

GATE

2018



31
YEARS
SOLUTIONS

GATE SOLUTIONS

ELECTRONICS AND COMMUNICATION

From (1987 - 2017)



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F-126, (Lower Basement), Katwaria Sarai, New Delhi-110016

Phone : 011-26522064, **Mobile** : 8130909220, 9711853908

E-mail : ies_master@yahoo.co.in, info@iesmaster.org

Web : iesmasterpublication.org

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PREFACE

It is an immense pleasure to present topic wise previous years solved paper of GATE Exam. This booklet has come out after long observation and detailed interaction with the students preparing for GATE exam and includes detailed explanation to all questions. The approach has been to provide explanation in such a way that just by going through the solutions, students will be able to understand the basic concepts and will apply these concepts in solving other questions that might be asked in future exams.

GATE exam now a days has become more important because it not only opens the door for higher education in institutes like IIT, IISc, NIT's but also many of the PSUs have started inducting students on the basis of GATE score. In PSU's, which are not inducting through GATE route, the questions in their exams are asked from GATE previous year papers. Thus, availability of authentic solutions to the students is the need of the day. Towards this end this booklet becomes indispensable.

I am thankful to IES master team without whose support, I don't think, this book could have been flawlessly produced.

Every care has been taken to bring an error free book. However comments for future improvement are most welcome.

Mr. Kanchan Kumar Thakur
Director Ex-IES

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1

Network Theory

■ UNIT ■

Syllabus

Network solution methods : nodal and mesh analysis; Network theorem; superposition, Thevenin and Norton's, maximum power transfer; Wye-Delta transformation; Steady state sinusoidal analysis using phasors; Time domain analysis of simple linear circuits; solution of network equations using Laplace transform; Frequency domain analysis of RLC circuits; Linear 2-port network parameters: driving point and transfer functions; State equations for network

■ CONTENTS

1. Basics of Network Analysis	01–24
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1

Chapter

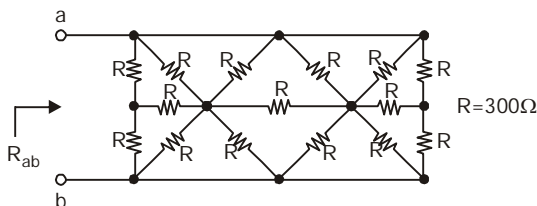
Basics of Network Analysis

1 – Mark

1. A connection is made consisting of resistance A in series with a parallel combination of resistances B and C. Three resistors of the value 10Ω , 5Ω , 2Ω are provided. Consider all possible permutations of the given resistors into the positions A, B, C, and identify the configurations with maximum possible overall resistance, and also the ones with minimum possible overall resistance. The ratio of maximum to minimum value of the resistances (upto second decimal place) is _____

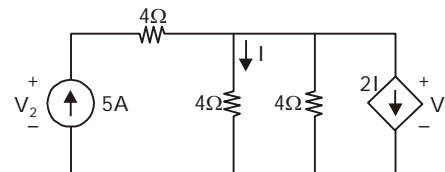
[GATE-2017]

2. In the network shown in the figure, all resistors are identical with $R = 300\Omega$. The resistance R_{ab} (in Ω) of the network is _____.



[GATE 2015]

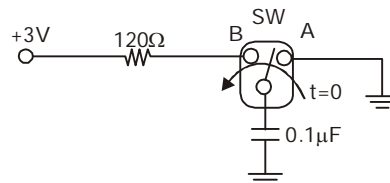
3. In the given circuit, the values of V_1 and V_2 respectively are



- (a) 5V, 25V (b) 10V, 30V
(c) 15V, 35V (d) 0V, 20V

[GATE 2015]

