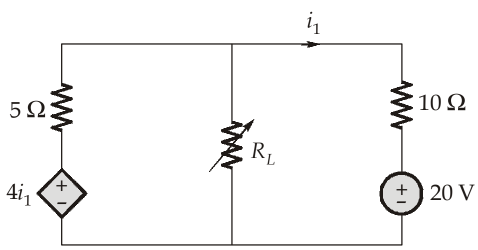
(a) 26 H
(b) 28 H
(c) 29 H
(d) 30 H

Q.23 It is intended that the two networks of the figure be equivalent with respect to their terminals. Then the value of L_2 will be



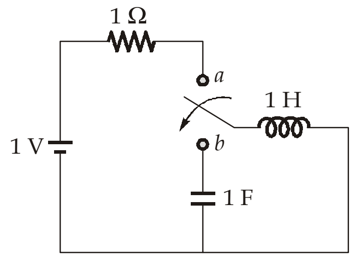
(a) $\frac{1}{5}$ H
(b) $\frac{1}{3}$ H
(c) $\frac{4}{3}$ H
(d) $\frac{2}{5}$ H

Q.24 For the circuit shown in the figure below, the maximum power delivered to the load R_L is



(a) 612.65 mW
(b) 181.81 mW
(c) 9.25 W
(d) 3.09 W

Q.25 Consider the circuit shown in the figure below:

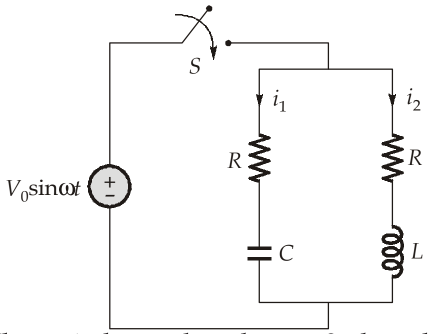


The steady state is reached with the switch at position '*a*'. At $t = 0$, switching is moved to '*b*'. The current post switching will be

(a) $\cos t$ (b) $\sin\sqrt{2}\,t$

(c) $\cos\sqrt{2}\,t$ (d) $-\sin t$

Q.26 Consider the circuit shown in the figure below:

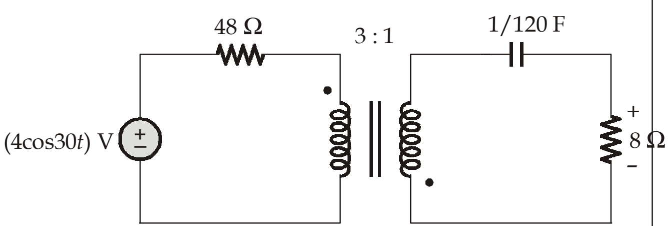


The switch get closed at $t = 0$, then the value of $\left.\frac{di_1}{dt}\right|_{(t=0^+)}$ in (A/s) is

(a) $\frac{-\omega V_0}{R}$ (b) $\frac{\omega V_0}{R}$

(c) $\frac{\omega V_0}{RC}$ (d) $\frac{V_0}{C}$

Q.27 Consider the circuit shown in the figure below:

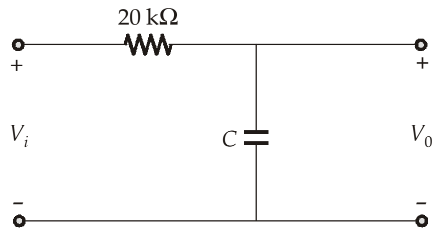


The average power absorbed by the 8 Ω resistor is

(a) 4.07 mW (b) 13.61 mW

(c) 36.63 mW (d) 1 W

Q.28 For a given low pass filter, if $|H(\omega)| = 0.2$ at a frequency of 20 MHz, then the value of capacitance C is



(a) 1.95 pF (b) 2.25 pF

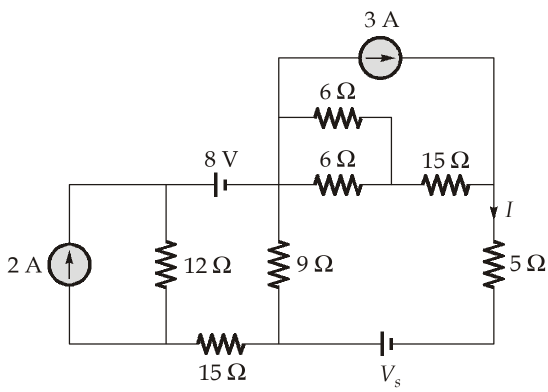
(c) 3.15 pF (d) 4.15 pF

Q.29 In a series RLC circuit, an AC voltage of $60\angle 0°$ volt is applied at a frequency of 200 rad/sec. The input current leads the voltage by 63.5°. If L = 50 mH and C = 75 μF. Then the resistance R will be

(a) 28 Ω (b) 32 Ω

(c) 35 Ω (d) 40 Ω

Q.30 Consider the circuit shown in the figure below:



