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Director's Message

B. Singh (Ex. IES)

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a career option.

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power"*. To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

Volume-I

ELECTRONICS & TELECOM. ENGG.

Objective Solved Questions

of UPSC Engineering Services Examination

Contents

UNIT

I

Network Theory

Syllabus

Network graphs & matrices; Wye-Delta transformation; DC circuits-Ohm's & Kirchhoff's laws, mesh and nodal analysis, circuit theorems; Linear constant coefficient differential equations- time domain analysis of RLC circuits; Solution of network equations using Laplace transforms- frequency domain analysis of RLC circuits; 2-port network parameters-driving point & transfer functions; State equations for networks; Single-phase AC circuits, Steady state sinusoidal analysis.

Contents

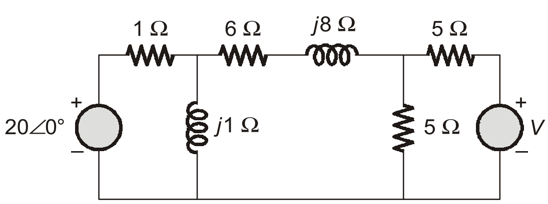
❍❍❍❍

1 Basics of Network Analysis

1.1 If a coil has diameter 'd', number of turns 'N' and form factor 'F' then the inductance of the coil is proportional to
(a) N^2dF (b) Nd^2F
(c) N^2d^2/F (d) N^2d/F [ESE-2000]

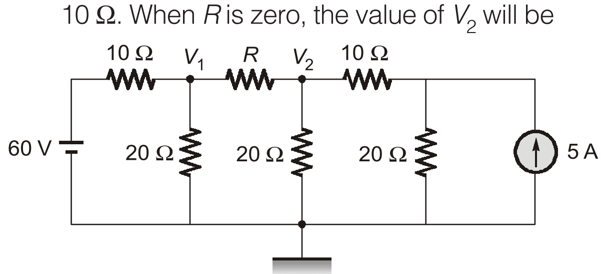
1.2 A coil would behave as
(a) an inductor at high frequencies
(b) a capacitor at very low frequencies
(c) a capacitor at very high frequencies
(d) a resistor at high frequencies
[ESE-2000]

1.3 In the circuit shown below, if the power dissipated in the 6 Ω resistor is zero then V is



(a) $20\sqrt{2}\angle 45°$ (b) $20\angle 30°$
(c) $20\angle 45°$ (d) $20\sqrt{2}\angle 30°$
[ESE-2000]

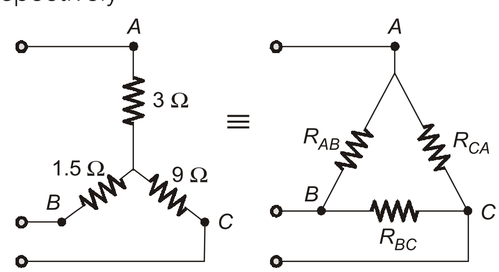
1.4 In the circuit shown below, V_1 = 40 V when R is 10 Ω. When R is zero, the value of V_2 will be



(a) 40 V (b) 30 V
(c) 20 V (d) 10 V [ESE-2000]

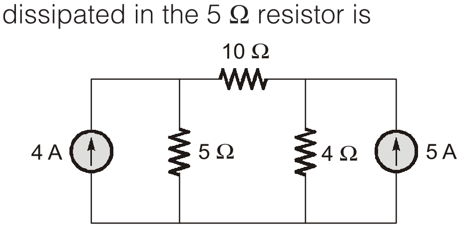
1.5 A network contains only independent current sources and resistors. If the values of all resistors are doubled, the values of the node voltages
(a) will become half
(b) will remain unchanged
(c) will become double
(d) cannot be determined unless the circuit configuration and the values of the resistors are known
[ESE-2000]

1.6 For the equivalent Δ 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
[ESE-2001]

1.7 In the circuit shown in the given figure, power dissipated in the 5 Ω resistor is



(a) zero (b) 80 W
(c) 125 W (d) 405 W
[ESE-2001]

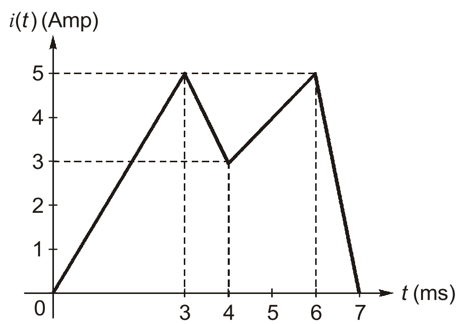
1.8 Consider the following:
Energy storage capability of basic passive elements is due to the fact that
1. resistance dissipates energy
2. capacitance stores energy
3. inductance dissipates energy
Which of the above is/are correct?
(a) 1, 2 and 3 (b) 1 and 3
(c) 3 alone (d) 1 and 2
[ESE-2002]

1.9 $\sqrt{\frac{L}{C}}$ has the dimension of

(a) time (b) capacitance
(c) inductance (d) resistance

[ESE-2002]

1.10 A current $i(t)$ as shown in the figure is passed through a capacitor.

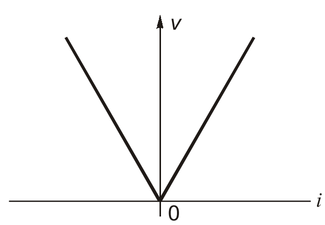


The charge (in micro-coulomb) acquired by the capacitor after 5 μs is

(a) 7.5 (b) 13.5
(c) 14.5 (d) 15

[ESE-2002]

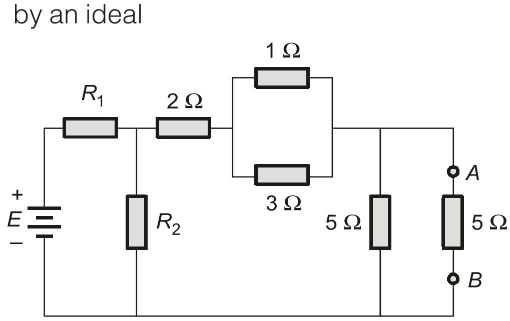
1.11 The v-i characteristic of an element is shown in the below figure. The element is



(a) Non-linear, active, non-bilateral
(b) Linear, active, non-bilateral
(c) Non-linear, passive, non-bilateral
(d) Non-linear, active, bilateral

[ESE-2003]

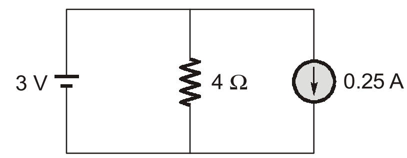
1.12 In the circuit shown below, the voltage across 2 Ω resistor is 20 V. The 5 Ω resistor connected between the terminals A and B can be replaced by an ideal



(a) Voltage source of 25 V with + terminal upward
(b) Voltage source of 25 V with + terminal downward
(c) Current source of 2 A upward
(d) Current source of 2 A downward

[ESE-2003]

1.13 The current flowing through the voltage source in the circuit shown below is



(a) 1.0 A (b) 0.75 A
(c) 0.5 A (d) 0.25 A

[ESE-2003]

1.14 Match **List-I** (Quantities) with **List-II** (Units) and select the correct answer:

	List-I		**List-II**
A.	R/L	**1.**	Second
B.	$1/LC$	**2.**	Ohm
C.	CR	**3.**	(Radian/Second)^2
D.	$\sqrt{L/C}$	**4.**	(Second)$^{-1}$

Codes:

	A	B	C	D
(a)	4	3	1	2
(b)	3	4	2	1
(c)	4	3	2	1
(d)	3	4	1	2

[ESE-2003]

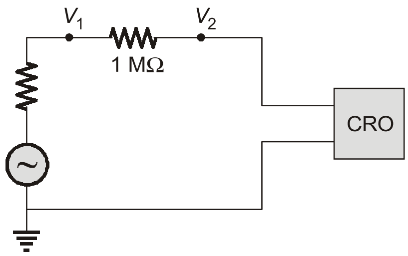
1.15 **Assertion (A):** Kirchhoff's voltage law states that a closed path in a network, the algebraic sum of all voltages in a single direction is zero.

