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INSTRUMENTATION ENGINEERING

Objective Practice Sets

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1 CHAPTER
Circuit Element and Energy Sources

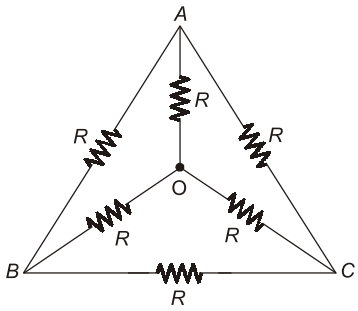
MCQ and NAT Questions

Q.1 The equivalent star impedance of a balanced delta connected load of value $6 + j9\ \Omega$ is given by

(a) $9 + j6\ \Omega$ (b) $2 + j3\ \Omega$

(c) $18 + j27\ \Omega$ (d) $6 - j9\ \Omega$

Q.2 The effective resistance between the terminals A and B in the circuit shown in the figure is



(a) R (b) $R - 1$

(c) $\frac{R}{2}$ (d) $\frac{6}{11}R$

Q.3 A network contains only independent current sources and resistors. If the values of all resistors are doubled, the values of the node voltages

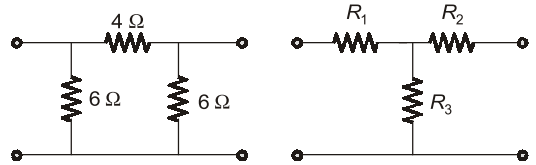
(a) will become half

(b) will remain unchanged

(c) will become double

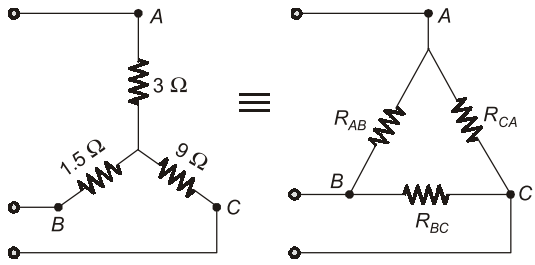
(d) cannot be determined unless the circuit configuration and the values of the resistors are known

Q.4 The value of R_1, R_2 and R_3 of the equivalent 'T' network for the given π network will be such that



	R_1	R_2	R_3
(a)	2.25 Ω	1.5 Ω	1.5 Ω
(b)	1.5 Ω	1.5	2.25 Ω
(c)	2.25 Ω	1.5 Ω	2.25 Ω
(d)	1.5 Ω	2.25 Ω	1.5 Ω

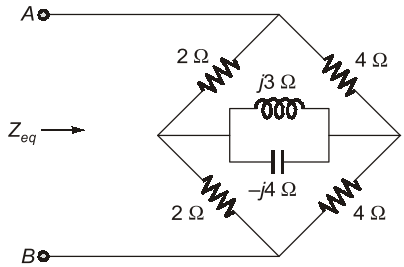
Q.5 For the equivalent @ figure circuit shown in the given figure, the values of R_{AB} and R_{BC} are respectively



(a) 5 Ω and 15 Ω (b) 15 Ω and 30 Ω

(c) 30 Ω and 5 Ω (d) 20 Ω and 35 Ω

Q.6 In the circuit of figure. The equivalent impedance seen across terminals A, B is _____ Ω.

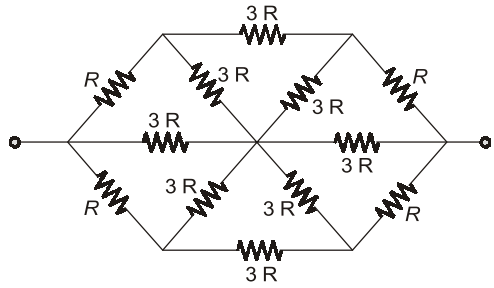


Q.7 If each branch of a delta circuit has impedance $Z/\sqrt{3}$ then, each branch of the equivalent Y circuit has impedance.

(a) $\frac{Z}{\sqrt{3}}$ (b) $\frac{Z}{3\sqrt{3}}$

(c) $3\sqrt{3}Z$ (d) $Z/3$

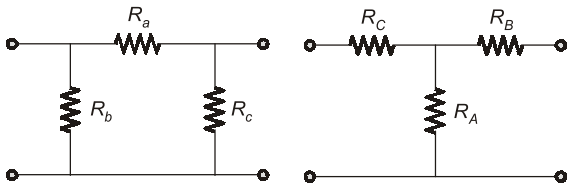
Q.8 The equivalent resistance between terminals A and B for the circuit shown is:



(a) R (b) $\frac{R}{3}$

(c) $\frac{3R}{2}$ (d) $2R$

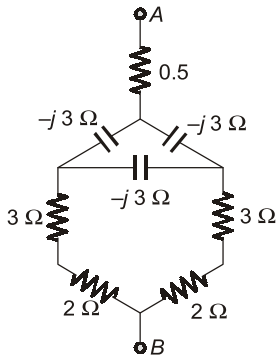
Q.9 Consider a delta connection of resistors and its equivalent star connection as shown below. If all elements of delta connection are scaled by a factor of K, $K > 0$, the elements of the corresponding star equivalent will be scaled by a factor of



(a) K^2 (b) K

(c) $1/K$ (d) $\sqrt{K}$

Q.10 For the circuit shown, the impedance between terminals A and B is:



(a) $9 - j3$ (b) $3 - j1.5$

(c) $j1.5$ (d) $0\ \Omega$

Q.11 A lamp rated at 10 watts, 50 volts is proposed to be used in 110 volts, system. The wattage and resistance of the resistor to be connected in series with the lamp should be

(a) 15 watt, 350 ohms

(b) 10 watts, 250 ohms

(c) 12 watts, 300 ohms

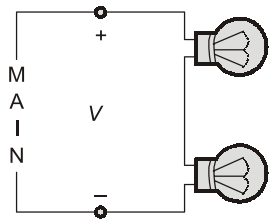
(d) 15 watts, 250 ohms

Q.12 The equivalent resistance of four resistors joined in parallel is 20 ohms. The currents flowing through them are 0.6, 0.3, 0.2 and 0.1 amp. The lowest value resistor is of

(a) 240 ohms (b) 120 ohms

(c) 80 ohms (d) 40 ohms

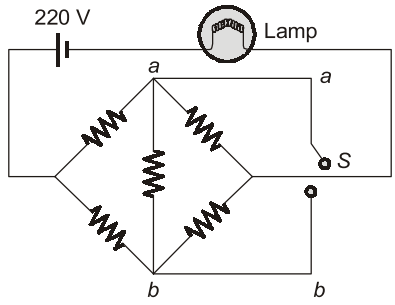
Q.13 The incandescent bulbs rated respectively as P_1 and P_2 for operation at a specified mains voltage are connected in series across the mains as shown in the below figure. Then the total power supplied by the mains to the two bulbs are



(a) $\frac{P_1 P_2}{P_1 + P_2}$ (b) $\sqrt{P_1^2 + P_2^2}$

(c) $(P_1 + P_2)$ (d) $\sqrt{P_1 \times P_2}$

Q.14 All resistances in the circuit in figure are of R ohms each. The switch is initially open. What happens to the lamp's intensity when the switch is closed?



(a) increases

(b) decreases

(c) remains the same

(d) answer depends on the value of R

Q.15 A practical current source is usually represented by

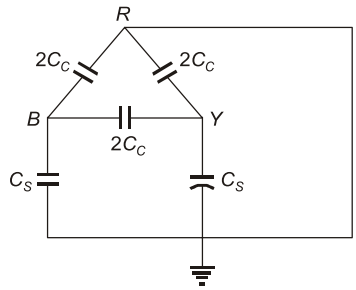
(a) a resistance in series with an ideal current source.

(b) a resistance in parallel with an ideal current source.

(c) a resistance in parallel with an ideal voltage source.

(d) none of these

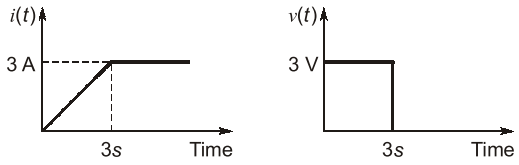
Q.16 For the circuit shown in figure, the capacitance measured between terminals B and Y will be



(a) $\frac{(C_s + 3C_c)}{2}$ (b) $C_s + \left(\frac{2c_c}{2}\right)$

(c) $\left(\frac{C_s + 6C_c}{2}\right)$ (d) $6C_c + 2C_s$

Q.17 The voltage and current waveforms for an element are shown in figure. The value of circuit element is _____.



(a) 3 H (b) 2 F

(c) 5 H (d) 3 F

Q.18 n resistors each of resistance R when connected in series offer an equivalent resistance of 50 Ω and when reconnected in parallel the effective resistance is 2 Ω. The value of R is

(a) 2.5 Ω (b) 5 Ω

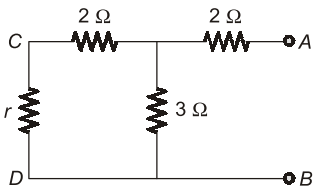
(c) 7.5 Ω (d) 10 Ω

Q.19 Three 30 Ω resistors are connected in parallel across an ideal 40 V source. What would be the equivalent resistance seen by the load connected across this circuit?