If current I through 5 Ω resistor is 2 A, then the voltage V_s is

(a) 1 V (b) 1.5 V

(c) 2 V (d) 2.5 V

■■■■

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NETWORK THEORY

ELECTRONICS ENGINEERING

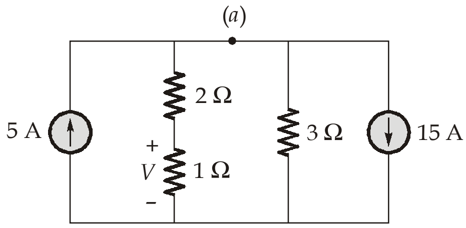
Date of Test : 05/07/2023

ANSWER KEY

1.	(a)	7.	(b)	13.	(d)	19.	(b)	25.	(a)
2.	(c)	8.	(c)	14.	(a)	20.	(b)	26.	(b)
3.	(a)	9.	(a)	15.	(c)	21.	(d)	27.	(c)
4.	(d)	10.	(b)	16.	(c)	22.	(b)	28.	(a)
5.	(b)	11.	(b)	17.	(b)	23.	(c)	29.	(a)
6	(c)	12.	(b)	18.	(c)	24.	(b)	30.	(b)

DETAILED EXPLANATIONS

1. (a)



Applying KCL at node (a), we get,

$$\frac{V_a}{3}+\frac{V_a}{3} = 5-15$$

$$6V_a = -90 \qquad \Rightarrow V_a = -15\text{ V}$$

$\because$ The current through 1 Ω resistor is $\frac{V_a}{3}=-\frac{15}{3}=-5\text{ A}$

$\therefore$ The voltage across 1 Ω resistor is –5 V.

2. (c)

We know that,

$$v_L(t) = L\frac{di_L(t)}{dt}$$

or,
$$i_L(t) = \frac{1}{L}\int v_L(t)\,dt=\frac{1}{2}\int 2\sin t\,dt$$

$$i_L(t) = -\cos t\text{ A}$$

also,
$$i_R(t) = 15\cos t\text{ A}$$

By KCL,

$$i_R(t) - i_C(t) + i_L(t) = 0$$

or,
$$i_C(t) = i_L(t) + i_R(t)$$
$$= 15\cos t - \cos t = 14\cos t\text{ A}$$

$$\text{RMS value of } i_C(t) = \frac{14}{\sqrt{2}}=7\sqrt{2}\text{ A}$$

3. (a)

The energy stored by the capacitor in the steady-state is = $\frac{1}{2}CV^2$

Energy supplied by the source, $E = \int_0^\infty p(t)dt = \int_0^\infty v\cdot i\,dt$

$\because$
$$i = \frac{V}{R}e^{-t/\tau}$$

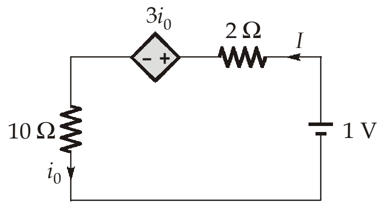
$$= \int_0^\infty \frac{V^2}{R}e^{-t/\tau}dt = CV^2$$

The total energy supplied by the voltage source $= CV^2$

$\therefore$ The ratio of energy stored by the capacitor to the energy supplied by the voltage source is $\frac{1}{2}$.

4. (d)

In order to find R_{Th}, let us take the inactive network and connect a 1 V source across the open terminals,



$$\text{Here,} \quad R_{Th} = \frac{1\text{ V}}{I}$$

$$\text{and} \quad I = i_0$$

By applying KVL to the loop, we get,

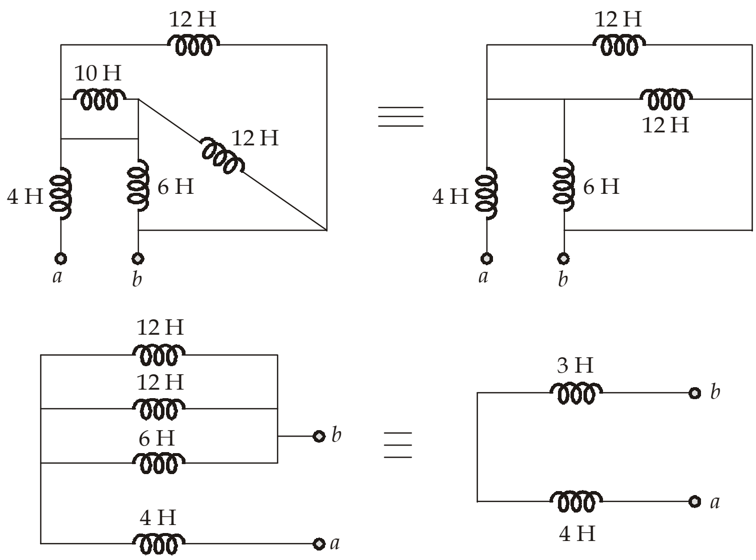
$$2I + 3i_0 + 10I = 1\text{ V}$$

$$2I + 3I + 10I = 1\text{ V}$$

$$\text{or,} \quad I = \frac{1\text{ V}}{15\ \Omega}$$

$$\text{or,} \quad R_{Th} = \frac{1\text{ V}}{I} = 15\ \Omega$$

5. (b)



$$L_{ab} = 7\text{ H}$$

6 (c)

The resonant frequency for a series RLC circuit is given by

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{20 \times 100 \times 10^{-12}}} = 3558.81\text{ Hz}$$

Now, $$f_0' = \frac{f_0}{2} = 1779.4 = \frac{1}{2\pi\sqrt{L \times 100\,\mu F}}$$