Reason (R): Law of conservation of charge is the basis of this law.

(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 the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2003]

1.16 Consider the following circuit:

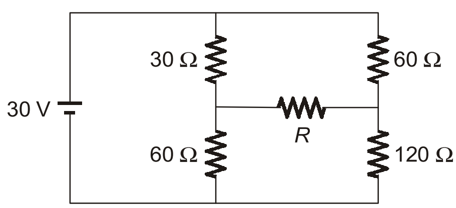


If V_1 = 5 V and V_2 = 3 V, then what is the input impedance of the CRO in the above circuit?

(a) 1 MΩ (b) 1.5 MΩ
(c) 3 MΩ (d) 5 MΩ

[ESE-2004]

1.17 Consider the following circuit:

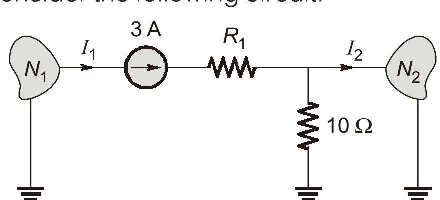


What is the power delivered to resistor R in the above circuit?

(a) –15 W
(b) 0 W
(c) 15 W
(d) Cannot be determined unless the value of R is known

[ESE-2004]

1.18 Consider the following circuit:

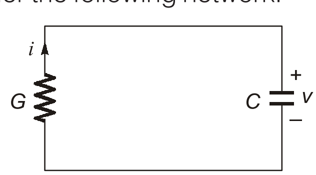


In the above circuit, the current I_2 is 2 A when the value of R_1 is 20 Ω. What will be the value of I_2, when R_1 is changed to 10 Ω?

(a) 1 A (b) 2 A
(c) 3 A (d) 4 A

[ESE-2004]

1.19 Consider the following network:



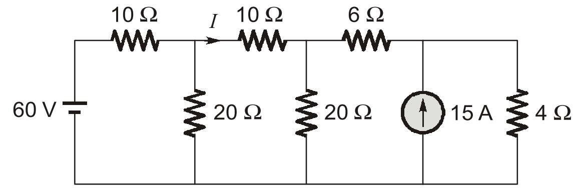
Which one of the following is the differential equation for v in the above network?

(a) $C\frac{dv}{dt}+Gv=0$ (b) $G\frac{dv}{dt}+Cv=0$

(c) $\frac{1}{C}\frac{dv}{dt}+Gv=0$ (d) $C\frac{dv}{dt}-Gv=0$

[ESE-2004]

1.20 Consider the following circuit:



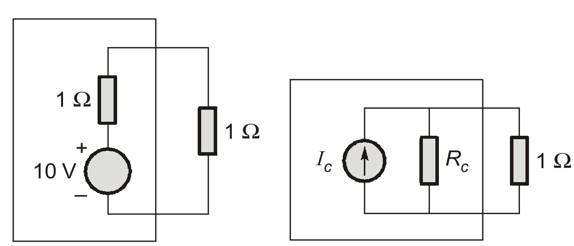
What is the current I in the above circuit?

(a) 0 A (b) 2 A
(c) 5 A (d) 6 A [ESE-2004]

1.21 Which one of the following statements is correct? In a four-branch parallel circuit, 50 mA current flows in the each branch. If one of the branches opens, the current in the other branches

(a) increase (b) decrease
(c) are unaffected (d) double [ESE-2004]

1.22 Consider the following statements:
Network N_A in Fig. (a) can be replaced by the network N_B shown in Fig. (b) below, when I_c and R_c, respectively, are:



N_A Fig. (a) N_B Fig. (b)

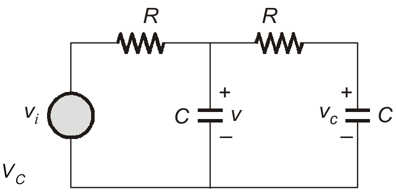
1. 5 A and 2 Ω 2. 10 A and 1 Ω
3. 15 A and 1/2 Ω 4. 30 A and 1/5 Ω

Which of the following statements given above is/are correct?

(a) 1 only
(b) 2, 3 and 4
(c) 1, 2, 3 and 4
(d) 2 and 3

[ESE-2005]

1.23 For the circuit given below, what is the expression for the voltage v?



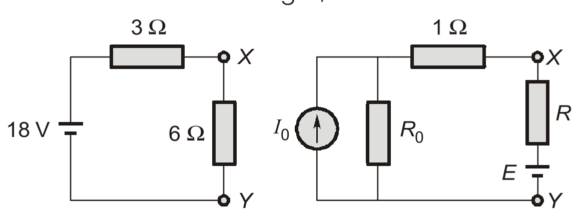
(a) $v + v_c$

(b) v_c

(c) $RC\frac{dv_c}{dt} - v_c$

(d) $RC\frac{dv_c}{dt} + v_c$ **[ESE-2005]**

1.24 If the two circuits shown below are equivalent, then which of the following is/are correct?



1. $E = 2$ V, $R = 5\ \Omega$
2. $E = 4$ V, $R = 4\ \Omega$
3. $E = 6$ V, $R = 3\ \Omega$
4. $E = 10$ V, $R = 1\ \Omega$

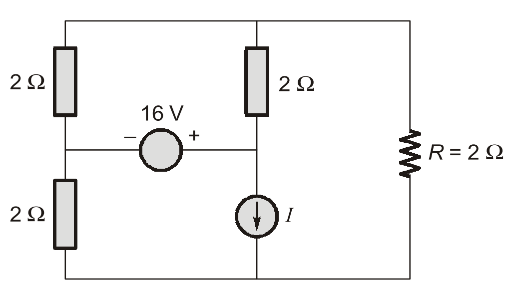
Select the correct answer using the codes given below:

(a) Only 1 and 2 (b) Only 3

(c) 1, 2, 3 and 4 (d) None of these

[ESE-2006]

1.25 In the circuit shown below, if the current through the resistor R is zero, what is the value of I?



(a) 1 A (b) 2 A

(c) 3 A (d) 4 A **[ESE-2007]**

1.26 Consider a circuit which consists of resistors and independent current sources, and one independent voltage source connected between the nodes i and j. The equations are obtained for voltage of n unknown nodes with respect to one reference node in the form

$$[\Delta]\begin{bmatrix} V_1 \\ V_2 \\ \vdots \\ V_n \end{bmatrix} = \begin{bmatrix} \vdots \\ \vdots \\ \vdots \\ \vdots \end{bmatrix}$$

What are the elements of the Δ?

(a) All conductances

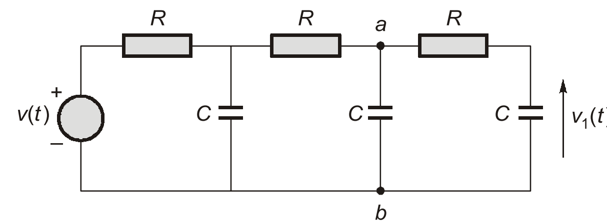
(b) All resistances

(c) Mixed conductances

(d) Mixed conductances and resistances

[ESE-2008]

1.27 In the circuit shown below, what is the voltage $v_{ab}(t)$?



(a) $\frac{dv_1}{dt} + v_1$ (b) v_1

(c) $\frac{dv_1}{dt} + RCv_1$ (d) $RC\frac{dv_1}{dt} + v_1$

[ESE-2008]

1.28 In a network containing active components, output voltage

(a) will always be greater than input voltage

(b) will always be equal to the input voltage

(c) can be less than or greater than input voltage only

(d) will be less than, equal to or greater than input voltage

[ESE-2008]

1.29 **Assertion (A):** The Kirchhoff's current law states that the sum of currents entering at any node is equal to the sum of currents leaving that node.