(a) 0 Ω (b) 10 Ω

(c) 20 Ω (d) 30 Ω

Q.20 For the circuit shown below the value of r connected between C and D is such that the equivalent resistance of the circuit by looking into circuit through terminals A and B is r only. Then the value of r is



(a) 2 Ω (b) 4 Ω

(c) 3 Ω (d) 6 Ω

Q.21 For a series and a parallel circuit, the equivalent total value of certain parameter X is given by

$$X_e = X_1 + X_2 + X_3 + X_4 + \cdots + X_n$$

where X_i is the ith value of the parameter and X_e is the equivalent value, and n is the number of elements.

The parameter X can be

(a) resistance (b) current

(c) voltage (d) power

Q.22 **Assertion (A):** Two wires of same length with different cross-sectional areas are connected in series. The heat produced by the current is more the thicker wire.

Reason (R): The thicker wire has low resistance.

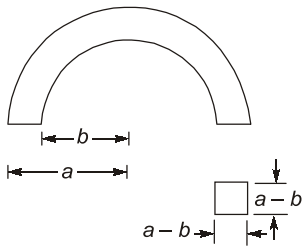
(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not a correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

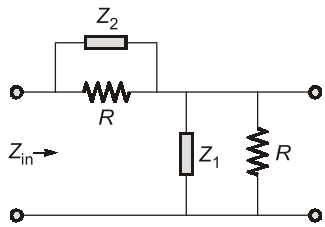
Q.23 The resistance measured between the two ends of the toroid shown in the below figure is R. What would be the resistance if both a and b are doubled?



(a) $2R$ (b) R

(c) $R/2$ (d) $R/4$

Q.24 What are the suitable values for Z_1 and Z_2 to make the input impedance, Z_{in} of the below network equal to R?



(a) R and R (b) $2R$ and R

(c) $3R$ and $2R$ (d) $4R$ and $4R$

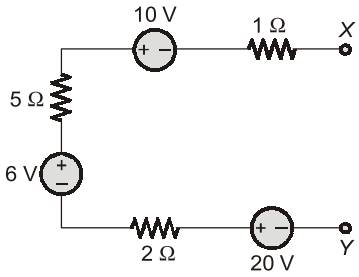
Q.25 **Assertion (A):** Inductors carrying steady direct currents act as effective short circuits with zero voltage across it.

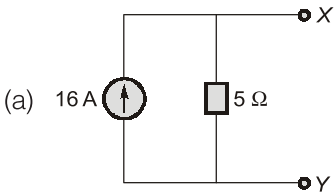
Reason (R): The voltage induced across an inductance is proportional to the rate of change of current *di*/*dt*.

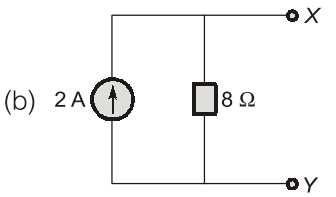
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not a correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

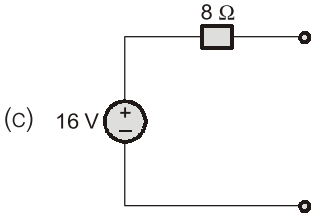
Multiple Select Questions (MSQs)

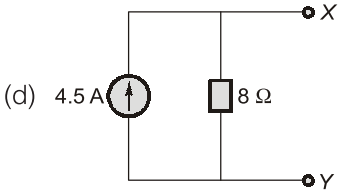
Q.26 The circuit shown below will be represented as



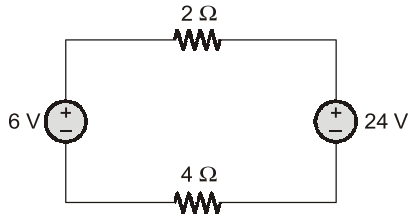
(a)


(b)


(c)


(d)


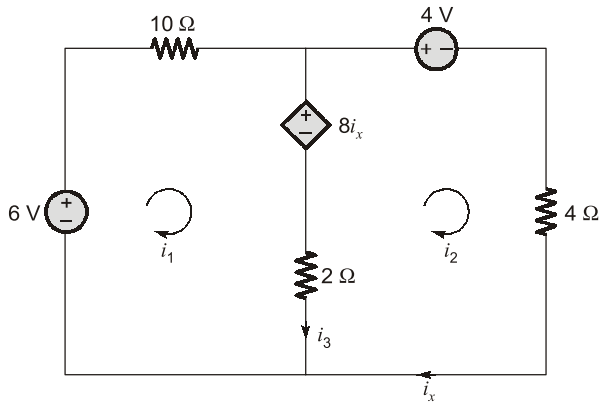
Q.27 For the circuit shown below :



Which of the following is correct?

(a) Power delivered by 24 V source is 72 W.
(b) Power absorbed by 4 Ω resistance is 36 W.
(c) Power delivered by 24 V source is 0 W.
(d) Power delivered by 6 V source is 18 W.

Q.28 For the circuit shown below :



Which of the following is correct?

