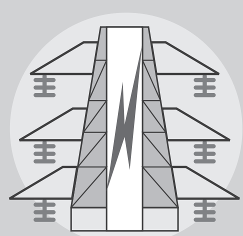
30 *Years*

Previous Solved Papers

GATE 2025

Electrical Engineering



- Fully solved with explanations
- Analysis of previous papers
- Topicwise presentation
- Thoroughly revised & updated

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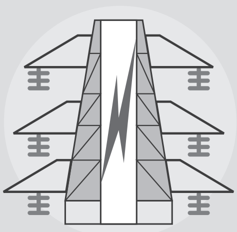

GATE - 2025

Electrical Engineering

Topicwise Previous GATE Solved Papers (1995-2024)

Editions

1st Edition	:	2008
2nd Edition	:	2009
3rd Edition	:	2010
4th Edition	:	2011
5th Edition	:	2012
6th Edition	:	2013
7th Edition	:	2014
8th Edition	:	2015
9th Edition	:	2016
10th Edition	:	2017
11th Edition	:	2018
12th Edition	:	2019
13th Edition	:	2020
14th Edition	:	2021
15th Edition	:	2022
16th Edition	:	2023
17th Edition	**:**	**2024**

Preface

Over the period of time the GATE examination has become more challenging due to increasing number of candidates. Though every candidate has ability to succeed but competitive environment, in-depth knowledge, quality guidance and good source of study is required to achieve high level goals.

The new edition of **GATE 2025 Solved Papers : Electrical Engineering** has been fully revised, updated and edited. The whole book has been divided into topicwise sections.

At the beginning of each subject, analysis of previous papers are given to improve the understanding of subject.

I have true desire to serve student community by way of providing good source of study and quality guidance. I hope this book will be proved an important tool to succeed in GATE examination. Any suggestions from the readers for the improvement of this book are most welcome.

B. Singh (Ex. IES)
Chairman and Managing Director
MADE EASY Group

GATE-2025

Electrical Engineering

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Electric Circuits

UNIT

I

CONTENTS

Electric Circuits

Syllabus

Network Elements: Ideal Voltage and Current Sources, Dependent Sources, R, L, C, M Elements;
Network Solution Methods: KCL, KVL, Node and Mesh analysis;
Network Theorems: Thevenin's, Norton's, Superposition and Maximum Power Transfer theorem; Transient response of DC and AC networks, sinusoidal steady-state analysis, resonance, two port networks, balanced three phase circuits, star-delta transformation, complex power and power factor in AC circuits.

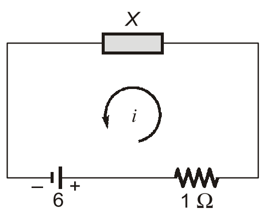
Analysis of Previous GATE Papers

Exam Year	1 Mark Ques.	2 Marks Ques.	5 Marks Ques.	Total Marks
1995	2	–	–	**2**
1996	3	1	–	**5**
1997	4	6	2	**26**
1998	3	2	3	**28**
1999	4	5	2	**24**
2000	1	3	1	**12**
2001	5	1	1	**12**
2002	1	7	3	**30**
2003	3	6	–	**15**
2004	1	7	–	**15**
2005	4	7	–	**18**
2006	2	6	–	**14**
2007	–	7	–	**14**
2008	2	6	–	**14**
2009	2	6	–	**14**
2010	–	3	4	**11**
2011	–	3	5	**13**

Exam Year	1 Mark Ques.	2 Marks Ques.	Total Marks
2012	5	6	**17**
2013	2	3	**8**
2014 Set-1	2	2	**6**
2014 Set-2	3	2	**7**
2014 Set-3	3	3	**9**
2015 Set-1	4	3	**10**
2015 Set-2	3	3	**9**
2016 Set-1	4	5	**14**
2016 Set-2	5	4	**13**
2017 Set-1	2	3	**8**
2017 Set-2	2	2	**6**
2018	3	4	**11**
2019	1	3	**7**
2020	2	2	**6**
2021	4	5	**14**
2022	5	1	**7**
2023	2	4	**10**
2024	3	2	**7**

1 Basics

1.1 In the circuit shown in figure, X is an element which always absorbs power. During a particular operation, it sets up a current of 1 amp in the direction shown and absorbs a power P_x. It is possible that X can absorb the same power P_x for another current i. Then the value of this current is



(a) $(3-\sqrt{14})$ Amps (b) $(3+\sqrt{14})$ Amps
(c) 5 Amps (d) None of these

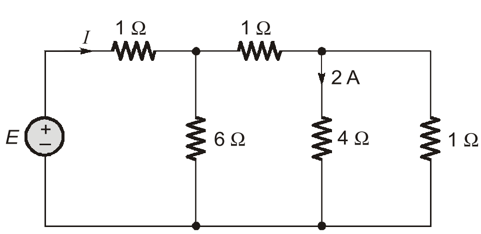
[1996 : 1 M]

1.2 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 [1997 : 1 M]

1.3 A 10 V battery with an internal resistance of 1 Ω is connected across a non-linear load whose V-I characteristic is given by $7I = V^2 + 2$ V. The current delivered by the battery is .... A.

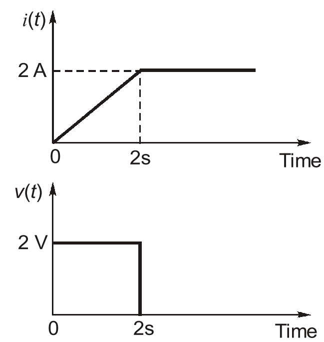
[1997 : 2 M]

1.4 The value of E and I for the circuit shown in the figure, are .... V and .... A.



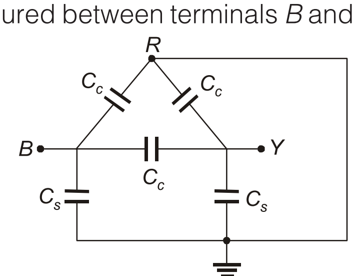
[1997 : 2 M]

1.5 The voltage and current waveforms for an element are shown in the figure. The circuit element is _____ and its value is _______.



[1997 : 2 M]

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



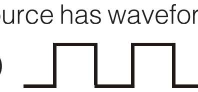
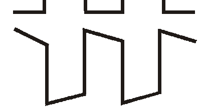
(a) $C_c + \left(\dfrac{C_s}{2}\right)$ (b) $C_s + \left(\dfrac{C_c}{2}\right)$
(c) $\dfrac{(C_s + 3C_c)}{2}$ (d) $3C_c + 2C_s$

[1999 : 1 M]

1.7 When a resistor R is connected to a current source, it consumes a power of 18 W. When the same R is connected to a voltage source having the same magnitude as the current source, the power absorbed by R is 4.5 W. The magnitude of the current source and the value of R are
(a) $\sqrt{18}$ A and 1 Ω (b) 3 A and 2 Ω
(c) 1 A and 18 Ω (d) 6 A and 0.5 Ω

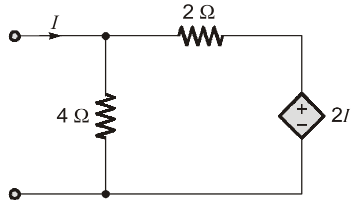
[1999 : 2 M]

1.8 When a periodic triangular voltage of peak amplitude 1 V and frequency 0.5 Hz is applied to a parallel combination of 1 Ω resistance and 1 F capacitance, the current through the voltage source has waveform.

(a)  (b) 
(c)  (d) 

[1999 : 2 M]

1.9 The circuit shown in the figure is equivalent to a load of



(a) $\frac{4}{3}\,\Omega$ (b) $\frac{8}{3}\,\Omega$

(c) 4 Ω (d) 2 Ω [2000 : 2 M]

1.10 Two incandescent light bulbs of 40 W and 60 W ratings are connected in series across the mains. Then

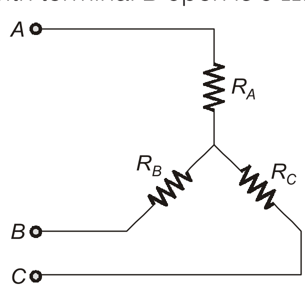
(a) the bulbs together consume 100 W.

(b) the bulbs together consume 50 W.

(c) the 60 W bulb glows brighter.