Reason (A): The Kirchhoff's current law is based on the law of conservation of charge.

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

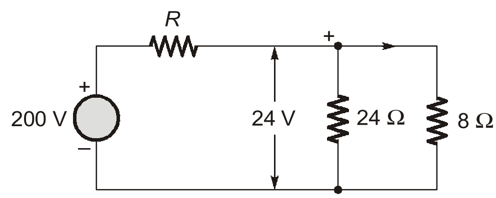
(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true **[ESE-2008]**

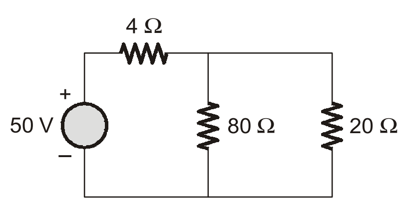
1.30 **Assertion (A) :** Ideal current sources and ideal voltage sources do not exist in reality.
Reason (R) : All sources have finite internal impedances.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true
[ESE-2009]

1.31 The value of R in the below circuit is



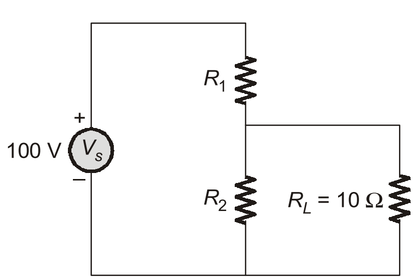
(a) 4 Ω (b) 40 Ω
(c) 44 Ω (d) 440 Ω
[ESE-2010]

1.32 The value of current in 80 Ω resistor of below circuit is



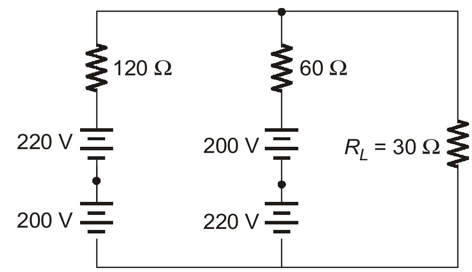
(a) 0.5 A (b) 2.0 A
(c) 5.0 A (d) 20.0 A [ESE-2010]

1.33 What is the voltage across the load resistance, R_L in the below circuit? The value of each resistor connected in the circuit is 10 Ω.



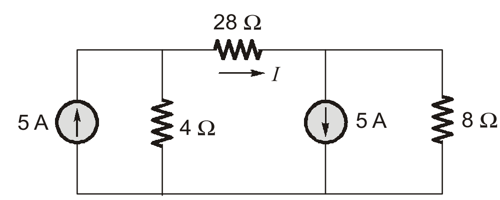
(a) 3.33 V (b) 33.33 V
(c) 333.33 V (d) 0 V
[ESE-2010]

1.34 In the circuit shown below, the current through R_L is



(a) 6 A (b) 4 A
(c) 2 A (d) 0
[ESE-2010]

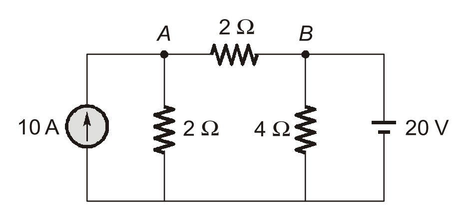
1.35 In the circuit shown below, the current I is



(a) 1 A (b) 1.5 A
(c) 2.5 A (d) 4 A
[ESE-2010]

1.36 It is required to find the current through a particular branch of a linear bilateral network without mutual coupling when the branch impedance takes four different values. Which one of the following methods will be preferred?
(a) Mesh analysis
(b) Thevenin's equivalent circuit
(c) Nodal analysis
(d) Superposition theorem
[ESE-2010]

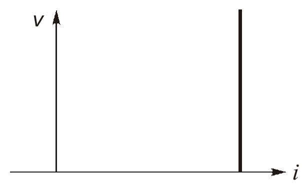
1.37 The current through the branch AB in the figure shown is



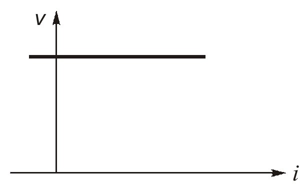
(a) 10 A, from A to B
(b) 10 A, from B to A
(c) 0
(d) 20 A, from B to A
[ESE-2011]

1.38 Which one of the following gives the *V-I* characteristic of an ideal voltage source?

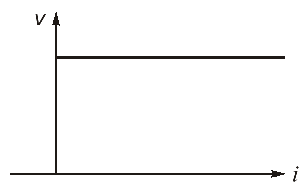
(a)



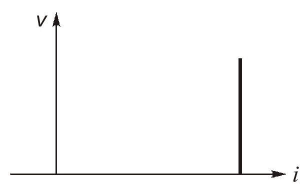
(b)



(c)

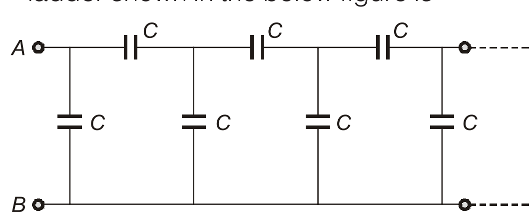


(d)



[ESE-2011]

1.39 The effective capacitance across *AB* of the infinite ladder shown in the below figure is



(a) $(1+\sqrt{3})C$ (b) $(1+\sqrt{7})C$

(c) $(1+\sqrt{5})C$ (d) $\frac{(1+\sqrt{5})}{2}C$

[ESE-2012]

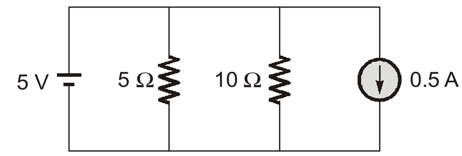
1.40 A capacitor of capacitance *C* is charged by connecting it to a battery of emf *E*. The capacitor is now disconnected and reconnected to the battery with the polarity reversed. The heat developed in the connecting wires is

(a) $0.5\ CE^2$ (b) CE^2

(c) $2\ CE^2$ (d) $3\ CE^2$

[ESE-2012]

1.41 The total resistance faced by the voltage source having zero internal resistance in the circuit is

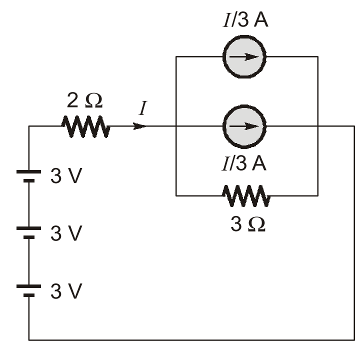


(a) 10 Ω (b) 5 Ω

(c) 2.5 Ω (d) 1.5 Ω

[ESE-2012]

1.42 In the circuit, the voltage across 3 Ω resistance is

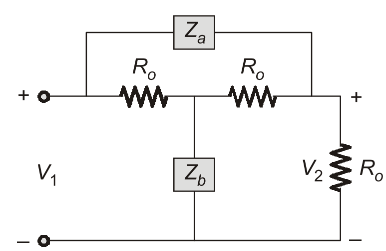


(a) 1 V (b) 3 V

(c) 6 V (d) 9 V

[ESE-2012]

1.43 The condition under which the input impedance at port 1 for the below network will be equal to R_o is



(a) $Z_a + Z_b = R_o$ (b) $Z_a Z_b = R_o^2$

(c) $Z_a/Z_b = 1$ (d) $Z_b/Z_a = 1/2$

[ESE-2012]