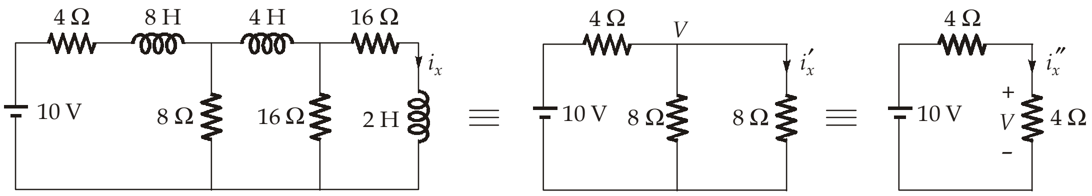
$$8.94 \times 10^{-5} = \sqrt{L \times 100\,\mu F}$$

$$L = 80\,\mu H$$

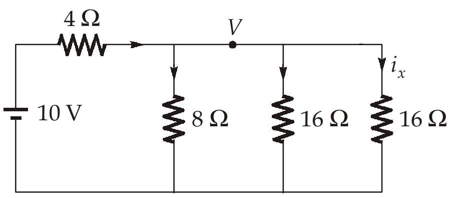
7. **(b)**

As the circuit has been connected for a long time. Therefore, the inductors behave like a short circuit for the dc voltage source,

∴ The circuit can be redrawn as



$$V = \frac{10}{(4+4)} \times 4 = 5\text{ V}$$



By KCL,

$$i_x = \frac{V}{16} = \frac{5}{16}\text{ A}$$

8. **(c)**

$$i(0^+) = \lim_{s\to\infty} sI(s) = \lim_{s\to\infty} s \cdot sC \cdot V(s)$$

$$= \lim_{s\to\infty} s^2 \times \frac{1}{2} \times \frac{s+1}{s^3+s^2+s+1} = \frac{1}{2}\text{ A}$$

9. **(a)**

For an ideal transformer, $K = 1$

∴ $$M = \sqrt{L_1 L_2}$$

Given, $$X_{L1} = j\omega L_1 = 6\,j$$

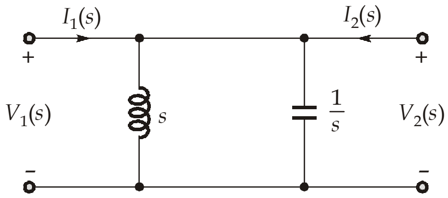
and $$X_{L2} = j\omega L_2 = 9\,j$$

∴ $$M = \sqrt{\frac{6j}{j\omega} \times \frac{9j}{j\omega}} = \frac{1}{\omega}\sqrt{6 \times 9}$$

$$= \frac{7.35}{\omega} = \frac{7.35}{1000} = 7.35\text{ mH}$$

10. (b)

Redrawing the given network in Laplace domain, we get,



From transmission line parameter,

$$V_1 = AV_2 + B(-I_2)$$
$$I_1 = CV_2 + D(-I_2)$$

For calculation of parameter $C(s)$, the output port must be open circuited and thereby,

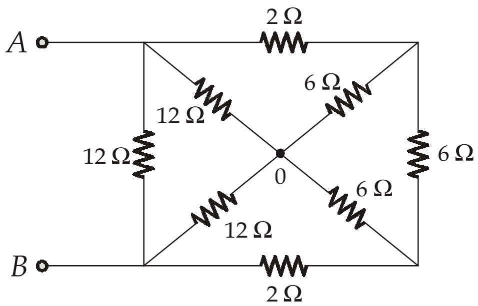
$$I_2(s) = 0$$

$$\therefore \qquad V_2(s) = \frac{s \times \frac{1}{s}}{s + \frac{1}{s}} I_1(s)$$

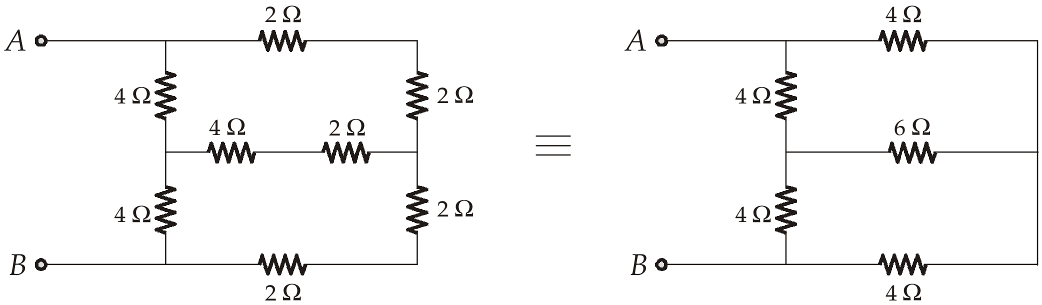
$$\text{or} \qquad C(s) = \frac{I_1(s)}{V_2(s)} = \frac{s^2+1}{s} = s + \frac{1}{s}$$

11. (b)