(d) the 40 W bulb glows brighter. [2001 : 1 M]

1.11 Consider the star network shown in the figure. The resistance between terminals *A* and *B* with terminal *C* open is 6 Ω, between terminals *B* and *C* with terminal *A* open is 11 Ω, and between terminals *C* and A with terminal *B* open is 9 Ω. Then



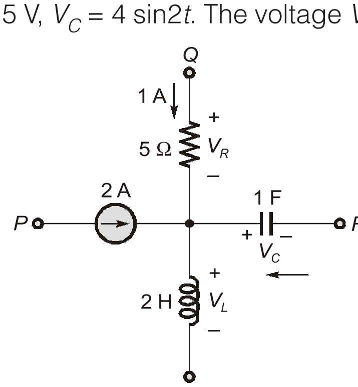
(a) $R_A = 4\,\Omega$, $R_B = 2\,\Omega$, $R_C = 5\,\Omega$

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

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

(d) $R_A = 5\,\Omega$, $R_B = 1\,\Omega$, $R_C = 10\,\Omega$ [2001 : 2 M]

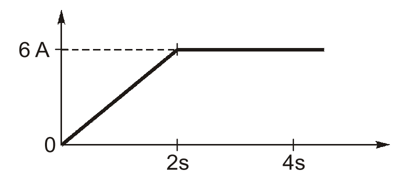
1.12 A segment of a circuit is shown in the figure $V_R = 5$ V, $V_C = 4\sin 2t$. The voltage V_L is given by



(a) $3 - 8\cos 2t$ (b) $32\sin 2t$

(c) $16\sin 2t$ (d) $16\cos 2t$ [2003 : 1 M]

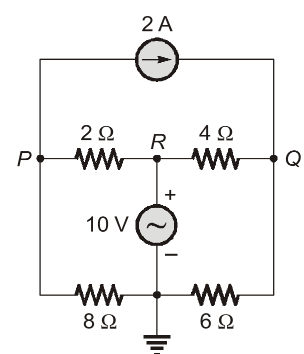
1.13 The figure shows the waveform of the current passing through an inductor of resistance 1 Ω and inductance 2 H. The energy absorbed by the inductor in the first four seconds is



(a) 144 J (b) 98 J

(c) 132 J (d) 168 J [2003 : 1 M]

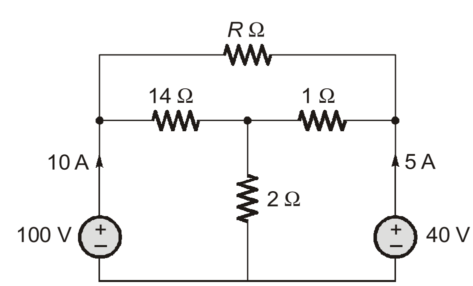
1.14 In the figure, the potential difference between points *P* and *Q* is



(a) 12 V (b) 10 V

(c) –6 V (d) 8 V [2003 : 2 M]

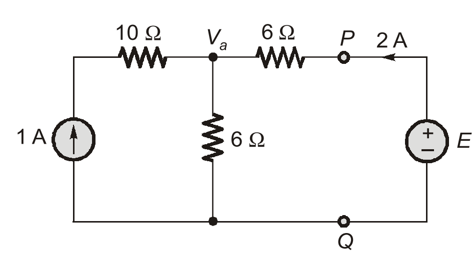
1.15 In the figure, the value of *R* is



(a) 10 Ω (b) 18 Ω

(c) 24 Ω (d) 12 Ω [2003 : 2 M]

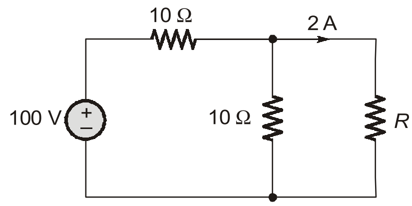
1.16 In the figure, the value of the source voltage is



(a) 12 V (b) 24 V

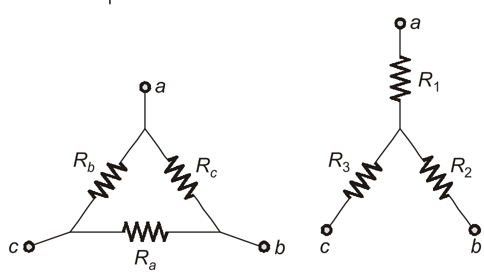
(c) 30 V (d) 44 V [2004 : 2 M]

1.17 In the figure, the value of resistance R in Ω is



(a) 10 (b) 20
(c) 30 (d) 40 **[2004 : 2 M]**

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

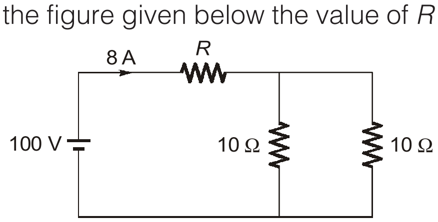


(a) 2.5, 5, 5 (b) 5, 2.5, 5
(c) 5, 5, 2.5 (d) 2.5, 5, 2.5 **[2004 : 2 M]**

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

(a) 10 A (b) 14.14 A
(c) 15 A (d) 17.32 A **[2004 : 2 M]**

1.20 In the figure given below the value of R is

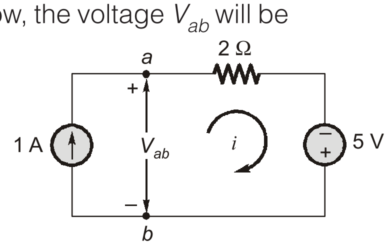


(a) 2.5 Ω (b) 5.0 Ω
(c) 7.5 Ω (d) 10.0 Ω **[2005 : 1 M]**

1.21 A 3 V dc supply with an internal resistance of 2 Ω supplies a passive non-linear resistance characterized by the relation $V_{NL} = I_{NL}^2$. The power dissipated in the non linear resistance is

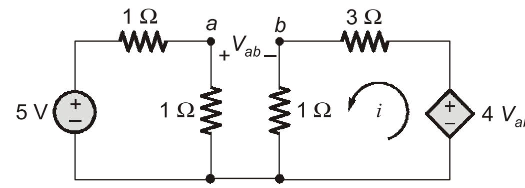
(a) 1.0 W (b) 1.5 W
(c) 2.5 W (d) 3.0 W **[2007 : 2 M]**

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



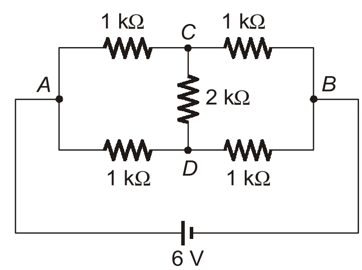
(a) –3 V (b) 0 V
(c) 3 V (d) 5 V **[2008 : 2 M]**

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



(a) 0.31 A (b) 1.25 A
(c) 1.75 A (d) 2.5 A **[2008 : 2 M]**

1.24 The current through the 2 kΩ resistance in the circuit shown is

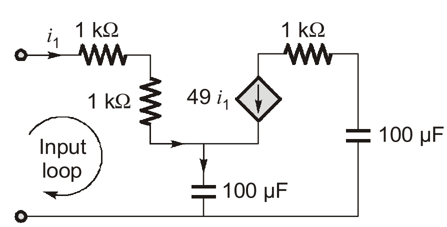


(a) 0 mA (b) 1 mA
(c) 2 mA (d) 6 mA **[2009 : 1 M]**

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

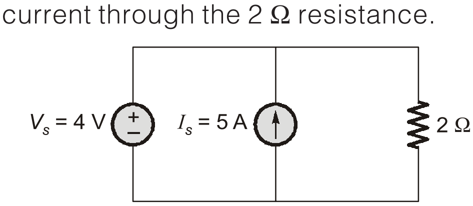
(a) Not possible (b) 4
(c) 3 (d) 2 **[2009 : 1 M]**

1.26 The equivalent capacitance of the input loop of the circuit shown is



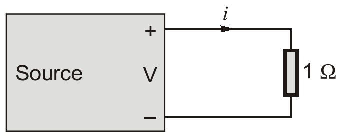
(a) 2 μF (b) 100 μF
(c) 200 μF (d) 4 μF **[2009 : 2 M]**