1.44 A coil of inductance 2 H and resistance 1 Ω is connected to a 10 V battery with negligible internal resistance. The amount of energy stored in the magnetic field is

(a) 8 J (b) 50 J

(c) 25 J (d) 100 J [ESE-2013]

1.45 The total capacitance of two capacitors is 25 F when connected in parallel and 4 F when connected in series. The individual capacitances of the two capacitors are

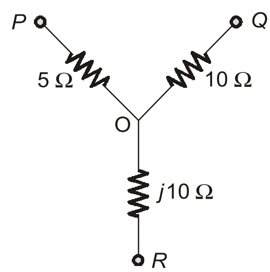
(a) 1 F and 24 F (b) 3 F and 21 F

(c) 5 F and 20 F (d) 10 F and 15 F

[ESE-2013]

1.46 Two lamps each of 230 V and 60 W rating are connected in series across a single phase 230 V supply. The total power consumed by the two lamps would be
(a) 120 W (b) 60 W
(c) 30 W (d) 15 W
[ESE-2013]

1.47 In the delta equivalent of the below star connected circuit, Z_{QR} is equal to



(a) 40 Ω
(b) $(20 + j10)\Omega$
(c) $\left(5 + j\frac{10}{3}\right)\Omega$
(d) $(10 + j30)\Omega$
[ESE-2013]

1.48 The number of branches in a network is b, the number of nodes is n and number of dependent loop is l. The number of independent current equations will be
(a) $n - l - 1$ (b) $b - l$
(c) $b - n$ (d) $n - 1$
[ESE-2013]

1.49 If a capacitor is energized by a symmetrical square wave current source, then the steady-state voltage across the capacitor will be a
(a) square wave (b) triangular wave
(c) step function (d) impulse function
[ESE-2013]

1.50 A network N consists of resistors and independent voltage and current sources. Its value of the determinant based on the node analysis
1. cannot be negative
2. cannot be zero
3. is independent of the values of voltages and current sources
(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only
[ESE-2013]

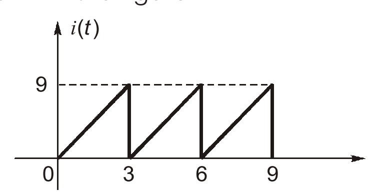
1.51 A battery is connected to a resistance causing a current of 0.5 A in the circuit. The current drops to 0.4 A when an additional resistance of 5 Ω is connected in series. The current will drop to 0.2 A when the resistance is further increased by
(a) 10 Ω (b) 15 Ω
(c) 25 Ω (d) 40 Ω [ESE-2013]

1.52 How many 6 μF, 200 V capacitors are needed to make a capacitor of 18 μF, 600 V?
(a) 18 (b) 9
(c) 3 (d) 27
[ESE-2014]

1.53 A 12 V automobile light is rated at 30 W. The total charge that flows through the filament in one minute is
(a) 30 C (b) 12 C
(c) 150 C (d) 180 C
[ESE-2014]

1.54 A capacitor of 100 μF stores 10 mJ of energy. What is the amount of charge (in Coulomb) stored in it?
(a) 1.414×10^{-6} (b) 1.414×10^{-3}
(c) 2.303×10^{-6} (d) 2.303×10^{-3}
[ESE-2014]

1.55 The current waveform $i(t)$ in a pure resistor of 20 Ω is shown in the figure.



The power dissipated in the resistor is
(a) 135 W (b) 270 W
(c) 540 W (d) 14.58 W
[ESE-2014]

1.56 A network N consists of resistors, dependent and independent voltage and current sources. If the current in one particular resistance is I A, it will be doubled if the values of all the
(a) independent voltage sources are doubled
(b) independent current sources are doubled
(c) dependent and independent voltage and current sources are doubled
(d) independent voltage and current sources are doubled
[ESE-2014]

1.57 Consider the following statements:
Any element is redundant if connected in
1. series with an ideal current source
2. parallel with an ideal current source
3. series with an ideal voltage source
4. parallel with an ideal voltage source

Which of the above statements are correct?

(a) 1 and 3 (b) 1 and 4

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

[ESE-2014]

1.58 The four band colour code on a carbon composite resistor is as follows:

First band colour : Yellow

Second band colour : Violet

Third band colour : Red

Fourth band colour : Silver

The specification of the resistor is

(a) 35 kΩ ± 10%

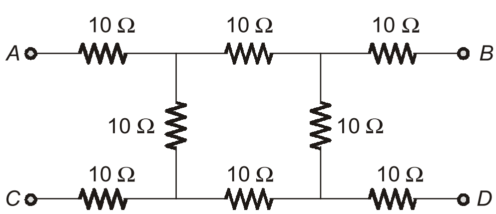
(b) 4.7 kΩ ± 10%

(c) 6.7 kΩ ± 5%

(d) 46 kΩ ± 2%

[ESE-2015]

1.59 The equivalent resistance between the points A and D is

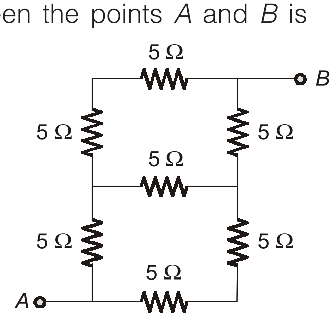


(a) 10 Ω (b) 20 Ω

(c) 30 Ω (d) 40 Ω

[ESE-2015]

1.60 Seven resistances each of 5 Ω are connected as shown in the figure. The equivalent resistance between the points A and B is



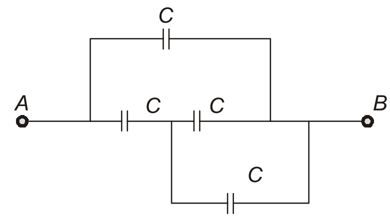
(a) 3 Ω

(b) 11 Ω

(c) 15 Ω

(d) None of the above [ESE-2015]

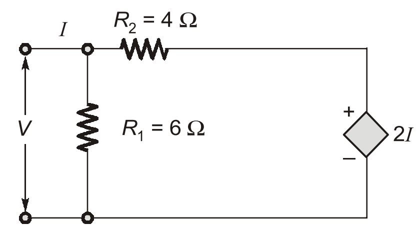
1.61 The capacitance of each capacitor is C = 3μF in the figure shown. The effective capacitance between points A and B is



(a) 2 μF (b) 3 μF

(c) 4 μF (d) 5 μF [ESE-2015]

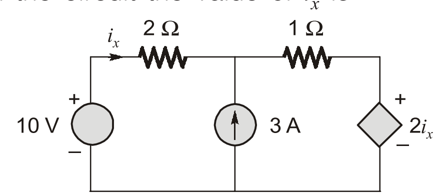
1.62 For the active network shown in figure, the value of V/I is



(a) 2 Ω (b) 2.4 Ω

(c) 3.6 Ω (d) 10 Ω [ESE-2015]

1.63 In the circuit the value of i_x is



(a) 2 A (b) –0.6 A

(c) 2.6 A (d) 1.4 A [ESE-2015]

1.64 If the three resistors in a delta network are all equal in values i.e. R_{DELTA}, then the value of the resultant resistors in each branch of the equivalent star network i.e. R_{STAR} will be equal to

(a) $\frac{R_{DELTA}}{3}$ (b) $\frac{R_{DELTA}}{2}$

(c) $2R_{DELTA}$ (d) R_{DELTA}

[ESE-2016]

1.65 Consider the following factors:

1. Number of turns of the coil
2. Length of the coil
3. Area of cross-section of the coil
4. Permeability of the core

On which of the above factors does inductance depend?