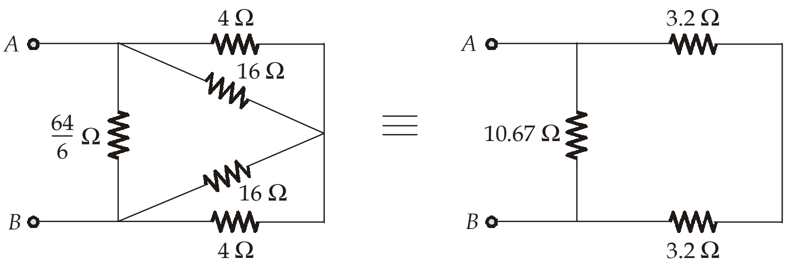
Redrawing the given circuit, we get,



Using Δ to Y conversion, we get,



Again using Y to Δ conversion, we have



or, $R_{AB} = 10.67\ \Omega \ || \ (3.2\ \Omega + 3.2\ \Omega)$

$$= \frac{10.67 \times 6.4}{10.67 + 6.4} = 3.99\ \Omega \approx 4\ \Omega$$

12. (b)

The current lags the voltage by 50° – 5° = 45°

$$\therefore \quad \omega L > \frac{1}{\omega C}$$

$$\tan 45° = 1 = \frac{\omega L - \frac{1}{\omega C}}{R}$$

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

$$\frac{100}{10} = \sqrt{2}\,R$$

or $R = 7.07\ \Omega$

$$\because \quad R = \omega L - \frac{1}{\omega C}$$

$$\frac{1}{\omega C} = 314 \times 40 \times 10^{-3} - 7.07$$

$$\frac{1}{\omega C} = 12.56 - 7.07 = 5.49$$

or
$$C = \frac{1}{314 \times 5.49} \approx 580\ \mu\text{F}$$

13. (d)

$$Z_L = R \,\|\, (-jX_C) = \frac{R(-jX_C)}{R - jX_C} = \frac{R(-jX_C)}{R - jX_C} \times \frac{R + jX_C}{R + jX_C}$$

$$= \frac{RX_C^2}{R^2 + X_C^2} - j\frac{R^2 X_C}{R^2 + X_C^2} \qquad \text{...(i)}$$

For maximum power transfer $Z_L = Z_s^*$

$\because \quad Z_s = 100 + j200$

$\therefore \quad Z_L = 100 - j200 \qquad$ ...(ii)

On comparing equation (i) and (ii), we get,

$$\frac{RX_C^2}{R^2 + X_C^2} = 100 \quad \text{and} \quad \frac{R^2 X_C}{R^2 + X_C^2} = 200$$

on solving, we get, $X_C = 250\ \Omega$

$$C = \frac{1}{500 X_C} = 8\ \mu\text{F}$$

and $R = 500\ \Omega$

14. (a)

Let 'R' be the value of each resistor,

When connected in parallel, the equivalent resistor is given by

$$R_{eq} = \frac{1}{\frac{1}{R}+\frac{1}{R}+\frac{1}{R}+\frac{1}{R}} = \frac{R}{4}\ \Omega$$

∴ Power dissipated by the circuit,

$$P = \frac{V^2}{R_{eq}}$$

$$150 = \frac{V^2}{R/4}$$

or $$\frac{V^2}{R} = \frac{150}{4} \quad \text{...(i)}$$

Now, the resistors are connected in series,

The equivalent resistor is given by,

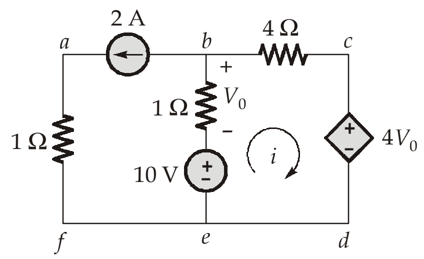
$$R_{eq} = R + R + R + R = 4R$$

∴ Power dissipated by the circuit,

$$P = \frac{V^2}{R_{eq}} = \frac{V^2}{4R} = \frac{1}{4}\left(\frac{150}{4}\right) = \frac{150}{16} = 9.375\text{ W}$$

15. (c)

Redrawing the given circuit, we get,



In loop *bcdeb*,

$$-10 - V_0 + 4i + 4V_0 = 0$$

$$3V_0 + 4i = 10 \quad \text{...(i)}$$

But, $$V_0 = -(i+2)1 = -i - 2 \quad \text{...(ii)}$$

Using the above relation, we get,

$$3(-i-2) + 4i = 10$$

$$-3i + 4i = 16$$

$$i = 16\text{ A}$$

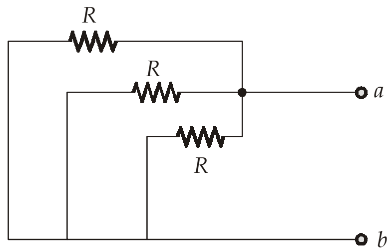
∴ $$V_0 = -i - 2 = -16 - 2 = -18\text{ V}$$

∴ Power absorbed by dependent source = $4V_0 \times i = 4(-18) \times (16) = -1152$ W

(Here negative sign indicates that the dependent source deliveres the power)

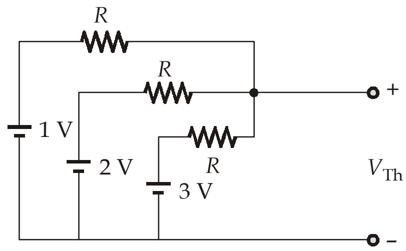
16. (c)