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



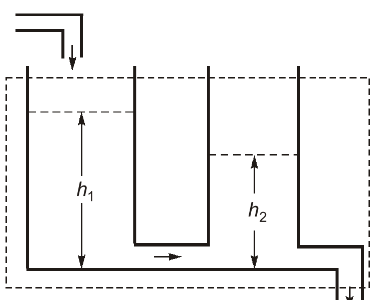
(a) (5 A; Put V_s = 20 V)
(b) (2 A; Put V_s = 8 V)
(c) (5 A; Put I_s = 10 A)
(d) (7 A; Put I_s = 12 A) [2009 : 2 M]

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

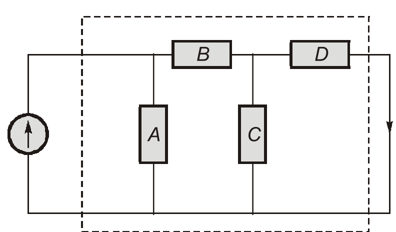


(a) 25 A (b) 50 A
(c) 100 A (d) 200 A [2010 : 1 M]

1.29 If the electrical circuit of figure (b) is an equivalent of the coupled tank system of figure (a), then



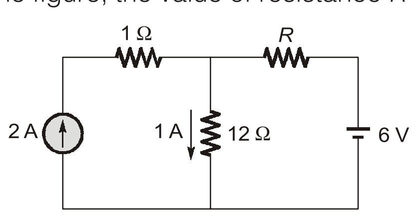
(a) Coupled tank



(b) Electrical equivalent

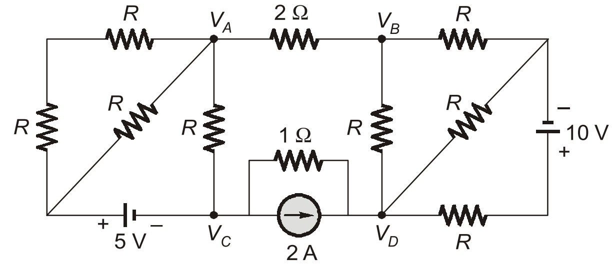
(a) A, B are resistances and C, D capacitances
(b) A, C are resistances and B, D capacitances
(c) A, B are capacitances and C, D resistances
(d) A, C are capacitances and B, D resistances [2010 : 1 M]

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



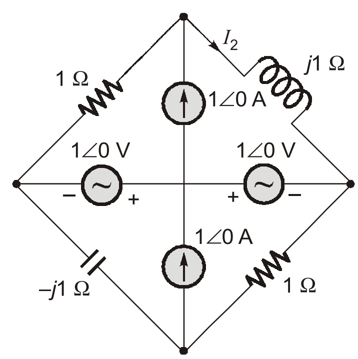
(a) 4 Ω (b) 6 Ω
(c) 8 Ω (d) 18 Ω [2010 : 2 M]

1.31 If $V_A - V_B = 6$ V, then $V_C - V_D$ is



(a) –5 V (b) 2 V
(c) 3 V (d) 6 V [2012 : 2 M]

1.32 In the circuit shown below, the current through the inductor is

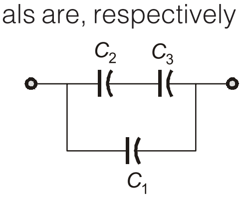


(a) $\frac{2}{1+j}$ A (b) $\frac{-1}{1+j}$ A

(c) $\frac{1}{1+j}$ A (d) 0 A

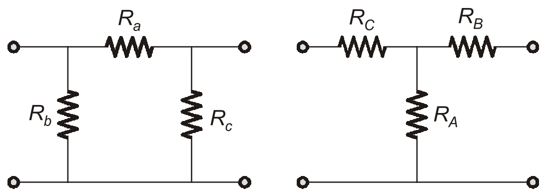
[2012 : 1 M]

1.33 Three capacitors C_1, C_2 and C_3 whose values are 10 μF, 5 μF, and 2 μF respectively, have breakdown voltages of 10 V, 5 V and 2 V respectively. For the interconnection shown below, the maximum safe voltage in volts that can be applied across the combination, and the corresponding total charge in μC stored in the effective capacitance across the terminals are, respectively



(a) 2.8 and 36 (b) 7 and 119
(c) 2.8 and 32 (d) 7 and 80 [2013 : 2 M]

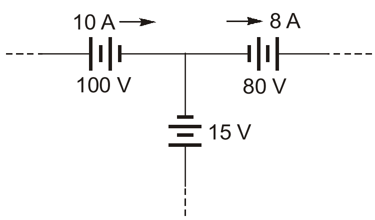
1.34 Consider a delta connection of resistors and its equivalent star connection as shown below. If all elements of the delta connection are scaled by a factor k, $k > 0$, the elements of the corresponding star equivalent will be scaled by a factor of



(a) k^2 (b) k

(c) $1/k$ (d) $\sqrt{k}$ [2013 : 1 M]

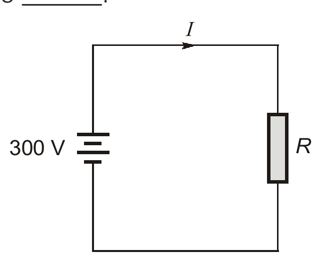
1.35 The three circuit elements shown in the figure are part of an electric circuit. The total power absorbed by the three circuit elements in watts is ______ .



[2014 : 1 M, Set-1]

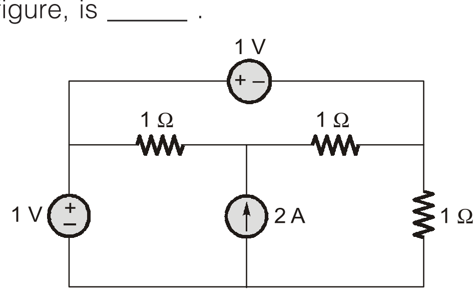
1.36 An incandescent lamp is marked 40 W, 240 V. If resistance at room temperature (26°C) is 120 Ω, and temperature coefficient of resistance is 4.5×10^{-3}/°C, then its 'ON' state filament temperature in °C is approximately ______. [2014 : 2 M, Set-1]

1.37 In the figure, the value of resistor R is $\left(25 + \frac{I}{2}\right)$ ohms, where I is the current in amperes. The current I is ______.



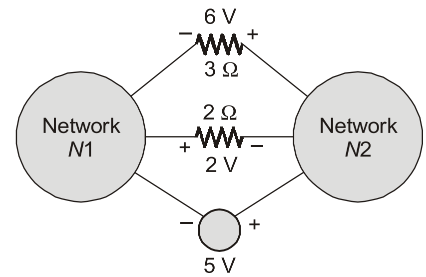
[2014 : 2 M, Set-1]

1.38 The power delivered by the current source, in the figure, is ______ .



[2014 : 2 M, Set-3]

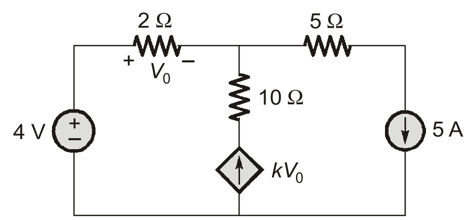
1.39 The voltages developed across the 3 Ω and 2 Ω resistors shown in the figure are 6 V and 2 V respectively, with the polarity as marked. What is the power (in Watt) delivered by the 5 V voltage source?



(a) 5 (b) 7

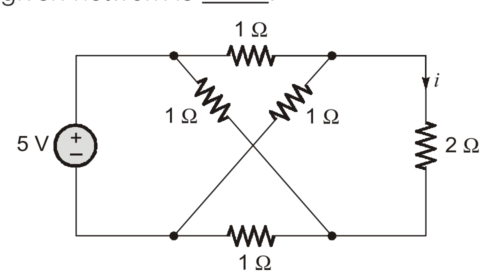
(c) 10 (d) 14 [2015 : 1 M, Set-1]

1.40 In the given circuit, the parameter k is positive, and the power dissipated in the 2 Ω resistor is 12.5 W. The value of k is ____.



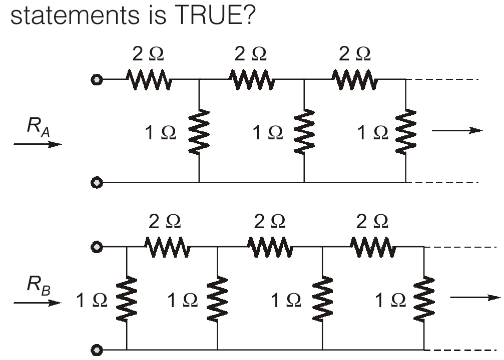
[2015 : 2 M, Set-1]

1.41 The current i(in Ampere) in the 2 Ω resistor of the given network is _____.



[2015 : 1 M, Set-2]

1.42 R_A and R_B are the input resistances of circuits as shown below. The circuits extend infinitely in the direction shown. Which one of the following statements is TRUE?