(a) 1, 2 and 3 only (b) 1, 3 and 4 only

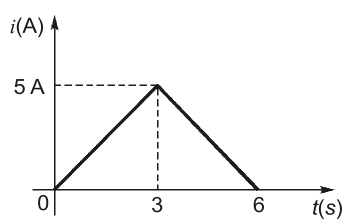
(c) 1, 2, 3 and 4 (d) 2 and 4 only

[ESE-2017]

1.66 A network in which all the elements are physically separable is called a
(a) distributed network
(b) lumped network
(c) passive network
(d) reactive network
[ESE-2017]

1.67 The Kirchhoff's current law works on the principle of conservation of
1. charge 2. energy 3. power
Which of the above is/ are correct?
(a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3
[ESE-2018]

1.68 A waveform shown in the figure is applied to a resistor of 20 Ω. The power dissipated in the resistor is



(a) 100 W (b) 600 W
(c) 900 W (d) 1000 W
[ESE-2018]

1.69 A coil of wire of 0.01 mm^2 area of 1000 turns is wound on a core. It is subjected to a flux density of 100 mWb/mm^2 by a 1 A current. The energy stored in the coil is
(a) 2.0 J (b) 1.5 J
(c) 1.0 J (d) 0.5 J
[ESE-2018]

1.70 Two resistances, one of 30 Ω and another of unknown value, are connected in parallel. The total power dissipated in the circuit is 450 W when the applied voltage is 90 V. The unknown resistance is
(a) 45 Ω (b) 35 Ω
(c) 30 Ω (d) 20 Ω
[ESE-2019]

1.71 A heater element is made of nichrome wire having resistivity equal to 100×10^{-8} Ωm and diameter of 0.4 mm. The length of the wire required to get a resistance of 40 Ω will be nearly
(a) 9 m (b) 7 m
(c) 5 m (d) 3 m
[ESE-2019]

1.72 A coil having resistance of 10 Ω and inductance of 1 H is switched on to a direct voltage of 100 V. The steady-state value of the current will be
(a) 10 A (b) 15 A
(c) 20 A (d) 25 A
[ESE-2019]

1.73 According to Kirchhoff's voltage law, the algebraic sum of all the voltage in any closed loop of a network is always
(a) Negative
(b) Positive
(c) Zero
(d) Determined by the battery emf
[ESE-2020]

1.74 Ohm's law is applicable to
(a) DC circuit only
(b) AC circuit only
(c) DC circuit as well as AC circuit, provided account is taken of the induced emf resulting from the self-inductance of circuit and of the distribution of current in cross-section of circuit
(d) DC circuit as well as AC circuit, provided account is taken of the induced emf resulting from mutual-inductance of circuit and of the distribution of current in cross-section of circuit
[ESE-2020]

1.75 Two coils are connected in parallel and a voltage of 200 V is applied to the terminals. The total current taken is 15 A and the power dissipated in one of the coils is 1500 W, the resistance of each coil will be nearly
(a) 26.7 Ω and 23.4 Ω (b) 22.4 Ω and 23.4 Ω
(c) 26.7 Ω and 26.7 Ω (d) 22.4 Ω and 26.7 Ω
[ESE-2020]

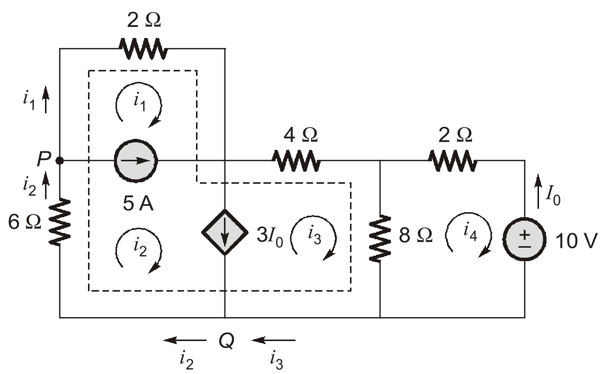
1.76 The value of total potential difference created between the electrodes, when the cell is **not** connected to an external circuit is known as its
(a) Electromotive force
(b) Electrostatic force
(c) Electromagnetic force
(d) Electrochemical force
[ESE-2020]

1.77 A wire of resistor 10 Ω is drawn out so that its length is increased to twice its original length. Then, the new resistance is

(a) 20 Ω (b) 5 Ω
(c) 30 Ω (d) 40 Ω

[ESE-2021]

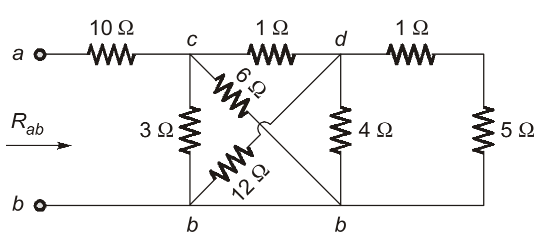
1.78 For the given circuit, the currents i_1 and i_3 are



(a) i_1 = –2.5 A and i_3 = 3.93 A
(b) i_1 = 7.5 A and i_3 = –2.5 A
(c) i_1 = 3.93 A and i_3 = 2.14 A
(d) i_1 = –7.5 A and i_3 = 3.93 A

[ESE-2021]

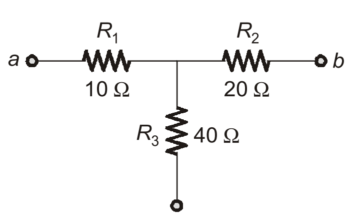
1.79 What is the equivalent resistance R_{ab} in the given circuit?



(a) 37.08 Ω (b) 11.20 Ω
(c) 42.16 Ω (d) 17.82 Ω

[ESE-2021]

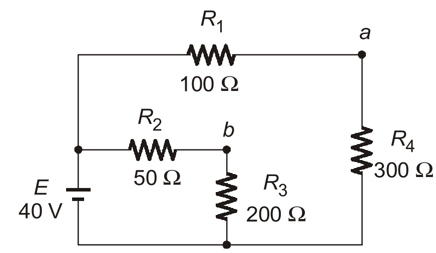
1.80 What are the values of R_a, R_b and R_c respectively, after transforming the Wye network shown in the figure to a delta network?



(a) 140 Ω, 70 Ω and 45 Ω
(b) 70 Ω, 140 Ω and 35 Ω
(c) 140 Ω, 70 Ω and 35 Ω
(d) 40 Ω, 70 Ω and 25 Ω

[ESE-2021]

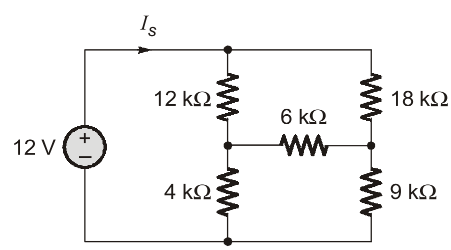
1.81 In the figure given below, the value of voltage drop across the resistor R_1 is



(a) 100 V (b) 10 V
(c) 1 V (d) 0.1 V

[ESE-2022]

1.82 What is the value of the source current (I_s) of the given network in the figure?



(a) 1.2 A (b) 12 A
(c) 1.2 mA (d) 12 mA

[ESE-2022]

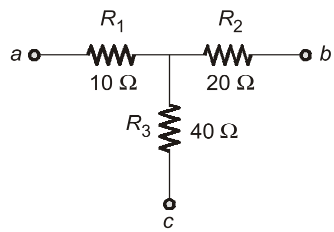
1.83 **Statement (I) :** Voltage (or potential difference) is the energy required to move a unit charge through an element.

Statement (II) : Power is the time rate of expending or absorbing energy.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true, but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true, but Statement (II) is false.
(d) Statement (I) is false, but Statement (II) is true.