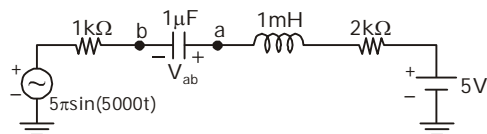
4. In the circuit shown, the switch SW is thrown from position A to position B at time $t = 0$. The energy (in μJ) taken from the 3V source to charge the $0.1\mu\text{F}$ capacitor from 0V to 3V is



- (a) 0.3 (b) 0.45
(c) 0.9 (d) 3

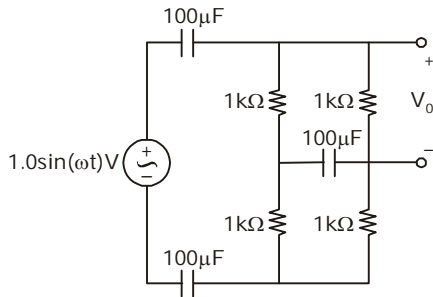
[GATE 2015]

5. In the circuit shown, the average value of the voltage V_{ab} (in Volts) in steady state condition is _____



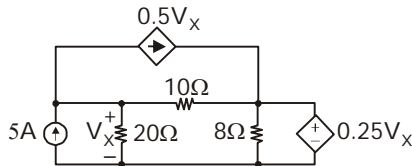
[GATE 2015]

6. At very high frequencies, the peak output voltage V_0 (in Volts) is _____



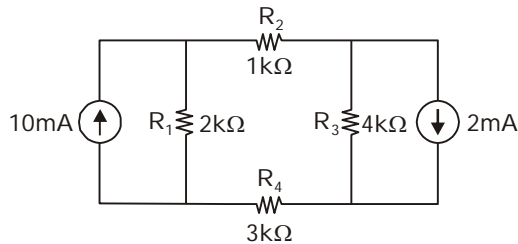
[GATE 2015]

7. In the circuit shown, the voltage V_x (in Volts) is _____



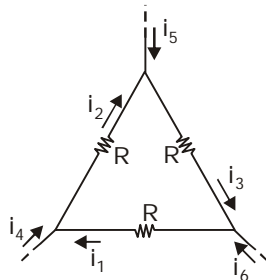
[GATE 2015]

8. The magnitude of current (in mA) through the resistor R_2 in the figure shown is _____.



[GATE 2014]

9. Consider the configuration in the figure which is a portion of a larger electrical network.

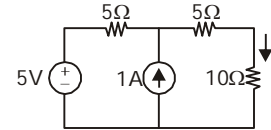


For $R = 1\Omega$ and currents $i_1 = 2A$, $i_4 = -1A$, $i_5 = -4A$, which one of the following is TRUE ?

- (a) $i_6 = 5A$
(b) $i_3 = -4A$

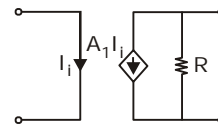
- (c) Data is sufficient to conclude that the supposed currents are impossible.
(d) Data is insufficient to identify the currents i_2 , i_3 and i_6 . [GATE 2014]

10. In the figure shown, the value of the current I (in Amperes) is _____.



[GATE 2014]

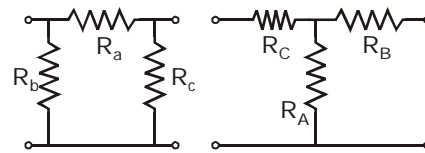
11. The circuit shown in the figure represents a



- (a) voltage controlled voltage source
(b) voltage controlled current source
(c) current controlled current source
(d) current controlled voltage source

[GATE 2014]

12. 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}

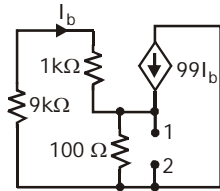
[GATE 2013]

13. The average power delivered to an impedance $(4 - j3)\Omega$ by a current $5\cos(100\pi t + 100)A$ is

- (a) 44.2 W
(b) 50 W
(c) 62.5 W
(d) 125 W

[GATE 2012]