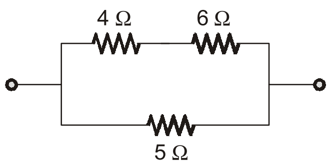


(a) $R_A = R_B$ (b) $R_A = R_B = 0$

(c) $R_A < R_B$ (d) $R_B = R_A/(1 + R_A)$

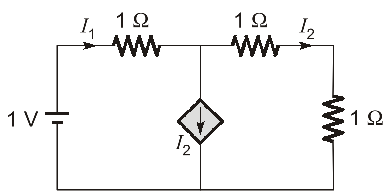
[2016 : 1 M, Set-1]

1.43 In the portion of a circuit shown, if the heat generated in 5 Ω resistance is 10 calories per second, then heat generated by the 4 Ω resistance, in calories per second, is _____.



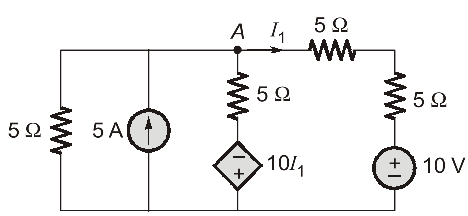
[2016 : 1 M, Set-1]

1.44 In the given circuit, the current supplied by the battery (in Ampere) is _________.



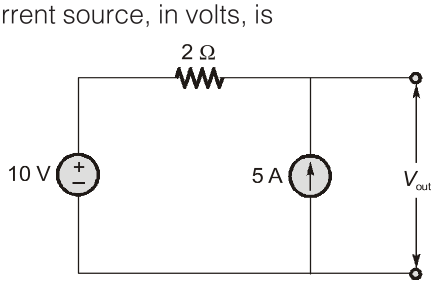
[2016 : 1 M, Set-1]

1.45 In the circuit shown below, the node voltage V_A is ______ V.



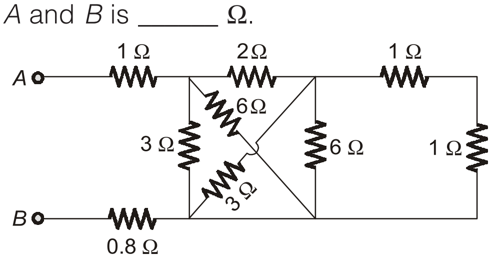
[2016 : 2 M, Set-1]

1.46 In the circuit shown below, the voltage and current sources are ideal. The voltage (V_{out}) across the current source, in volts, is



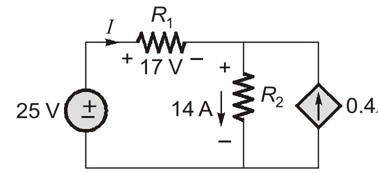
(a) 0 (b) 5
(c) 10 (d) 20 [2016 : 1 M]

1.47 The equivalent resistance between the terminals *A* and *B* is ______ Ω.



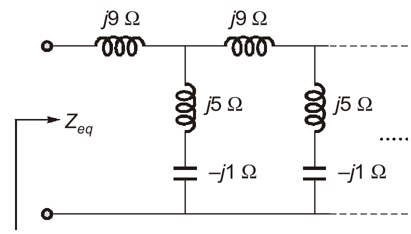
[2017 : 1 M, Set-1]

1.48 The power supplied by the 25 V source in the figure shown below is ________ W.



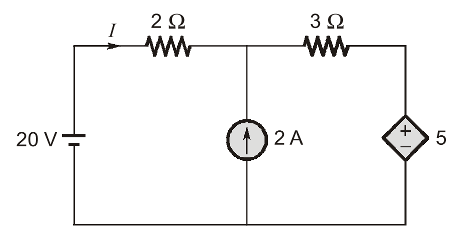
[2017 : 1 M, Set-1]

1.49 The equivalent impedance Z_{eq} for the infinite ladder circuit shown in the figure is



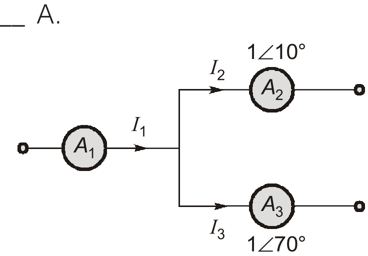
(a) *j*12 Ω (b) –*j*12 Ω
(c) *j*13 Ω (d) 13 Ω [2018 : 2 M]

1.50 The current *I* flowing in the circuit shown below in Amperes (round off to one decimal place) is ____.



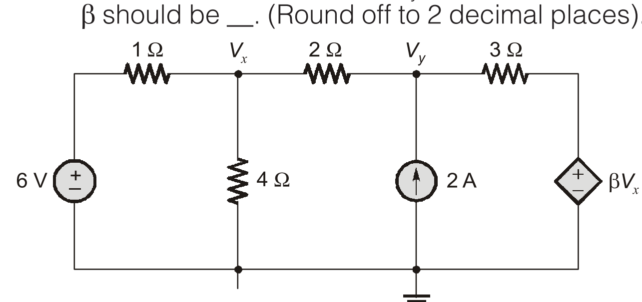
[2019 : 1 M]

1.51 Currents through ammeters A_2 and A_3 in fig.are $1\angle 10°$ and $1\angle 70°$ respectively. The reading of the ammeter A_1 (rounded off to 3 decimal places) is ______ A.



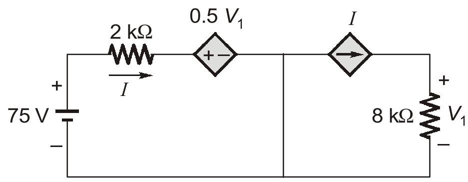
[2020 : 1 M]

1.52 In given circuit, for voltage V_y to be zero, value of β should be __. (Round off to 2 decimal places).



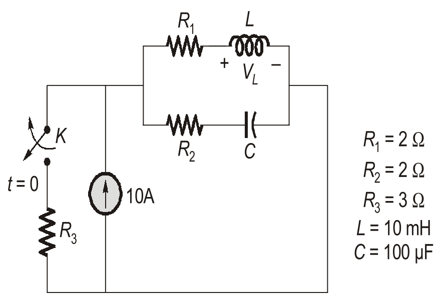
[2021 : 1 M]

1.53 In circuit shown below, the magnitude of voltage V_1 in volts, across the 8 kΩ resistor is _____.



[2022 : 2 M]

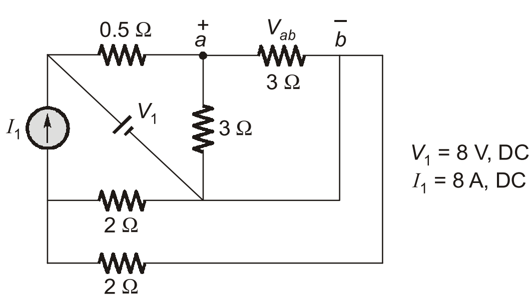
1.54 The value of parameters of the circuit shown in the figure are :
R_1 = 2 Ω, R_2 = 2 Ω, R_3 = 3 Ω, L = 10 mH, C = 100 μF



For time $t < 0$, the circuit is at steady state with the switch 'K' in closed condition. If the switch is opened at $t = 0$, the value of the voltage across the inductor (V_L) at $t = 0^+$ in Volts is _____ (Round off to 1 decimal place).

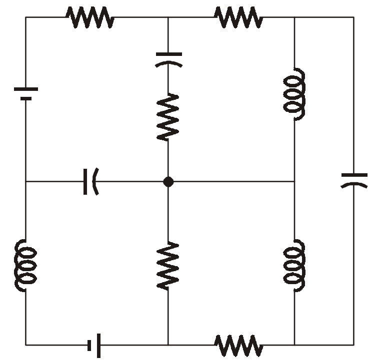
[2023 : 1 M]

1.55 For the circuit shown in the figure, V_1 = 8 V, DC and I_1 = 8 A, DC. The voltage V_{ab} in Volts is _________ (Round off to 1 decimal place).