[ESE-2022]

1.84 What are the values of delta-connected branch resistances R_{ab}, R_{bc} and R_{ac} of the star-connected network shown in the figure using star to delta transformation respectively?

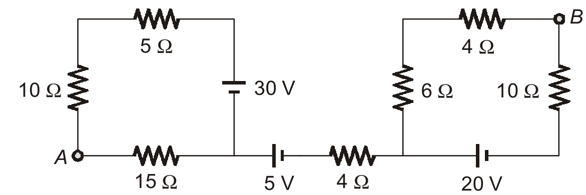


(a) 35 Ω, 140 Ω and 70 Ω
(b) 35 Ω, 60 Ω and 70 Ω
(c) 70 Ω, 60 Ω and 35 Ω
(d) 70 Ω, 150 Ω and 35 Ω [ESE-2023]

1.85 A coil consists of 1000 turns of copper wire having a cross-sectional area of 0.8 mm^2. The mean length per turn is 80 cm and the resistivity of copper is 0.02 μΩ-m. What are the values of resistance of the coil and power absorbed by the coil when connected across 100 V DC supply respectively?

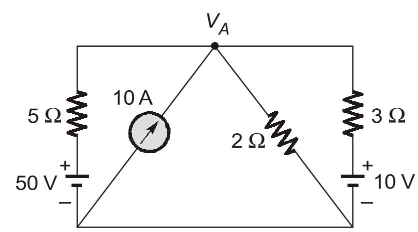
(a) 20 Ω and 250 W (b) 40 Ω and 250 W
(c) 20 Ω and 500 W (d) 40 Ω and 500 W
[ESE-2023]

1.86 What is the value of voltage between points *A* and *B* of the network shown in the figure?



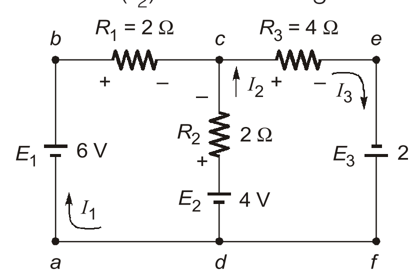
(a) 15 V (b) 30 V
(c) –30 V (d) –15 V [ESE-2023]

1.87 What is the value of voltage at node V_A shown in the network below?



(a) 21.65 V (b) 22.65 V
(c) –21.65 V (d) –22.65 V [ESE-2023]

1.88 The current (I_2) of the circuit given below is



(a) 2 mA (b) 20 mA
(c) 0.2 A (d) 2 A [ESE-2024]

Answers Basics of Network Analysis

1.1 (c)	1.2 (c)	1.3 (a)	1.4 (a)	1.5 (c)	1.6 (a)	1.7 (b)	1.8 (d)	1.9 (d)
1.10 (d)	1.11 (a)	1.12 (a)	1.13 (a)	1.14 (a)	1.15 (c)	1.16 (b)	1.17 (b)	1.18 (b)
1.19 (a)	1.20 (a)	1.21 (c)	1.22 (b)	1.23 (d)	1.24 (c)	1.25 (d)	1.26 (a)	1.27 (d)
1.28 (c)	1.29 (a)	1.30 (a)	1.31 (c)	1.32 (a)	1.33 (b)	1.34 (a)	1.35 (b)	1.36 (b)
1.37 (c)	1.38 (b)	1.39 (d)	1.40 (c)	1.41 (c)	1.42 (b)	1.43 (b)	1.44 (d)	1.45 (c)
1.46 (c)	1.47 (d)	1.48 (d)	1.49 (b)	1.50 (a)	1.51 (c)	1.52 (d)	1.53 (c)	1.54 (b)
1.55 (c)	1.56 (d)	1.57 (b)	1.58 (b)	1.59 (c)	1.60 (d)	1.61 (d)	1.62 (c)	1.63 (d)
1.64 (a)	1.65 (c)	1.66 (b)	1.67 (a)	1.68 (*)	1.69 (d)	1.70 (a)	1.71 (c)	1.72 (a)
1.73 (c)	1.74 (d)	1.75 (c)	1.76 (a)	1.77 (d)	1.78 (d)	1.79 (b)	1.80 (c)	1.81 (b)
1.82 (c)	1.83 (b)	1.84 (a)	1.85 (c)	1.86 (b)	1.87 (b)	1.88 (c)		

Explanations Basics of Network Analysis

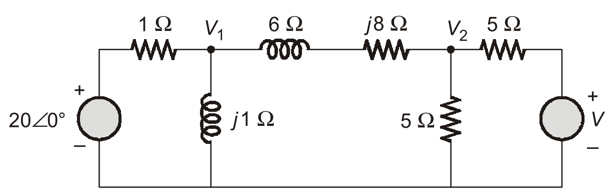
1.1 (c)

Inductance, $L \propto \frac{N^2 A}{F}$

But $A = \pi d^2/4$

$$\therefore \quad L \propto \frac{N^2 d^2}{F}$$

1.3 (a)



$$V_1 = \frac{j1}{1+j1}\cdot 20\angle 0°$$

$$\Rightarrow \quad V_1 = \frac{20}{\sqrt{2}}\angle 45°$$

Power dissipated in 6 Ω resistor is zero.

⇒ current through 6 Ω resistor is zero.

$$\Rightarrow \quad V_1 = V_2$$

$$V_2 = \frac{20}{\sqrt{2}}\angle 45° = \frac{5}{5+5}\cdot V = \frac{V}{2}$$

$$\Rightarrow \quad V = 20\sqrt{2}\angle 45°$$

1.4 (a)

V_1 is independent of R.

when $R = 0$, $V_1 = 40$ V

Since $R = 0$, so $V_1 = V_2$

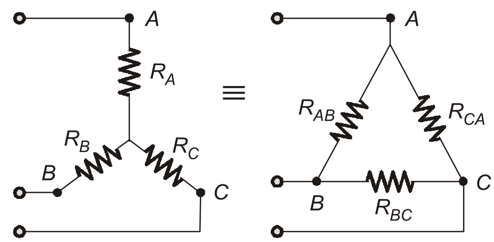
⇒ $V_2 = 40$ V

1.5 (c)

Since the network contains only independent current sources, so changing all 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.

Note: If there are only independent voltage sources, then doubling all resistors, the node voltages will remain same but the current through each branch will be half.

1.6 (a)



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

$$R_A = \frac{R_{AB}\times R_{CA}}{R_{AB}+R_{BC}+R_{CA}}$$

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

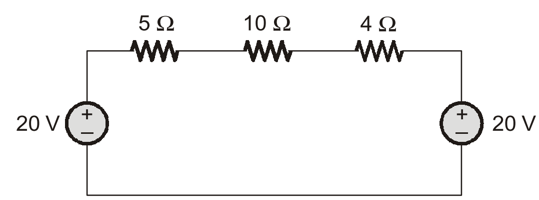
$$= 3 + 1.5 + 0.5 = 5\ \Omega$$

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

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

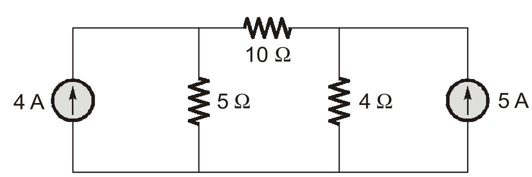
1.7 (b)

The circuit can be redrawn as shown below:



Net current in 10 Ω resistor is zero.

The whole 4 A current flows only through 5 Ω resistor.



Power dissipated in the 5 Ω resistor,

$$P = (4)^2\, 5 = 80 \text{ W}$$

1.8 (d)

Resistance dissipates energy and inductance and capacitance store the energy.