(a) $i_1 = -1$ A (b) $i_2 = -3$ A
(c) $i_3 = 4$ A (d) $i_x = 3$ A

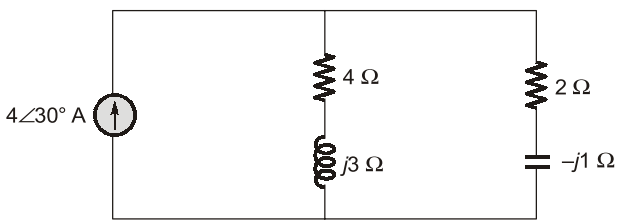
Q.29 A series circuit containing passive elements has the following current and applied voltage :

$$V = A\sin\left(\omega t + \frac{\pi}{4}\right)\text{V} \quad ; \quad i = B\sin\left(\omega t - \frac{\pi}{6}\right)\text{A}$$

The circuit elements :

(a) may be resistance and inductance.
(b) may be inductance, capacitance and resistance.
(c) may be resistance.
(d) may be resistance and capacitance.

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



Which of the following statement is correct?

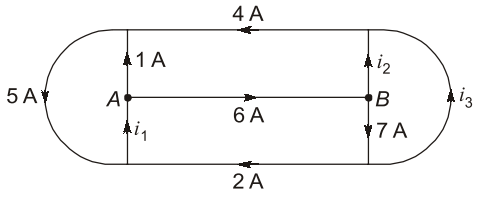
(a) The power supplied by the current source is 14 W.

(b) The average power absorbed by the capacitor is 0 W.

(c) The average power absorbed by the 4 Ω resistor is 4 W.

(d) The average power absorbed by the 2 Ω resistor is 11 W.

Q.31 For the given circuit :



Which of the following is correct?

(a) $i_1 = 7$ A (b) $i_3 = 5$ A

(c) $i_2 = 1$ A (d) $i_2 = -1$ A

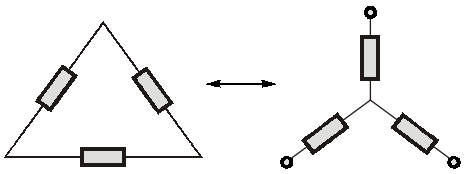
■■■■

Answers Circuit Element and Energy Sources

1.	(b)	**2.**	(c)	**3.**	(c)	**4.**	(b)	**5.**	(a)	**6.**	(2.67)	**7.**	(b)
8.	(c)	**9.**	(b)	**10.**	(b)	**11.**	(c)	**12.**	(d)	**13.**	(a)	**14.**	(c)
15.	(b)	**16.**	(c)	**17.**	(a)	**18.**	(d)	**19.**	(a)	**20.**	(b)	**21.**	(d)
22.	(d)	**23.**	(c)	**24.**	(a)	**25.**	(a)	**26.**	(b, c)	**27.**	(a, b)	**28.**	(a, d)
29.	(a, b)	**30.**	(a, b, c)	**31.**	(a, b, d)								

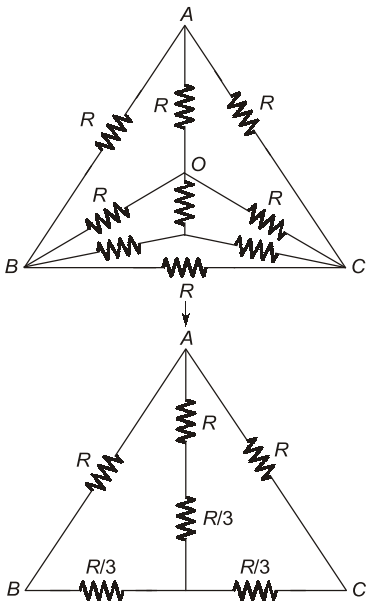
Explanations Circuit Element and Energy Sources

1. (b)



$$Z' = \frac{Z \times Z}{3Z} = \frac{Z}{3} = \frac{6 + j9}{3} = 2 + j3$$

2. (c)



$$R_{AB} = R \left\| \left(\frac{R}{3} + \left(\frac{4R}{3} \right\| \frac{4R}{3} \right) \right) = \frac{R}{2}$$

3. (c)

Since the network contains only independent current sources, so changing resistors in the same proportion the current through each branch will remain same but node voltages will change in the same proportion. Hence, doubling all resistors, node voltages will be doubled.