For finding R_{Th} across terminal a and b:



$$R_{Th} = \frac{R}{3}\,\Omega$$

For finding V_{Th}:



Using KCL, we get,

$$\frac{V_{Th}-1}{R}+\frac{V_{Th}-2}{R}+\frac{V_{Th}-3}{R} = 0$$

$$3V_{Th} = 6$$

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

∴ Maximum power transferred will be given by

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}}$$

$$5 \times 10^{-3} = \frac{2\times 2}{4\times\frac{R}{3}}$$

$$\frac{R}{3} = \frac{10^3}{5}$$

or $$R = \frac{3}{5}\times 10^3 = 600\,\Omega$$

17. (b)

Following switching, the differential equation representing the circuit is,

$$Ri(t)+\frac{1}{C}\int i(t)\,dt = V = 10$$

Taking Laplace transform, we get,

$$I(s)+\frac{I(s)}{2\times 10^{-6}s}+\frac{Q_0}{2\times 10^{-6}s} = \frac{10}{s} \qquad \because Q_0 = -250\ \mu\text{C}$$

Therefore,

$$I(s)+\frac{I(s)}{2\times 10^{-6}s}-\frac{250}{2s} = \frac{10}{s}$$

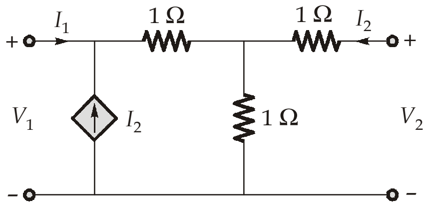
$$I(s) + \frac{I(s)}{2\times10^{-6}s} = \frac{135}{s}$$

or
$$I(s) = \frac{135}{(s+5\times10^{5})}$$

Taking inverse Laplace transform, we get,
$$i(t) = (135e^{-5\times10^{5}t})\ \text{A}$$

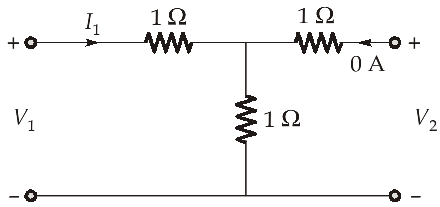
18. (c)

Let us first calculate z_{11} and z_{21} by open circuiting the output port,



$\because \quad I_2 = 0$

$\therefore$ The circuit can be redrawn as



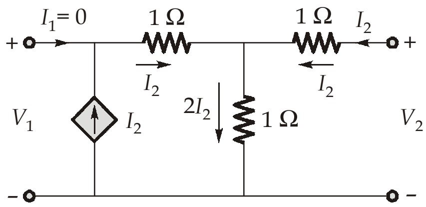
$$V_1 = 2I_1$$

and
$$V_2 = I_1$$

$\therefore$
$$z_{11} = \frac{V_1}{I_1} = 2\,\Omega$$

and
$$z_{21} = \frac{V_2}{I_1} = 1\,\Omega$$

Similarly z_{22} and z_{12} can be obtained by open circuiting the input port as,



$$V_1 = I_2 + 2I_2 = 3I_2$$

and
$$V_2 = I_2 + 2I_2 = 3I_2$$

$\therefore$
$$z_{22} = \frac{V_2}{I_2} = 3\,\Omega$$

and
$$z_{12} = \frac{V_1}{I_2} = 3\,\Omega$$

$\therefore$ z-parameter matrix
$$= \begin{bmatrix} 2\,\Omega & 3\,\Omega \\ 1\,\Omega & 3\,\Omega \end{bmatrix}$$

19. (b)

For an RLC circuit,

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}} \qquad \text{...(i)}$$

and
$$f_2 - f_1 = \text{Bandwidth (BW)} = \frac{1}{2\pi}\times\frac{R}{L} \qquad \text{...(ii)}$$

from equation (i) and (ii)

$$\frac{BW}{f_0^2} = \frac{\frac{1}{2\pi}\times\frac{R}{L}}{\frac{1}{4\pi^2}\times\frac{1}{LC}} = 2\pi RC$$

or

$$C = \frac{BW}{2\pi\times R\times f_0^2} = \frac{7.2\times10^3}{2\times\pi\times4.5\times8\times10^6\times8\times10^6} = 3.978 \text{ pF}$$

20. (b)

Given equations,

$$3V_1 = I_1 - 4I_2 \quad ...(i)$$

and

$$5V_2 = 4I_1 + 2I_2 - 6V_1 \quad ...(ii)$$

From equation (i), putting the value of V_1 in equation (ii), we get,

$$5V_2 = 4I_1 + 2I_2 - \frac{6}{3}(I_1 - 4I_2)$$

$$= 4I_1 + 2I_2 - 2I_1 + 8I_2$$

$$= 2I_1 + 10I_2$$

∴

$$z = \begin{bmatrix} 1/3 & -4/3 \\ 2/5 & 10/5 \end{bmatrix}$$

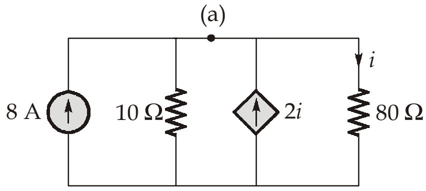
where

$$y_{21} = -\frac{z_{21}}{\Delta z} = \frac{-2/5}{\frac{1}{3}\times\frac{10}{5}+\frac{2}{5}\times\frac{4}{3}} = -\frac{1}{3}\ ℧$$

$$= -0.33\ ℧$$

21. (d)