1.9 (d)

$$V_L = L\frac{di}{dt}$$

$$L = V_L\frac{dt}{di} \text{ V sec/A}$$

$$i = C\frac{dv}{dt}$$

$$C = i \times \frac{dt}{dv} \text{ A sec/V}$$

$$\sqrt{\frac{L}{C}} = \sqrt{\frac{\text{V sec/A}}{\text{A sec/V}}}$$

$$= \sqrt{\frac{\text{V sec}}{\text{A}} \times \frac{V}{\text{A sec}}} = \frac{V}{R} = R$$

1.10 (d)

Charge $q(t) = \int i(t)dt$

= Area under the curve from $t = 0$ to $t = 5$.

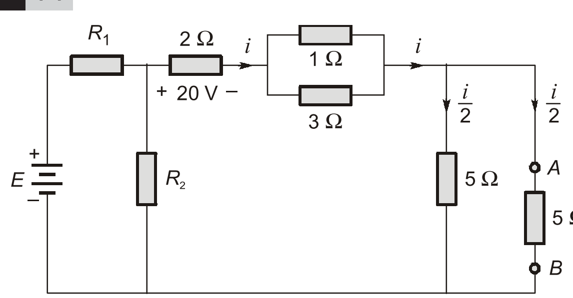
$$= \frac{1}{2}\times 5\times 3+\frac{1}{2}\times(5+3)\times 1+\frac{1}{2}\times(3+4)\times 1$$

$$= \frac{1}{2}(15+8+7)\mu C = 15\ \mu C$$

1.11 (a)

Slope of the characteristic is negative between –∞ to 0; so characteristic is of active element.

1.12 (a)



The current through 2 Ω resistor,

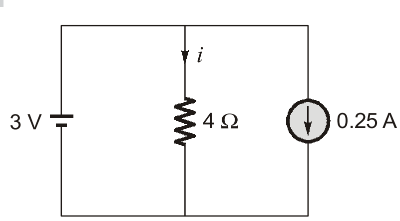
$$i = \frac{20}{2} = 10 \text{ A}$$

This current will divide equally in both 5 Ω resistors.

$$V_{AB} = 5 \times 5 = 25 \text{ V}$$

So, the 5 Ω resistor connected between the terminals *A* and *B* can be replaced by an ideal voltage source of 25 V with +ve terminal upward.

1.13 (a)



$$i = \frac{3}{4} = 0.75 \text{ A}$$

Current flowing through the voltage source

= 0.75 + 0.25 = 1 A

1.14 (a)

(i) Time constant

$$\tau = \frac{L}{R} = CR \qquad \text{(measured in seconds)}$$

(ii) $\omega = \frac{1}{\sqrt{LC}}$ (measured in rad/s)

(iii) $\sqrt{\frac{L}{C}} = R$ (measured in Ohms)

1.15 (c)

(i) KVL is based on the law of conservation of energy.

(ii) KCL is based on the law of conservation of charge.

1.16 (b)

Current flowing through 1 MΩ resistor,

$$i = \frac{V_1 - V_2}{10^6} = \frac{5-3}{10^6} = 2\ \mu A$$

Input impedance of the CRO,

$$Z_{in} = \frac{V_2}{i} = \frac{3}{2} = 1.5 \text{ M}\Omega$$

1.17 (b)

It is a balanced Wheatstone bridge. The current through *R* is zero. So power delivered to *R* is zero.

1.18 (b)

I_2 is independent of R_1. So, I_2 will remain 2 A whatever be the value of R_1.

1.19 (a)

$$i = C\frac{dv}{dt}$$

Applying KVL,

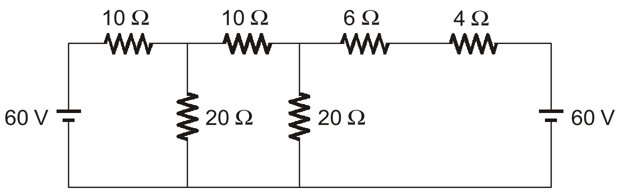
$$\frac{1}{G}i + v = 0$$

$$\Rightarrow \quad i + Gv = 0$$

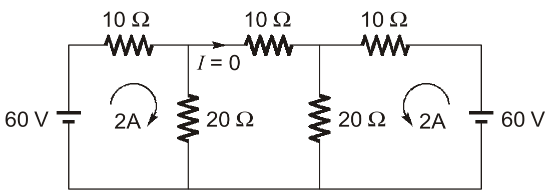
$$\Rightarrow \quad C\frac{dv}{dt} + Gv = 0$$

1.20 (a)

Using source transformation, the circuit is redrawn.



Further,



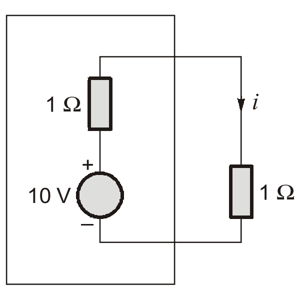
It is a symmetrical network.

So, $I = 0$.

1.21 (c)

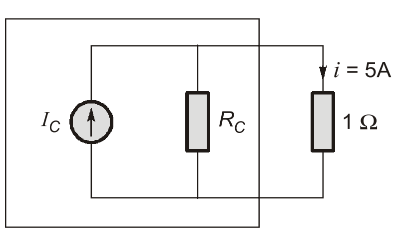
Since, it being parallel circuit, the voltage across each branch is fixed and will not change on opening one of the branches. Since $V = iR$, therefore, currents in the other branches are also unaffected.

1.22 (b)



N_A

$$i = \frac{10}{1+1} = 5\text{ A}$$



N_B

$$i = 5 = \frac{R_C}{R_C + 1} \cdot I_C$$

Following values satisfy the above equation.

(i) 10 A and 1 Ω

(ii) 15 A and $\frac{1}{2}$Ω

(iii) 30 A and $\frac{1}{5}$Ω

1.23 (d)

$$-v + Ri + v_c = 0$$

$$\Rightarrow -v + RC\frac{dv_c}{dt} + v_c = 0$$

$$\Rightarrow v = RC\frac{dv_c}{dt} + v_c$$

1.24 (c)

$$V_{XY} = \frac{6}{6+3} \times 18 = 12\text{ V}$$

Current through terminal X-Y is $I = \frac{18}{9} = 2\text{A}$.

$$V_{XY} = IR + E$$

$$V_{XY} = 2R + E$$

Putting the values given,

(i) $2 \times 5 + 2 = 12$

(ii) $2 \times 4 + 4 = 12$

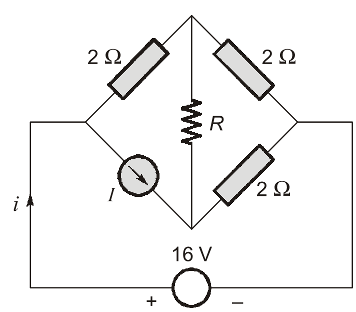
(iii) $2 \times 3 + 6 = 12$

(iv) $2 \times 1 + 10 = 12$

All values satisfy the equation.

1.25 (d)

Rearranging the circuit,



The given circuit is a Wheatstone's bridge. So, the current source I can be replaced by 2 Ω.

$$i = \frac{16}{R_{eq}}$$

where, $R_{eq} = (2 + 2) \parallel (2 + 2) = 2\ \Omega$

$$i = \frac{16}{2} = 8\text{ A}$$

The current i will divide equally because the network is symmetric.

Therefore, $I = 4$ A.

1.27 (d)

$$v_{ab}(t) = Ri + v_1(t)$$

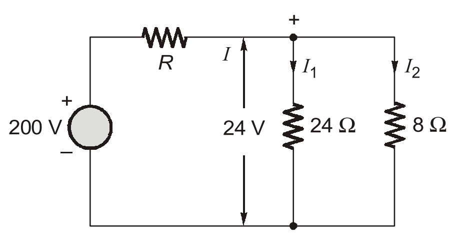
but $$i = C \cdot \frac{dv_1(t)}{dt}$$

So, $$v_{ab}(t) = RC\frac{dv_1}{dt} + v_1$$

1.28 (c)

Active element has property of internal amplification.