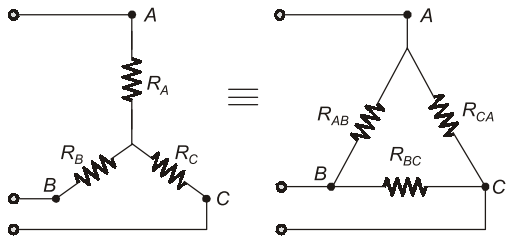
4. (b)

$$R_1 = \frac{4 \times 6}{4 + 6 + 6} = \frac{24}{16} = 1.5\ \Omega$$

$$R_2 = \frac{6 \times 4}{16} = 1.5\ \Omega$$

$$R_3 = \frac{6 \times 6}{16} = 2.25\ \Omega$$

5. (a)



$$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

$$R_{AB} = 3 + 1.5 + \frac{3 \times 1.5}{9}$$

$$= 3 + 1.5 + 0.5 = 5\ \Omega$$

$$R_{BC} = 9 + 1.5 + \frac{9 \times 1.5}{3}$$

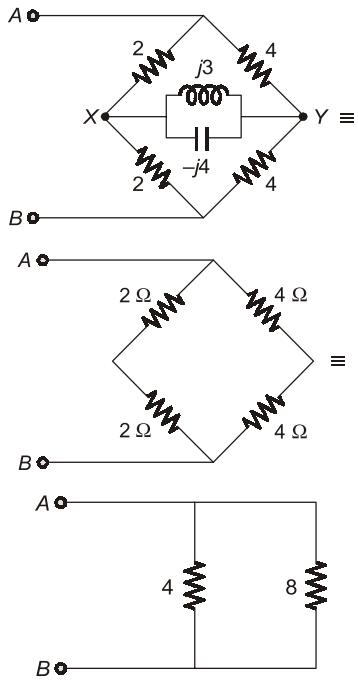
$$= 9 + 1.5 + 4.5 = 15\ \Omega$$

$$R_{CA} = R_A + R_C + \frac{R_A R_C}{R_B}$$

$$= 3 + 9 + \frac{3 \times 9}{1.5} = 30\ \Omega$$

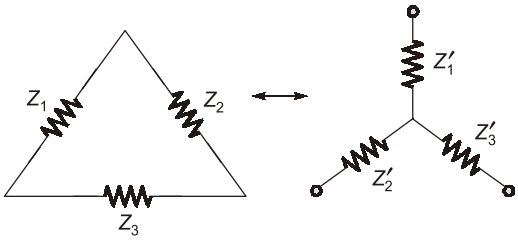
6. Sol.

The above circuit is a Wheatstone bridge circuit, thus no current will flow through branch XY.



$$Z_{eq} = 8 \,||\, 4 = \frac{8 \times 4}{12} = \frac{8}{3} = 2.67\ \Omega$$

7. (b)



$$Z_1' = \frac{Z_1 Z_2}{Z_1 + Z_2 + Z_3}$$

$$Z_2' = \frac{Z_1 Z_3}{Z_1 + Z_2 + Z_3}$$

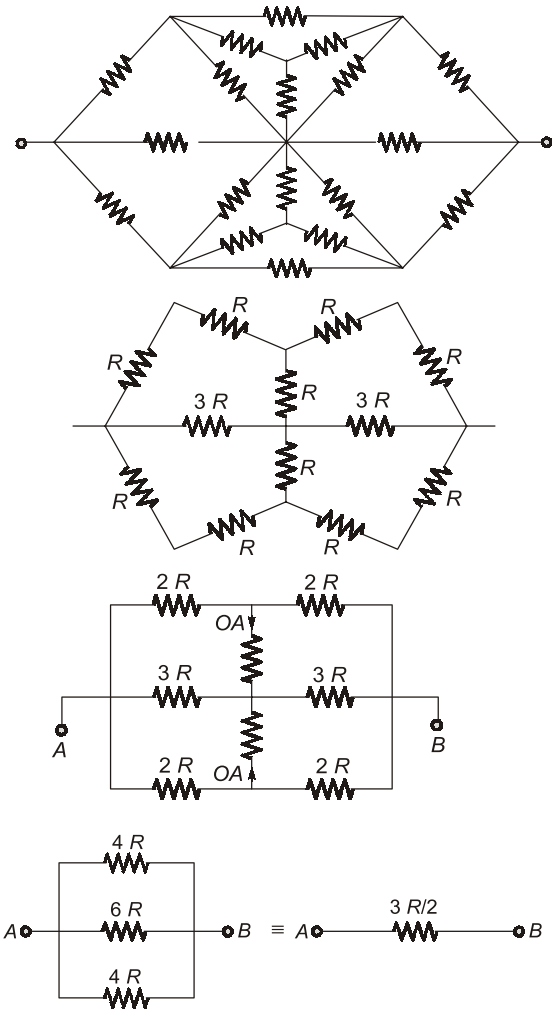
$$Z_3' = \frac{Z_2 Z_3}{Z_1 + Z_2 + Z_3}$$

$$Z_1' = \frac{\frac{Z}{\sqrt{3}} \times \frac{Z}{\sqrt{3}}}{\frac{Z}{\sqrt{3}} + \frac{Z}{\sqrt{3}} + \frac{Z}{\sqrt{3}}}$$

$$= \frac{\frac{Z^2}{(\sqrt{3})^2}}{\frac{3Z}{\sqrt{3}}} = \frac{Z^2\sqrt{3}}{3Z \times 3}$$

$$\Rightarrow \quad Z'_1 = \frac{Z}{3\sqrt{3}}$$

8. (c)