[2023 : 1 M]

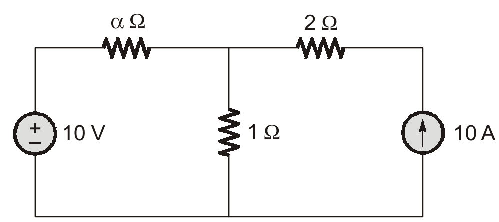
1.56 The number of junctions in the circuit is



(a) 8 (b) 6
(c) 7 (d) 9

[2024 : 1 M]

1.57 All the elements in the circuit are ideal. The power delivered by the 10 V source in watts is



(a) 100
(b) 0
(c) dependent on the value of α
(d) 50

[2024 : 1 M]

■■■■

Answers Basics

1.1 (c)	1.2 (b)	1.3 (5)	1.4 (31)	1.5 (2)	1.6 (c)	1.7 (b)
1.8 (d)	1.9 (b)	1.10 (d)	1.11 (b)	1.12 (b)	1.13 (c)	1.14 (c)
1.15 (d)	1.16 (c)	1.17 (b)	1.18 (a)	1.19 (d)	1.20 (c)	1.21 (a)
1.22 (a)	1.23 (b)	1.24 (a)	1.25 (d)	1.26 (a)	1.27 (b)	1.28 (b)
1.29 (d)	1.30 (b)	1.31 (a)	1.32 (c)	1.33 (c)	1.34 (b)	1.35 (330)
1.36 (2470.44°)	1.37 (10)	1.38 (3)	1.39 (a)	1.40 (0.5)	1.41 (0)	1.42 (d)
1.43 (2)	1.44 (0.5)	1.45 (11.42)	1.46 (d)	1.47 (3)	1.48 (250)	1.49 (a)
1.50 (1.4)	1.51 (1.732)	1.52 (–3.25)	1.53 (100)	1.54 (8)	1.55 (6)	1.56 (b)
1.57 (b)						

Explanations Basics

1.1 (c)

$$P_x = P_{6\,V} - P_{1\,\Omega} = 6 \times 1 - 1^2 \times 1 = 5 \text{ W}$$

By putting the options, it can be concluded that for $i = 5$ A.

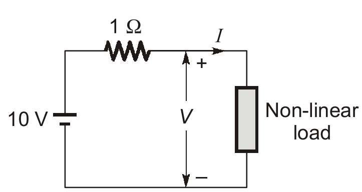
$$P_x = (6 \times 5) - (5^2 \times 1) = 5 \text{ W}$$

Option (c) is correct.

1.2 (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.

1.3 Sol.



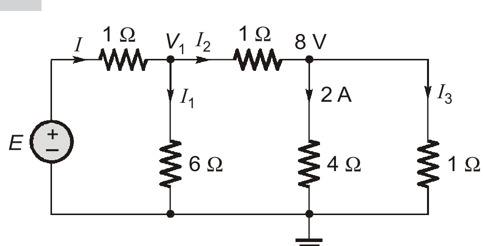
Using KVL, $V + I = 10$ ...(i)

Given, $7I = V^2 + 2V$ ...(ii)

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

$$V = 5 \text{ V}, \quad I = 5 \text{ A}$$

1.4 Sol.



Voltage across 4 Ω resistor = 4 × 2 = 8 V

Current through 1 Ω resistor,

$$I_3 = \frac{8}{1} = 8\text{A}$$

$$I_2 = I_3 + 2 = 10 \text{ A}$$

$$V_1 = 8 + 1 \times 10 = 18 \text{ V}$$

Current through 6 Ω resistor,

$$I_1 = \frac{18}{6} = 3 \text{ A}$$

Current through 1 Ω resistor,

$$I = I_1 + I_2 = 3 + 10 = 13 \text{ A}$$

$$E = V_1 + I \cdot 1 = 18 + 13 \times 1 = 31 \text{ V}$$

1.5 Sol.

For the given waveforms,

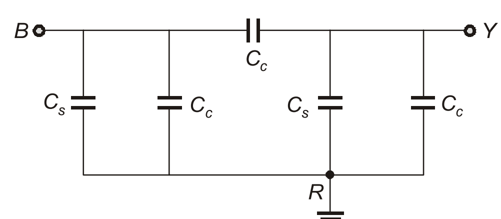
$$v(t) = 2\frac{di(t)}{dt}$$

Comparing it with $v(t) = L\frac{di(t)}{dt}$

We get, $L = 2$ H

1.6 (c)

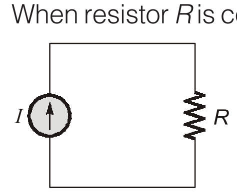
Given circuit can be redrawn as:



$$C_{BY} = \frac{C_s + C_c}{2} + C_c = \frac{C_s + 3C_c}{2}$$

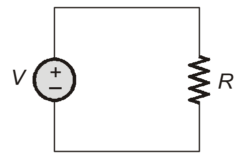
1.7 (b)

When resistor R is connected to a current source,



$$P = I^2 R = 18 \text{ W}$$

When resistor R is connected to a voltage source,



$$P = \frac{V^2}{R} = 4.5 \text{ W}$$

Given, $\quad V = I$ (in magnitude)

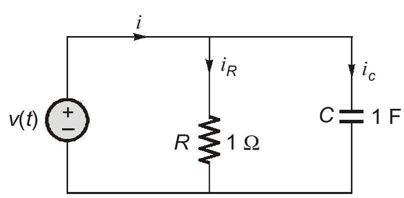
$$\Rightarrow \quad I^2R = 18 \qquad \text{...(i)}$$

$$\frac{I^2}{R} = 4.5 \qquad \text{...(ii)}$$

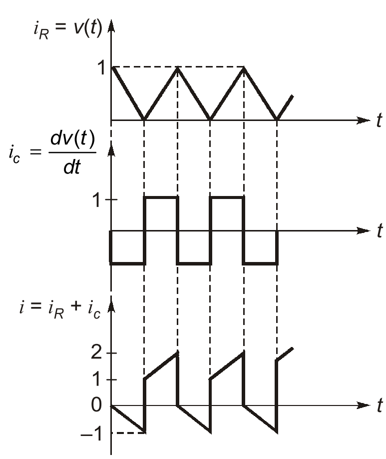
On solving these two equations, we get,

$$I = 3 \text{ A}; \quad R = 2\,\Omega$$

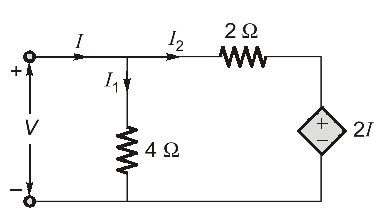
1.8 (d)



$$i = i_R + i_c = \frac{v(t)}{1} + 1 \cdot \frac{dv(t)}{dt}$$



1.9 (b)



Current through 4 Ω resistor, $I_1 = \dfrac{V}{4}$

Current through 2 Ω resistor, $I_2 = \dfrac{V - 2I}{2}$

Total current, $I = I_1 + I_2 = \dfrac{V}{4} + \dfrac{V - 2I}{2}$

$$\Rightarrow \quad I = \frac{V}{4} + \frac{V}{2} - I \Rightarrow 2I = \frac{3}{4}\text{V}$$

$$\text{Load} = \frac{V}{I} = \frac{8}{3}\,\Omega$$

1.10 (d)

$$\because \quad P \propto \frac{1}{R}$$

Therefore resistance of 40 W bulb > resistance of 60 W bulb.

For series connection, current through both the bulbs will be same $P = I^2R$ (for series connection).

Power consumed by 40 W bulb > power consumed by 60 W bulb.

Hence, the 40 W bulb glows brighter.

1.11 (b)

When C is open, $R_{AB} = R_A + R_B = 6\,\Omega$

When B is open, $R_{AC} = R_A + R_C = 9\,\Omega$

When A is open, $R_{BC} = R_B + R_C = 11\,\Omega$

On solving above equations

$R_A = 2\,\Omega$, $R_B = 4\,\Omega$ and $R_C = 7\,\Omega$

1.12 (b)

By KCL,

$$I_P + I_Q + I_C + I_L = 0$$

$$2 + 1 + I_C + I_L = 0$$

But, $\quad I_C = C \times \dfrac{dv}{dt}$

$$= 1 \times \frac{d}{dt}(4\sin 2t) = (8\cos 2t)$$

$$\therefore \quad I_L = -(2 + 1 + 8\cos 2t)$$

$$= -3 - 8\cos 2t$$

$$\therefore \quad V_L = L\left(\frac{di}{dt}\right) = 2 \times 2 \times 8 \sin 2t$$

$$= 32 \sin 2t$$

Note: KCL is based on the law of conservation of charges.