1.31 (c)



$$I_1 = \frac{24}{24} = 1\text{ A}$$

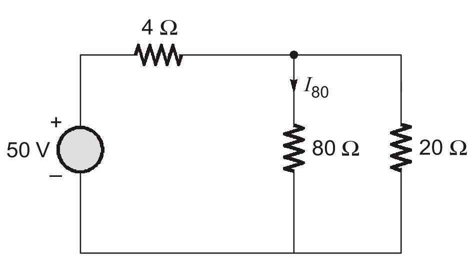
$$I_2 = \frac{24}{8} = 3\text{ A}$$

∴ $$I = I_1 + I_2 = 1 + 3 = 4\text{ A}$$

Now $$I = \frac{200 - 24}{R} = 4$$

⇒ $$R = \frac{176}{4} = 44\ \Omega$$

1.32 (a)



Applying KCL at node 1,

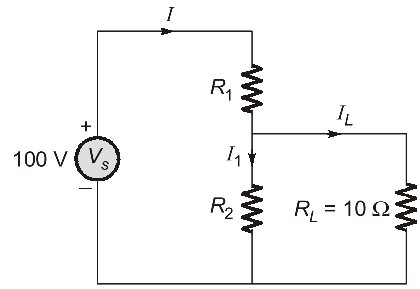
$$\frac{V_1 - 50}{4} + \frac{V_1}{80} + \frac{V_1}{20} = 0$$

$$V_1 = 40\text{ V}$$

∴ $$I_{80} = \frac{V_1}{80} = \frac{40}{80}$$

$$I_{80} = 0.5\text{ A}$$

1.33 (b)



Given, $R_1 = R_2 = R_L = 10\ \Omega$

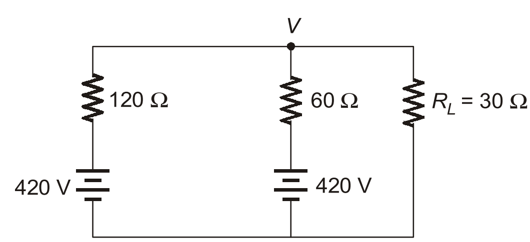
$$I = \frac{100}{R_1 + \frac{R_2 \times R_L}{R_2 + R_L}} = \frac{100}{10 + 5} = \frac{100}{15}$$

∴ $$I_L = I_1 = \frac{I}{2} = \frac{100}{30}\text{ A}$$

So, voltage across R_L

$$V_L = I_L R_L = \frac{100}{30} \times 10 = 33.333\text{ V}$$

1.34 (a)



Applying KCL at node V

$$\frac{V - 420}{120} + \frac{V - 420}{60} + \frac{V}{30} = 0$$

$$\frac{V}{120} + \frac{V}{60} + \frac{V}{30} = \frac{420}{120} + \frac{420}{60}$$

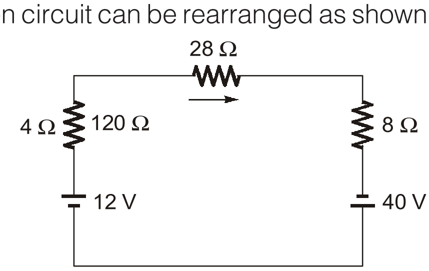
$$V = 180\text{ volt}$$

∴ Current through R_L is

$$I_L = \frac{V}{R_L} = \frac{180}{30} = 6\text{ A}$$

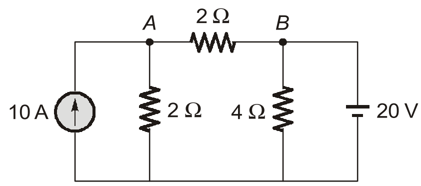
1.35 (b)

Given circuit can be rearranged as shown below:



$$I = \frac{20 + 40}{4 + 28 + 8} = 1.5\text{ A}$$

1.37 (c)



Applying KCL at node A

$$\frac{V_A}{2}+\frac{V_A-V_B}{2} = 10$$

$$\Rightarrow \quad 2V_A - V_B = 20 \quad \text{...(i)}$$

But, $V_B = 20$ V

So, $2V_A - 20 = 20$

$\Rightarrow$ $V_A = 20$ V

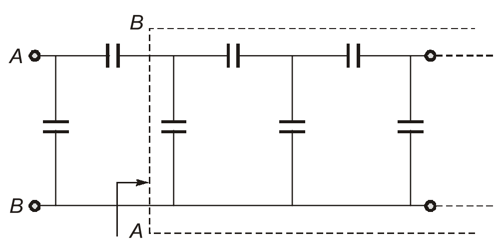
Hence current through branch AB

$$= \frac{V_A-V_B}{2} = \frac{20-20}{2} = 0$$

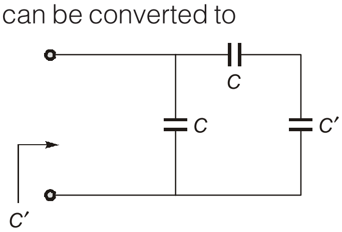
1.38 (b)

Ideal voltage source delivers constant voltage irrespective of the value of current through it.

1.39 (d)



This is infinite combination of capacitors. This circuit can be converted to



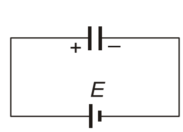
So, $$C' = C+\frac{C'C}{C+C'}$$

$$CC'+C'^2 = C^2+CC'+CC'$$

$$C'^2 - CC' - C^2 = 0$$

$$\Rightarrow \quad C' = \left(\frac{1+\sqrt{5}}{2}\right)C$$

1.40 (c)



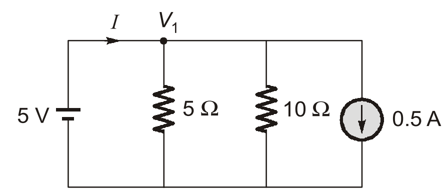
Initially, capacitance gets charged with $Q = CE$

Finally initial voltage on capacitance = E

New charge on capacitor is = $Q' = C\cdot(2E) = 2CE$

$$\therefore \quad \text{Heat developed} = \frac{1}{2}\frac{Q'^2}{C} = \frac{1}{2}\times\frac{4C^2E^2}{C} = 2CE^2$$

1.41 (c)



The total resistance faced by the voltage source is equal to the ratio of the voltage developed by the source to the current delivered by it.

Applying KCL at node V_1

$$\frac{V_1}{5}+\frac{V_1}{10}+0.5 = I$$

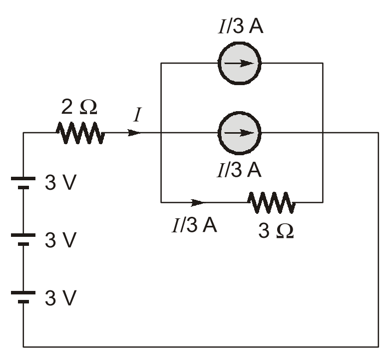
$$\therefore \quad V_1 = 5\text{ V}$$

$$\frac{5}{5}+\frac{5}{10}+0.5 = I$$

$$\Rightarrow \quad I = 2\text{ Amp.}$$

$$\text{So resistance} = \frac{V_1}{I} = \frac{5}{2} = 2.5\ \Omega$$

1.42 (b)



Applying KVL to mesh

$$-3-3-3+2I+3\frac{I}{3} = 0$$

$$3I = 9 \quad \Rightarrow \quad I = 3\text{ Amp.}$$

So voltage developed across 3 Ω

$$= 3\frac{I}{3} = 3\text{ V}$$