9. (b)

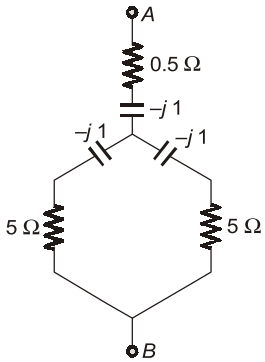
$$R_A = \frac{R_b R_c}{R_a + R_b + R_c} = K \cdot \left(\frac{R_c R_b}{R_a + R_b + R_c} \right)$$

$$R_B = \frac{R_a R_c}{R_a + R_b + R_c} = K \cdot \left(\frac{R_a R_c}{R_a + R_b + R_c} \right)$$

$$R_C = \frac{R_a \cdot R_b}{R_a + R_b + R_c}$$

$$= \frac{K^2 \cdot R_a R_b}{K(R_a + R_b + R_c)} = \frac{K \cdot R_a R_b}{R_a + R_b + R_c}$$

10. (b)

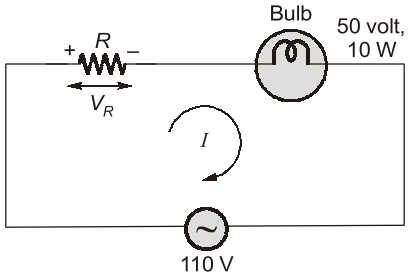


$$[(5 - j) \parallel (5 - j)] + (0.5 - j)$$

$[2.5 - j/2] + (0.5 - j)$

$(3 - j\,1.5)\ \Omega$

11. (c)



$V_R = 110 - 50 = 60$ volt

Current in the circuit,

$$I = \frac{10}{50} = \frac{1}{5} \text{A}$$

Hence wattage of resistor

$$P_R = VI = 60 \times \frac{1}{5} = 12 \text{ W}$$

As $P_R = I^2 R$

$$\therefore \quad R = \frac{P_R}{I^2} = \frac{12}{(1/5)^2} = 300\ \Omega$$

12. (d)

$$R_{eq} = 20\ \Omega$$

$$I = 0.6 + 0.3 + 0.2 + 0.1$$

$$= 1.2 \text{ A}$$

$$V = IR = 1.2 \times 20$$

$$= 24 \text{ V}$$

For maximum current, resistor R should be minimum.

$$\therefore \quad R_1 = \frac{V_1}{I_1} = \frac{24}{0.6} = 40\ \Omega$$

$$R_2 = \frac{V}{I_2} = \frac{24}{0.3} = 80\ \Omega$$

$$R_3 = \frac{V}{I_3} = \frac{24}{0.2} = 120\ \Omega$$

$$R_4 = \frac{V}{I_4} = \frac{24}{0.1} = 240\ \Omega$$

Hence, 40 Ω is the lowest value resistor.

13. (a)

$$R_1 = \frac{V^2}{P_1} \text{ and } R_2 = \frac{V^2}{P_2}$$

Bulbs are connected in series,

$$R_{eq} = R_1 + R_2$$

$$= V^2 \left[\frac{1}{P_1} + \frac{1}{P_2} \right]$$

$$= V^2 \left[\frac{P_1 + P_2}{P_1 P_2} \right]$$

$$\text{Total power} = \frac{V^2}{R_{eq}} = \frac{P_1 P_2}{P_1 + P_2}$$

14. (c)

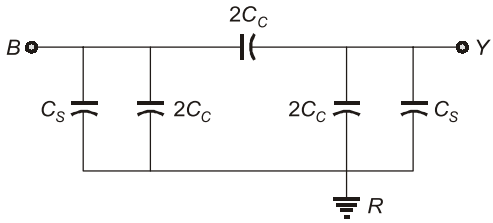
When we close the switch S, there will be no current in branch ab since it is a balanced Wheatstone bridge. So closing of switch will not effect lamp's intensity.

15. (b)

A practical current source is usually represented by a resistance in parallel with an ideal current source and a practical voltage source is usually represented by a resistance in series with an ideal voltage source.