1.13 (c)

For $0 < t < 2s$ current varies linearly with time and given as $i(t) = 3t$ and for $2s < t < 4s$ current is constant, $i(t) = 6$ A.

The energy absorbed by the inductor (Resistance neglected) in the first 2 sec,

$$E_L = \int_0^T Li\frac{di}{dt}\,dt = E_{L_1} + E_{L_2}$$

$$E_{L_1} = \int_0^2 Li\left(\frac{di}{dt}\right)dt = \int_0^2 2 \times 3t \times 3\,dt$$

$$= 18\int_0^2 t\,dt = 18 \times \frac{t^2}{2}\Big|_0^2 = 18\times\left[\frac{4}{2} - 0\right] = 36\text{ J}$$

The energy absorbed by the inductor in (2 s < t < 4 s) second,

$$E_{L_2} = \int_2^4 Li\left(\frac{di}{dt}\right) dt = \int_2^4 2\cdot 6\cdot 0\,dt = 0\text{ J}$$

A pure inductor does not dissipate energy but only stores it. Due to resistance, some energy is dissipated in the resistor. Therefore, total energy absorbed by the inductor is the sum of energy stored in the inductor and the energy dissipated in the resistor.

The energy dissipated by the resistance in 4 sec.

$$E_R = \int_0^T i^2 R\,dt = \int_0^2 (3t)^2 \times 1\,dt + \int_2^4 6^2 \times 1\,dt$$

$$= \int_0^2 (9t^2)\,dt + 36\int_2^4 1\,dt$$

$$= 9\times\frac{t^3}{3}\Big|_0^2 + 36t\big|_2^4 = 9\times\left(\frac{8}{3}\right) + 36\times 2$$

$$= 24 + 72 = 96\text{ J}$$

The total energy absorbed by the inductor in 4 sec = 96 J + 36 J = 132 J

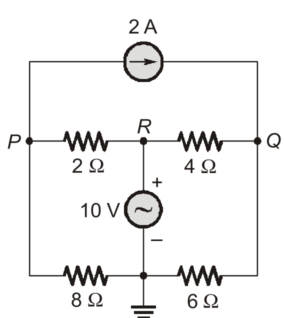
1.14 (c)

Given: $V_R = 10$ V

By KCL,

$$\frac{V_P - 10}{2} + 2 + \frac{V_P}{8} = 0 \quad ...(i)$$

$$\frac{V_Q - 10}{4} - 2 + \frac{V_Q}{6} = 0 \quad ...(ii)$$



From equation (i),

$$4(V_P - 10) + 2\times 8 + V_P = 0$$

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

$$5V_P - 24 = 0 \Rightarrow V_P = 4.8$$

From equation (ii),

$$6(V_Q - 10) - 2\times 4\times 6 + 4V_Q = 0$$

$$10V_Q - 108 = 0$$

$\therefore$ $$V_Q = 10.8$$

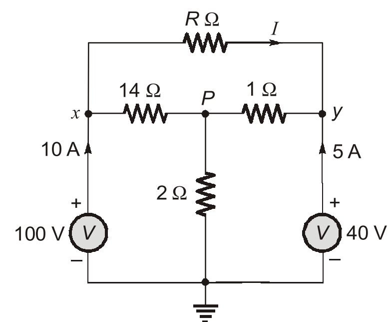
$\therefore$ $$V_P - V_Q = -6\text{ V}$$

1.15 (d)

By KCL,

$$\therefore \quad \frac{V_P - 40}{1} + \frac{V_P - 100}{14} + \frac{V_P}{2} = 0$$

$$22V_P = 660$$



$\therefore$ $$V_P = 30\text{ V}$$

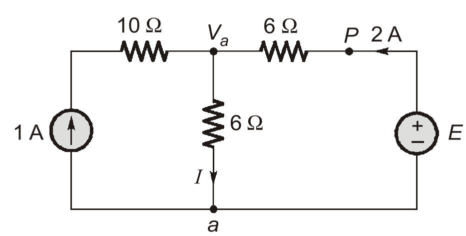
Potential difference between node x and y = 60 V

By taking KCL at node y

$$-I - 5 + \frac{40 - 30}{1} = 0$$

$\therefore$ $$I = 5\text{ A} \Rightarrow I = \frac{60}{5} = 12\ \Omega$$

1.16 (c)



Method-1: Using KCL,

$$\frac{V_a - E}{6} + \frac{V_a}{6} - 1 = 0$$

$$\Rightarrow \quad 2V_a - E = 6 \quad ...(i)$$

Where, $$\frac{E - V_a}{6} = 2$$

$$\Rightarrow \quad E - V_a = 12 \quad ...(ii)$$

Solving equation (i) and (ii), we get

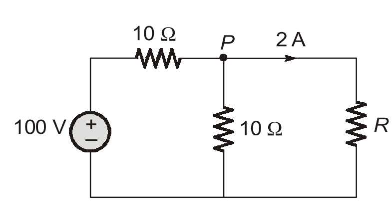
$$V_a = 18\text{ V and } E = 30\text{ V}$$

Method-2: $I = 2 + 1 = 3$ A

Apply KVL in second loop,

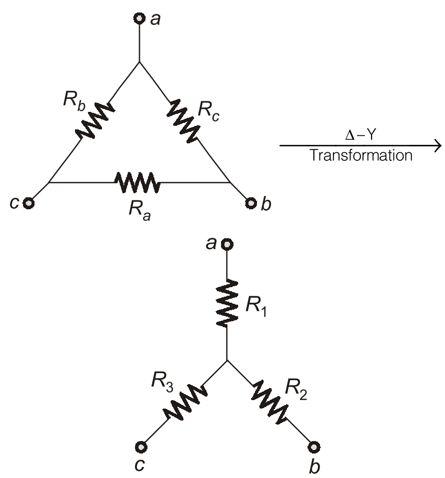
$$E = 2\times 6 + 3\times 6 = 30\text{ V}$$

1.17 (b)



$$\frac{V_P - 100}{10} + \frac{V_P}{10} + 2 = 0$$
$$2V_P - 100 + 20 = 0$$
$$\therefore \quad V_P = \frac{80}{2} = 40 \text{ V}$$
$$\therefore \quad R = \frac{V_P}{2} = \frac{40}{2} = 20\,\Omega$$

1.18 (a)



Given: $R_a = 20\ \Omega$

$R_b = 10\ \Omega$ and $R_c = 10\ \Omega$

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c} = \frac{10 \times 10}{20 + 10 + 10} = 2.5\ \Omega$$
$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c} = \frac{10 \times 20}{20 + 10 + 10} = 5\ \Omega$$
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c} = \frac{20 \times 10}{20 + 10 + 10} = 5\ \Omega$$

Remember: If all the branches of Δ-connection has same impedance Z, then impedance of branch of Y-connection be $Z/3$.