For $t < 0$, the switch was closed and the capacitor will act as an open circuit,



Using KCL at node (a), we get,

$$\frac{V_a}{10}+\frac{V_a}{80} = 8 + 2i$$

$$\frac{V_a}{10}+\frac{V_a}{80} = 8+2\left(\frac{V_a}{80}\right) \qquad \left[\because i = \frac{V_a}{80}\right]$$

$$\frac{V_a}{10}+\frac{V_a}{80}-\frac{V_a}{40} = 8$$

or

$$8V_a + V_a - 2V_a = 640$$

or

$$V_a = \frac{640}{7}\text{ V}$$

∴

$$i = \frac{640}{7\times80} = \frac{8}{7}\text{ A} = 1.142 \text{ A}$$

22. (b)

For series *RL* circuit, if the circuit is initially relaxed then,

$$i(t) = i(\infty)\,(1 - e^{-t/\tau})$$

$$0.3i(\infty) = i(\infty)\,(1 - e^{-t/\tau})$$

$$0.7 = e^{-t/\tau}$$

Taking *ln* both the sides, we get,

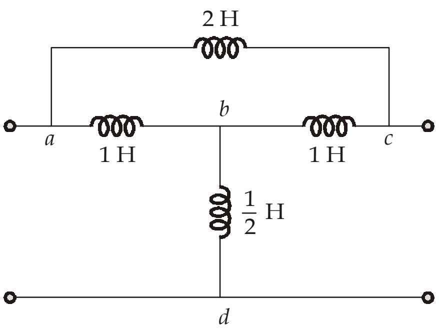
$$ln0.7 = \frac{-t}{\tau} \qquad \left(\text{where, } \tau = \frac{L}{R} = \frac{L}{5}\right)$$

$$ln0.7 = \frac{-2}{L/5} = \frac{-10}{L}$$

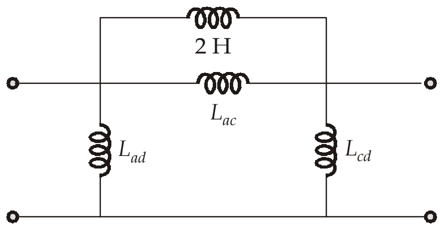
or, $$L = \frac{-10}{ln0.7} = 28.036 \text{ H}$$

23. (c)

The given circuit can be drawn as,



Converting '*Y*' '*acd*' to 'Δ', we get

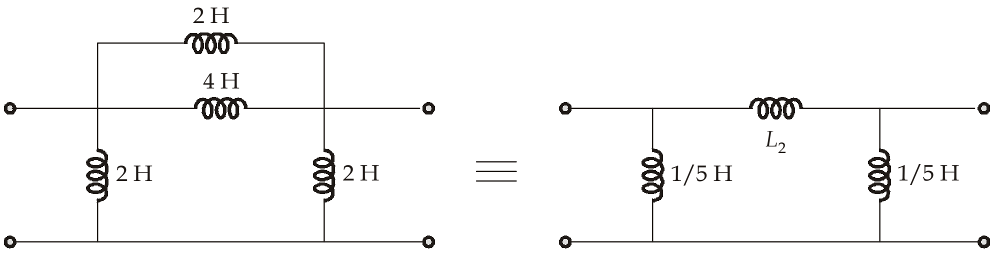


Here, $$L_{cd} = \frac{1\times\frac{1}{2}+1\times\frac{1}{2}+1\times 1}{1} = 2 \text{ H}$$

$$L_{ad} = \frac{1\times\frac{1}{2}+1\times\frac{1}{2}+1\times 1}{1} = 2 \text{ H}$$

$$L_{ac} = \frac{1\times 1+1\times\frac{1}{2}+1\times\frac{1}{2}}{\frac{1}{2}} = 4 \text{ H}$$

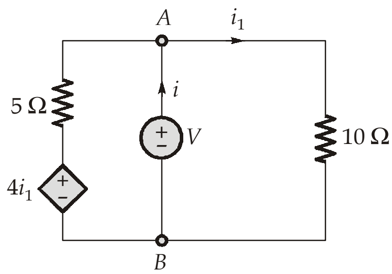
$\therefore$ The circuit can be redrawn as



where, $L_2 = \frac{2\times4}{2+4} = \frac{8}{6} = \frac{4}{3}$ H

24. (b)

For maximum power transfer, let us calculate the Thevenin's equivalent resistance,



Using KCL at node A, we get,

$$\frac{V-4i_1}{5} + \frac{V}{10} = i$$

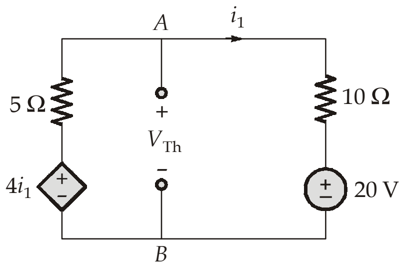
$$2V - 8i_1 + V = 10i$$

$$2V - 8\left(\frac{V}{10}\right) + V = 10i$$

$$(20 + 10 - 8)V = 100i$$

or $$R_{Th} = \frac{V}{i} = \frac{100}{22}\,\Omega = 4.545\,\Omega$$

Finding V_{Th}:



Using KCL at node A, we get,

$$\frac{V_{Th}-4i_1}{5} + \frac{V_{Th}-20}{10} = 0$$

$$2V_{Th} + V_{Th} - 20 = 8i_1$$

$$3V_{Th} = 8\left(\frac{V_{Th}-20}{10}\right) + 20$$

$$3V_{Th} - 20 = \frac{8V_{Th}}{10} - \frac{160}{10}$$

$$3V_{Th} - 0.8V_{Th} = 4$$

$$V_{Th} = \frac{4}{2.2} = 1.818 \text{ V}$$

∴ Maximum power transferred will be,

$$P = \frac{V_{Th}^2}{4R_{Th}} = \frac{V_{Th}^2}{4R_{Th}} = \frac{(1.818)^2}{4 \times 4.545} = 181.81 \text{ mW}$$

25. (a)

At steady state,

$$I = \frac{E}{R} = 1 \text{ A}$$

When switch moves from position 'a' to 'b', the tapped energy in L starts discharging through 'C'.

∴ By KVL in the circuit

$$L\frac{di}{dt} + \frac{1}{C}\int i\,dt = 0$$

or, $$sLI(s) - Li_L(0^+) + \frac{1}{Cs}I(s) + \frac{v_c(0^+)}{s} = 0$$

∵ $$i_L(0^-) = i_L(0^+) = \frac{E}{R} = 1 \text{ A}$$

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

Thus,

$$\frac{1}{Cs}I(s) + sLI(s) + \left(-\frac{E}{R}\right) = 0$$

or, $$I(s) = \frac{Es/R}{L\left[s^2 + \frac{1}{LC}\right]}$$

taking inverse Laplace transform of the above equation, we get,

$$i(t) = \frac{1}{L} \cdot \frac{E}{R} \cos\left(\frac{t}{\sqrt{LC}}\right)$$

By putting the values of parameters, we get,

$$i(t) = \cos t \text{ A}$$

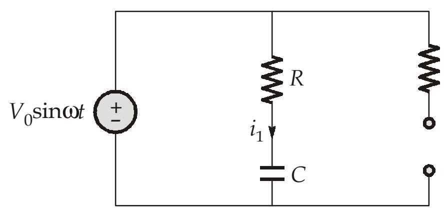
26. (b)

Before $t = 0$, the circuit is a source free circuit.

Thus, $$v_C(0^-) = v_C(0^+) = 0 \text{ V}$$

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

at $t = 0^+$, the circuit can be redrawn as



Writing the mesh equation, we get

$$V_0 \sin\omega t = Ri_1(t) + \frac{1}{C}\int_0^t i_1(t)\,dt$$

or
$$\omega V_0 \cos\omega t = R\frac{di_1(t)}{dt} + \frac{i_1(t)}{C}$$

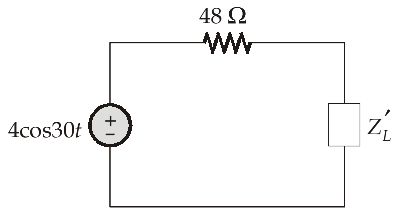
$$\frac{di_1}{dt} = \left[\omega V_0 \cos\omega t - \frac{i_1(t)}{C}\right] \times \frac{1}{R}$$

$$\frac{di_1}{dt}(0^+) = \frac{\omega V_0 \cos\omega t}{R}\bigg|_{t=0^+} - \frac{i_1(t)}{RC}\bigg|_{t=0^+}$$

$$\frac{di_1}{dt}(0^+) = \frac{\omega V_0}{R}\ \text{A/s}$$

27. (c)

Referring the secondary side, towards the primary, we get,



Where, $Z_L = 8 - \frac{j}{\omega C} = (8 - j4)\,\Omega$ and $n = \frac{1}{3}$

$\because$ $Z_L' = \frac{Z_L}{n^2} = 9Z_L = (72 - j36)\,\Omega$

$\therefore$ $I_1 = \frac{4\angle 0^\circ}{48 + 72 - j36} = \frac{4\angle 0^\circ}{125.28\angle -16.70^\circ}$

$$I_1 = 0.0319\angle 16.70^\circ$$

$\therefore$ $P_{8\,\Omega} = \left|\frac{I_1^2}{2}\right| \times 72 = 0.5088 \times 10^{-3} \times 72$

$$P_{8\,\Omega} = 36.63\ \text{mW}$$

28. (a)

For the given low pass filter

$$|H(\omega)| = \frac{K}{\sqrt{1 + \left(\frac{\omega}{\omega_L}\right)^2}}$$

where $\omega_L = \frac{1}{RC}$

$\therefore$ $$0.2 = \frac{K}{\sqrt{1 + \left(\frac{\omega}{\omega_L}\right)^2}}$$