16. (c)

Given circuit can be redrawn is



$$C_{BY} = \frac{C_s + 2C_c}{2} + 2C_c = \frac{C_s + 6C_c}{2}$$

17. (3)

For the given waveforms

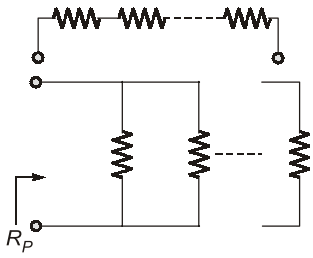
$$v(t) = \frac{3\,di(t)}{dt}$$

comparing it with

$$v(t) = \frac{L\,di(t)}{dt}$$

We get, $L = 3\ \text{H}$

18. (d)



$$R_S = nR$$

$$R_P = \frac{R}{n}$$

$$\Rightarrow \quad n \cdot R = 50$$

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

$$R = \frac{50}{n} \qquad ...(1)$$

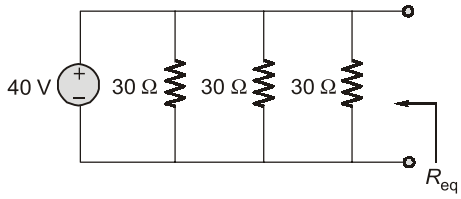
$$\Rightarrow \quad R = 2n \qquad ...(2)$$

Multiplying equation (1) and (2),

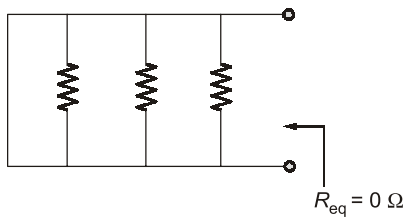
$$R^2 = \frac{50}{n} \times 2n = 100$$

$$\Rightarrow \quad R = \sqrt{100} = 10\ \Omega$$

19. (a)



Replacing voltage source by a short circuit,



20. (b)

$$r = \frac{(r+2)\times 3}{r+2+3} + 2$$

On solving, $r = 4\ \Omega$

21. (d)

As the circuit is a combination of series and parallel circuit and we know in series circuit current is same and in parallel voltage is same therefore X can not be current/voltage/resistance.

According to Tellegen's theorem the total instantaneous power given out by different sources always equals to the power consumed by various passive elements in various branches of the network at that time.

Therefore option (d) is correct.

22. (d)

$$R = \rho\frac{l}{A} \qquad A \rightarrow \text{area of cross-section}$$

$$R_1 = \rho\frac{l}{A_1}$$

$$R_2 = \rho\frac{l}{A_2}$$

$$A_2 > A_1 \Rightarrow R_2 < R_1$$

Heat produced,

$$H_1 \propto I^2 R_1$$

$$H_2 \propto I^2 R_2$$

$$H_2 < H_1$$

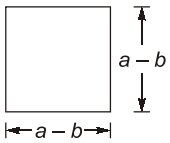
(A) – False

(R) – True

23. (c)

$$\text{Mean length of toroid} = \pi\left(b + \left(\frac{a-b}{2}\right)\right)$$

$$\text{Where mean radius} = b + \left(\frac{a-b}{2}\right) = \frac{a+b}{2}$$



Area of cross section = $\pi(a-b)^2$

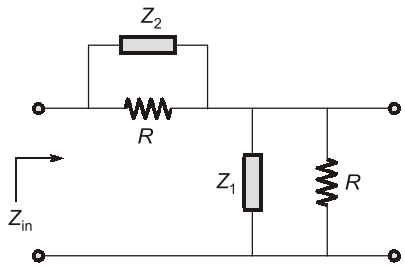
$$R = \frac{\rho l}{A} = \frac{\pi\rho\left(\frac{a+b}{2}\right)}{\pi(a-b)^2} = \frac{\rho}{2}\frac{(a+b)}{(a-b)^2}$$

with 'a' and 'b' doubled,

$$R' = \frac{\rho}{2}\frac{(2a+2b)}{(2a-2b)^2}$$

$$= \frac{\rho}{4}\frac{a+b}{(a-b)^2} = \frac{R}{2}$$

24. (a)



$$Z_{in} = R$$

$$\frac{Z_{in}}{R} = \frac{Z_1}{R+Z_1} + \frac{Z_2}{R+Z_2}$$

$$\frac{R}{R} = 1 = \frac{Z_1}{R+Z_1} + \frac{Z_2}{R+Z_2}$$

$$1 - \frac{Z_1}{R+Z_1} = \frac{Z_2}{R+Z_2}$$

$$\frac{R}{R+Z_1} = \frac{Z_2}{R+Z_2}$$

$$Z_2 = R$$

$$Z_1 = Z_2 = R$$

25. (a)

$$V_L \propto \frac{di}{dt}; \quad V_L = L\frac{di}{dt}$$

For d.c. $\frac{di}{dt} = 0 \Rightarrow v = 0$

Inductor acts as short-circuit.