1.19 (d)

R.M.S value of d.c current = 10 A = I_{dc}

R.M.S value of sinusoidal current = $\left(\frac{20}{\sqrt{2}}\right)$ A $= I_{ac}$

R.M.S value of resultant,

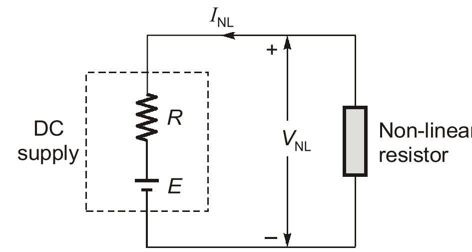
$$I_R = \sqrt{I_{dc}^2 + I_{ac}^2} = \sqrt{10^2 + \left(\frac{20}{\sqrt{2}}\right)^2} = 17.32 \text{ A}$$

1.20 (c)

The Resultant (R) when viewed from voltage source

$$= \frac{100}{8} = 12.5$$
$$R + 10\,||\,10 = 12.5\ \Omega$$
$$\therefore\ R = 12.5 - 10\,||\,10 = 12.5 - 5 = 7.5\ \Omega$$

1.21 (a)



$$V_{NL} = I_{NL}^2 \qquad \text{...(i)}$$
$$V_{NL} = E - I_{NL}R \quad \text{where, } E = 3 \text{ V}$$
and $R = 2\ \Omega$
$$V_{NL} = 3 - 2\,I_{NL} = I_{NL}^2$$
$$I_{NL}^2 + 2I_{NL} - 3 = 0$$
$$I_{NL} = -3 \text{ A or } 1 \text{ A}$$

–3 A is rejected, because the non-linear resistor is passive and the only active element in the circuit is 3 V DC supply. Which is supplying the power to the resistor. So, $I_{NL} = 1$ A

Power dissipated in the non-linear resistor

$$= V_{NL}I_{NL} = I_{NL}^2 I_{NL} = I_{NL}^3 = 1^3 = 1 \text{ W}$$

1.22 (a)

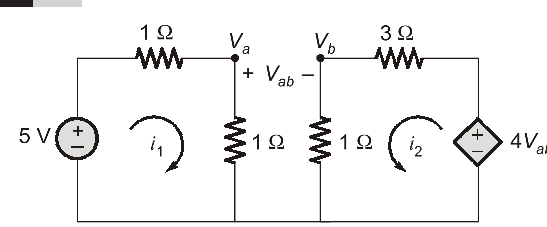
$$i = 1 \text{ A}$$

Applying KVL, we get

$$V_{ab} - 2i + 5 = 0$$
$$V_{ab} = -5 + 2i = -5 + 2 \times 1 = -3 \text{ V}$$

Note: KVL is based on the conservation of energy.

1.23 (b)



By KVL in Loop-1,

$$5 - i_1 - i_1 = 0$$
$$i_1 = \frac{5}{2} = 2.5 \text{ A}$$
$$\therefore \quad V_a = 2.5 \text{ V}$$

By KVL in Loop-2,

$$4V_{ab} = 3i_2 + i_2$$
$$i_2 = \frac{4V_{ab}}{4} = V_{ab}$$
$$\therefore \quad V_b = 1 \times i_2 = V_{ab}$$
$$V_b = V_a - V_b = \frac{V_a}{2} = \frac{2.5}{2} = 1.25 \text{ V}$$
$$i_2 = V_{ab} = V_b \Rightarrow i_2 = 1.25 \text{ A}$$

1.24 (a)

Bridge is balanced i.e., node C and node D are at same potential. Therefore, no current flows through 2 kΩ resistor.

1.25 (d)

Let resistance of a single incandescent lamp = R.
Power consumed by a single lamp, P = 200 W.
When connected across voltage, V = 220 V.

$$\text{So, } P = \frac{V^2}{R} \Rightarrow 200 = \frac{220^2}{R} \Rightarrow R = 242 \text{ W}$$

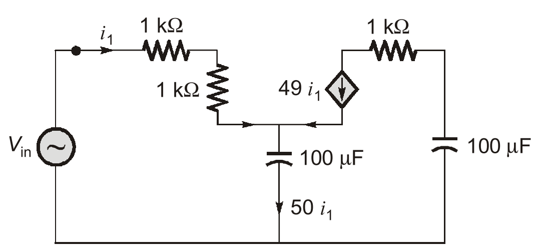
Let, n number of lamps are connected in series across voltage V = 200 V.
So total resistance of lamps,

$$R_{eq.} = nR = 242\,n$$

Total power consumed,

$$P = \frac{V^2}{R_{eq.}} \Rightarrow 100 = \frac{220^2}{242n} \Rightarrow n = 2$$

1.26 (a)



Applying KVL, we get

$$V_{in} - i_1(1 + 1) - 50\,i_1(-jX_C) = 0$$

$$\Rightarrow \quad V_{in} = i_1[2 - j50\,X_C]$$

$$\text{Input impedance} = \frac{V_{in}}{i_1} = 2 - j50X_C$$

As imaginary part is negative, input impedance has equivalent capacitive reactance $X_{C\,eq.}$

$$X_{C\,eq.} = 50\,X_C$$

$$\frac{1}{\omega C_{eq.}} = \frac{50}{\omega C} = \frac{50}{\omega \times 100} = \frac{1}{2\omega}$$

$$C_{eq.} = 2\,\mu\text{F}$$

1.27 (b)

Voltage across 2 Ω resistance = V_s = 4 V

$$\text{Current through 2 Ω resistance} = \frac{V_s}{R} = \frac{4}{2} = 2\text{ A}$$

Current source has no effect, when connected across voltage source.
So, to double current though 2 Ω resistance, voltage source is doubled, i.e.,

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

1.28 (b)

A resistor has linear characteristics

i.e., $V = Ri \Rightarrow V = i$

Load line, $V + i = 100$

$i + i = 100$

$$\text{Current through resistance, } i = \frac{100}{2} = 50\text{ A}$$

1.29 (d)

In such system, volumetric flow rate C is analogous to current and pressure is analogous to voltage. The hydraulic capacitance due to storage in gravity field is defined as,

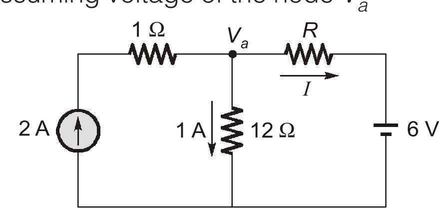
$$C = \frac{A}{\rho g}$$

where, A = Area of the tank
ρ = Density of the fluid
g = Acceleration due to gravity

The hydraulic capacitance is represented by A and C. Liquid trying to flow out of a container, can meet with resistance in several ways. If the outlet is a pipe, the friction between the liquid and the pipe walls produces resistance to flow. Such resistance is represented by B and D.

1.30 (b)

Assuming voltage of the node V_a



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

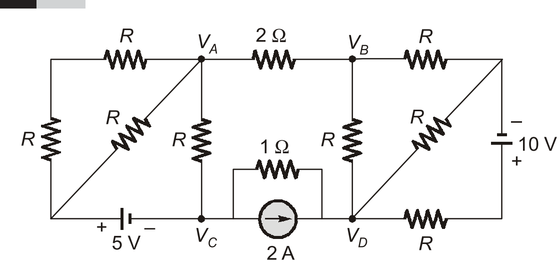
Applying KCL, we get

$$-2 + 1 + I = 0 \Rightarrow I = 1\text{ A}$$

$$I = \frac{V_a - 6}{R} = \frac{12 - 6}{R} = \frac{6}{R}$$

$$\Rightarrow \quad I = \frac{6}{R} \Rightarrow R = 6\,\Omega$$

1.31 (a)



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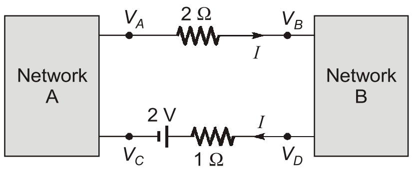
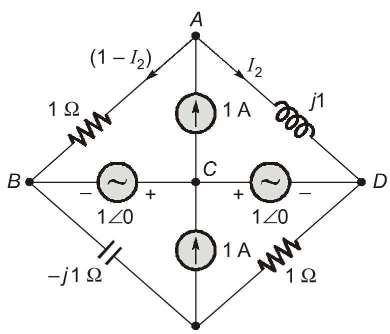


$$V_A - V_B = 2I \Rightarrow 2I = 6 = 3\text{ A}$$
$$V_C + 2 + 1 \times I = V_D$$
$$V_C - V_D = -2 - 3 = -5\text{ V}$$

1.32 (c)



Apply KCL node at 'A',
so, current flowing through 1 Ω is $(1 - I_2)$
Applying KVL in *ABCD* loop,
$1\angle 0 - 1\angle 0 + 1(1 - I_2) - jI_2 = 0$

$$I_2 = \frac{1}{1+j}$$

1.33 (c)

$$Q = CV$$
$$Q_1 = C_1V_1 = 10 \times 10^{-6} \times 10 = 100\ \mu\text{C}$$
$$Q_2 = C_2V_2 = 5 \times 10^{-6} \times 5 = 25\ \mu\text{C}$$
$$Q_3 = C_3V_3 = 2 \times 10^{-6} \times 2 = 4\ \mu\text{C}$$