For $K = 1$,

or, $$1+\left(\frac{\omega}{\omega_L}\right)^2 = (0.2)^{-2} = 25$$

⇒ $$\left(\frac{\omega}{\omega_L}\right)^2 = 24$$

or, $$\frac{\omega}{\omega_L} = \sqrt{24}$$

⇒ $$\omega_L = \frac{\omega}{\sqrt{24}} = \frac{2\pi f}{\sqrt{24}}$$

$$\frac{1}{RC} = \frac{2\pi\times 20\times 10^6}{\sqrt{24}}$$

or, $$C = \frac{\sqrt{24}}{2\pi\times 20\times 10^6\times 20\times 10^3} = 1.95\times 10^{-12}$$

$$C = 1.95 \text{ pF}$$

29. **(a)**

As we know,

$$X_L = \omega L = 200 \times 50 \times 10^{-3} = 10\ \Omega$$

and $$X_C = \frac{1}{\omega C} = \frac{1}{200\times 75\times 10^{-6}} = 66.67\ \Omega$$

∴ $$Z = R + j(X_L - X_C) = (R - j56.67)\ \Omega$$

Also, $$\tan^{-1}\left(\frac{X_L - X_C}{R}\right) = \phi$$

where ϕ is the angle between V and I in the circuit.

or, $$\tan(-63.5°) = \frac{X_L - X_C}{R} = \frac{10-66.67}{R}$$

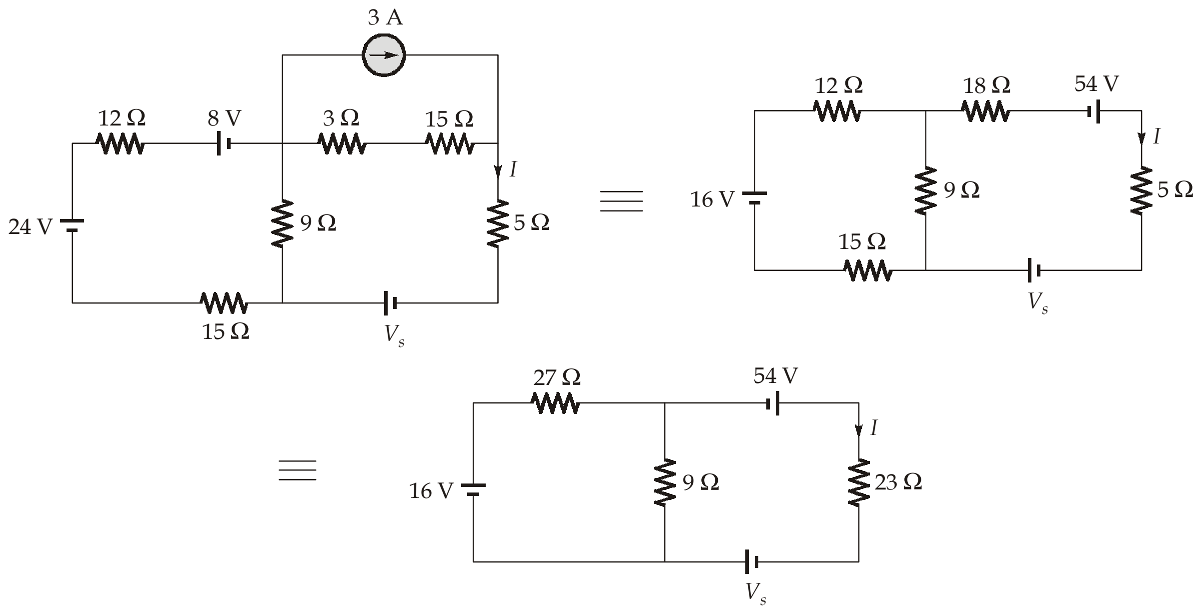
$$R = \frac{10-66.67}{-2.0056}$$

$$R = 28.255\ \Omega$$

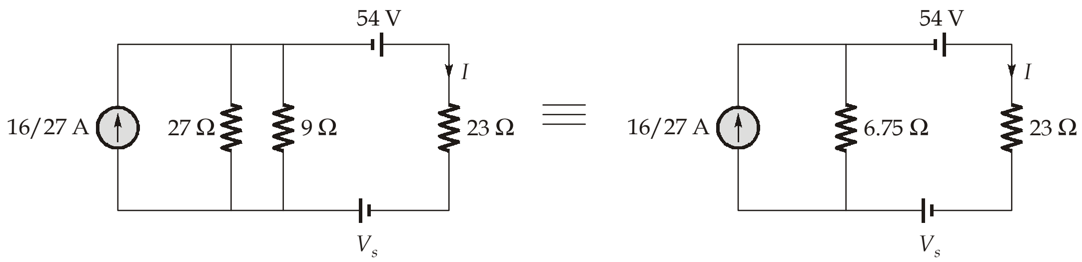
Here, negative sign of ϕ indicates the leading angle.

30. **(b)**

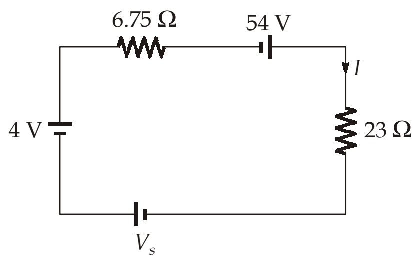
The given circuit can be simplified as



Using source transformation of 16 V source, we get,



Again using source transformation



Using KVL, we get,

$$4 + 54 + V_s = (23 + 6.75) \times 2$$

$$58 + V_s = 59.5$$

$$V_s = 59.5 - 58$$

$$V_s = 1.5 \text{ V}$$

■■■■