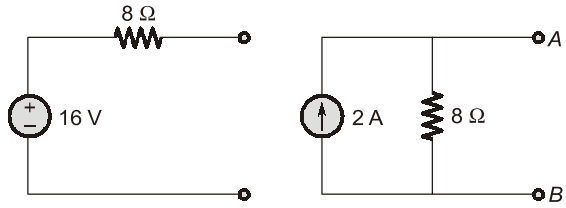
26. (b, c)

Equivalent voltage in the given circuit is

$V = 6 + 20 - 10 = 16$ V

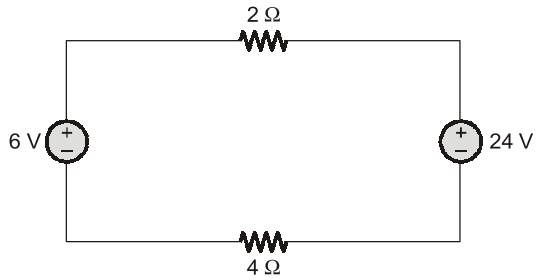
And equivalent resistance is

$R = 1 + 5 + 2 = 8\ \Omega$



27. (a, b)

Since $V_1 < V_2$, therefore the current will flow from V_2 to V_1 as shown below :



$$I = \frac{V_2 - V_1}{6} = \frac{24-6}{6} = 3\text{ A}$$

∴ Power delivered by 24 V voltage source

$= 72$ W

and Power absorbed by 6 V voltage source

$= 6 \times 3 = 18$ W

Power absorbed by 4 Ω resistance

$= 3^2 \times 4 = 36$ W

28. (a, d)

$10i_1 + 8i_x + 2(i_1 - i_2) = 6$ ...(1)

and $4 + 4i_2 + 2(i_2 - i_1) - 8i_x = 0$ ...(2)

$i_2 = i_x$ ...(3)

Substituting equation of 3 in equation (1) and (2), we get

$12i_1 + 6i_2 = 6$ ...(4)

$-2i_1 - 2i_2 = -4$

$i_1 + i_2 = 2$ ...(5)

$i_1 = -1$ A

$i_x = i_2 = 3$ A

$i_3 = i_1 - i_2$

$= -1 - 3 = -4$ A

29. (a, b)

Phase difference between V and i is

$$\phi = \frac{\pi}{4} - \left(-\frac{\pi}{6}\right)$$

$= 45° + 30° = 75°$

Since, i lags V therefore the circuit elements may be resistance and inductance.

$$Z = R + jX_L$$

or it may be resistance, inductance and capacitance.

$$Z = R + j(X_L - X_C)$$

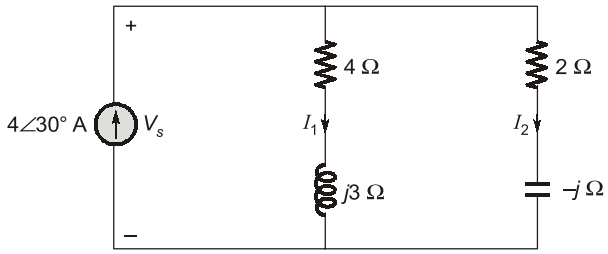
30. (a, b, c)

$$I_1 = \left(\frac{2-j}{2-j+4+3j}\right)(4\angle 30°)$$

$$= 1.414\angle -15° \text{ A}$$

$$I_2 = \left(\frac{4+j3}{4+j3+2-j}\right)(4\angle 30°)$$

$$= 3.16\angle 48.43° \text{ A}$$



$$V_S = I_1(4 + 3j)$$

$$= (1.414\angle -15)(4 + j3)$$

$$= 7.07\angle 21.87° \text{ V}$$

$$P_{IS} = \frac{V_m I_m}{2}\cos(\theta_V - \theta_i)$$

$$= \frac{(7.07)(4)}{2}\cos(21.87° - 30°)$$

$$= 14 \text{ W supplied.}$$

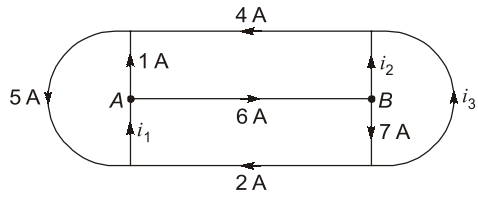
$$P_{4\Omega} = \frac{|I_1|^2 R}{2}$$

$$= \frac{(1.414)^2(4)}{2}$$

$$= 4 \text{ W absorbed}$$

$$P_{2\Omega} = \frac{I_2^2 R}{2} = \frac{(3.16)^2(2)}{2} = 10 \text{ W}$$

31. (a, b, d)



Applying KCL at A

$$1 + 6 = i_1$$

$$i_1 = 7 \text{ A}$$

Applying KCL at B

$$i_2 + 7 = 6$$

$$i_2 = -1 \text{ A}$$

Applying KCL at C

$$i_2 + i_3 = 4$$

$$-1 + i_3 = 4$$

$$i_3 = 5 \text{ A}$$

■■■■