Capacitors C_2 and C_3 are in series.
In series charge is same.
So, the maximum charge on C_2 and C_3 will be minimum of (Q_2, Q_3) = min(25 μC, 4 μC) = 4 μC = Q_{23}.
In series the equivalent capacitance of C_2 and C_3 is

$$C_{23} = \frac{C_2 C_3}{C_2 + C_3} = \frac{5 \times 2}{5 + 2} = \frac{10}{7}\mu\text{F}$$

So, the equivalent voltage,

$$V_{23} = \frac{Q_{23}}{C_{23}} = \frac{4 \times 10^{-6}}{\frac{10}{7} \times 10^{-6}} = \frac{28}{10} = 2.8\text{ V}$$

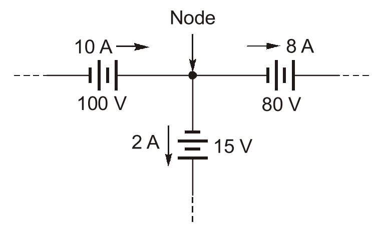
In parallel, the voltage is same.
$$V_1 = V_{23} = 2.8\text{ V}$$
Change in capacitor C_1
$$Q_1 = C_1V_1 = 10 \times 10^{-6} \times 2.8 = 28\ \mu\text{C}$$
In parallel, the total charge
$$Q = Q_1 + Q_{23} = 4 + 28 = 32\ \mu\text{C}$$

1.34 (b)

$$R_A = \frac{R_b R_c}{R_a + R_b + R_c}$$
$$R'_a = kR_a;\quad R'_b = kR_b;\quad R'_c = kR_c$$
$$R'_A = \frac{kR_b \cdot kR_c}{kR_a + kR_b + kR_c} = \frac{k^2 R_b R_c}{k(R_a + R_b + R_c)}$$
$$= k \times \frac{R_b R_c}{R_a + R_b + R_c} = kR_A$$

1.35 Sol.

Given electrical circuit is shown below:



Applying KCL at node, current through 15 V voltage source = 2 A.
∴ Power absorbed by 100 V voltage source = 10 × 100 = 1000 Watt.
Power absorbed by 80 V voltage source = –(80 × 8) = –640 Watts and power absorbed by 15 V voltage source = –(15 × 2) = –30 Watt.
∴ Total power absorbed by the three circuit elements = (100 – 640 – 30) Watts = 330 Watts

1.36 Sol.

Let the resistance of incandescent lamp

$$= R_T = \frac{V^2}{P} = \frac{(240)^2}{40} = 1440\ \Omega$$

Given, R_0 = 120 Ω, α = 4.5 × 10^{-3}/°C
Let, R_T be the resistance of the filament in ON state at temperature T.

Then, $R_T = R_0[1 + \alpha\Delta T]$

or, $[1 + \alpha\Delta T] = \frac{R_T}{R_0} = \frac{1440}{120} = 12$

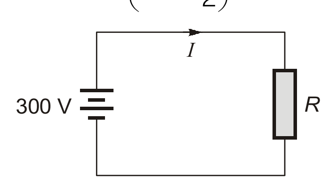
or, $\alpha\Delta T = 11$ or $\Delta T = 2444.44$°C

or, $T = 2444.44° + 26° = 2470.44$°C

∴ ON state temperature of filament = 2470.44°C

1.37 Sol.

Given, $R = \left(25 + \frac{I}{2}\right)\Omega$ or $I = (2R - 50)$



Applying KVL in given loop, we have:

$$300 = IR \text{ or } 300 = (2R - 50) \times R$$

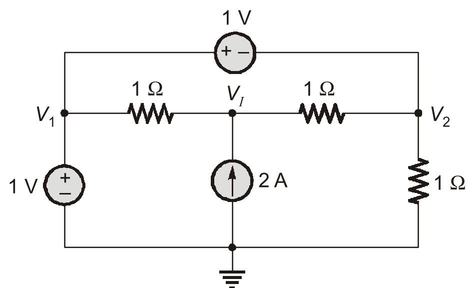
we get, $R = 30\ \Omega$ or $-5\ \Omega$

Since resistance can't be negative. Therefore,

$$R = 30\ \Omega$$

Hence, $I = (2R - 50) = (2 \times 30 - 50)\text{A} = 10\text{ A}$

1.38 Sol.



Applying nodal analysis at node P, we have:

$$\frac{V_I - V_1}{1} + \frac{V_I - V_2}{1} - 2 = 0$$

or, $2V_I - (V_1 + V_2) = 2$

or, $$V_I = \left[\frac{2 + (V_1 + V_2)}{2}\right] \quad \text{...(i)}$$

Also, $V_1 - V_2 = 1$ volt and $V_1 = 1$ volt

$\therefore$ $V_2 = V_1 - 1 = 1 - 1 = 0$ volt

Putting values of V_1 and V_2 in equation (i), we get:

$$V_I = \left[\frac{2 + (1 + 0)}{2}\right] = \frac{3}{2}\text{ volt}$$

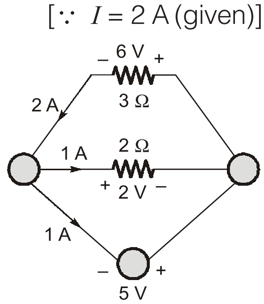
$\therefore$ Power delivered by the current source

$$= V_I \cdot I = \frac{3}{2} \times 2 = 3\text{ Watt} \qquad [\because I = 2\text{ A (given)}]$$

1.39 (a)

Power = 5×1

= 5 Watt

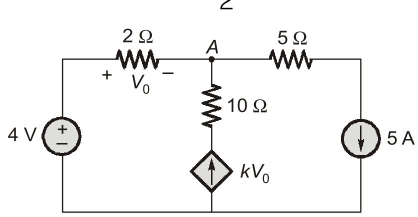


1.40 Sol.

$$\Rightarrow \quad \frac{V_0^2}{2} = 12.5$$

$$\Rightarrow \quad V_0^2 = 12.5 \times 2 \Rightarrow V_0 = 5$$

$$I_0 = \frac{5}{2} = 2.5\text{ A}$$



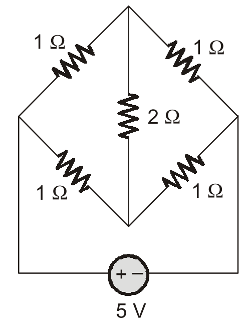
KCL at A,

$\Rightarrow$ $-2.5 - k(5) + 5 = 0 \Rightarrow k(5) = 2.5$

$$\Rightarrow \quad k = \frac{2.5}{5} = \frac{1}{2}$$

1.41 Sol.

Redrawing the circuit,



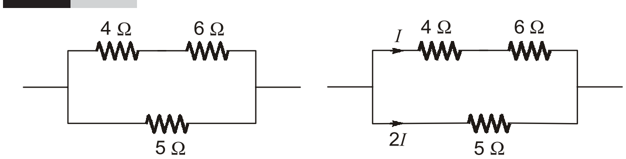
Bridge is balance, so current flowing through 2 Ω resistor is 0 A.

1.42 (d)

If the equivalent resistance of the first figure is R_A then from the second figure, we can see that the $R_B = R_A \parallel 1\ \Omega$.

$$R_B = \frac{R_A}{R_A + 1}$$

1.43 Sol.

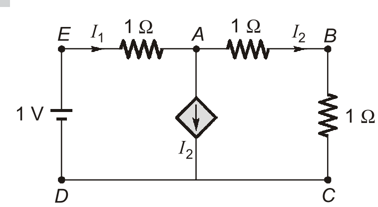


and $(2I)^2 \times 5 = 10$

$$\Rightarrow \quad I^2 = \frac{10}{5 \times 4} = \frac{2.5}{5} = 0.5$$

So, $I^2 \times 4 = 0.5 \times 4 = 2$ cal/sec.

1.44 Sol.



Applying KCL at node A,

$$-I_1 + I_2 + I_2 = 0 \Rightarrow 2I_2 = I_1 \quad \text{...(i)}$$

and applying KVL in loop ABCD,

$$1 - I_1 - I_2 - I_2 = 0 \Rightarrow I_1 + 2I_2 = 1 \quad \text{...(ii)}$$

From equation (i) and (ii),

$$\Rightarrow \quad 2I_2 + 2I_2 = 1 \Rightarrow 4I_2 = 1$$

$$\Rightarrow \quad I_2 = \frac{1}{4}\text{ A and } I_1 = 2 \times \frac{1}{4} = \frac{1}{2}\text{ A}$$

1.45 Sol.