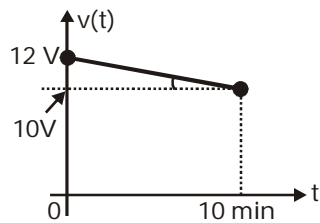
14. The impedance looking into nodes 1 and 2 in the given circuit is



- (a) 50Ω (b) 100Ω
(c) 5Ω (d) $10.1k\Omega$

[GATE 2012]

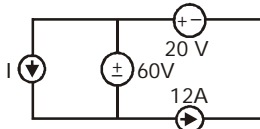
15. A fully charged mobile phone with a 12 V battery is good for a 10 minute talk-time. Assume that, during the talk-time, the battery delivers a constant current of a 2 A and its voltage drops linearly from 12 V to 10 V as shown in the figure. How much energy does the battery deliver during this talk-time?



- (a) 220 J (b) 12 kJ
(c) 13.2 kJ (d) 14.4 kJ

[GATE 2009]

16. In the interconnection of ideal sources shown in the figure, it is known that the 60 V source is absorbing power.

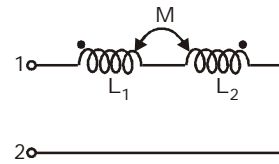


Which of the following can be the value of the current source I?

- (a) 10 A (b) 13 A
(c) 15 A (d) 18 A

[GATE 2009]

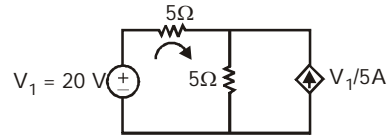
17. The equivalent inductance measured between the terminals 1 and 2 for the circuit shown in the figure is



- (a) $L_1 + L_2 + M$ (b) $L_1 + L_2 - M$
(c) $L_1 + L_2 + 2M$ (d) $L_1 + L_2 - 2M$

[GATE 2004]

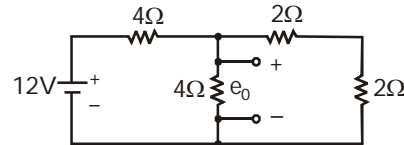
18. The dependent current source shown in given figure



- (a) delivers 80 W (b) absorbs 80 W
(c) delivers 40 W (d) absorbs 40 W

[GATE 2002]

19. The Voltage e_0 in the figure, is



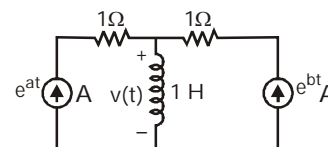
- (a) 2 V (b) $\frac{4}{3}$ V
(c) 4 V (d) 8 V

[GATE 2001]

20. If each branch of a Delta circuit has impedance $\sqrt{3}Z$, then each branch of the equivalent Wye circuit has impedance

- (a) $\frac{Z}{\sqrt{3}}$ (b) 3 Z
(c) $3\sqrt{3}Z$ (d) $\frac{Z}{3}$ [GATE 2001]

21. In the given circuit, the voltage $v(t)$ is



- (a) $e^{at} - e^{bt}$ (b) $e^{at} + e^{bt}$
(c) $ae^{at} - be^{bt}$ (d) $ae^{at} + be^{bt}$

[GATE 2000]



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ANSWER KEY**1 Mark**

1. (2.14)
2. (100)
3. (a)
4. (c)
5. (5)
6. (0.5)
7. (8)
8. (2.8)
9. (a)
10. (0.5)
11. (c)
12. (b)
13. (b)
14. (a)
15. (c)
16. (a)
17. (d)
18. (a)
19. (c)
20. (a)
21. (d)

22. (a)
23. (b)
24. (c)
25. (b)
26. (a)
27. (d)
28. (a)
29. (d)
30. (a & d)

2 Marks

1. (a)
2. (1)
3. (d)
4. (5)
5. (-1A)
6. (1.5)
7. (20)
8. (29.09)
9. (2.504)
10. (10)
11. (0.4083)
12. (2.618)

13. (c)
14. (d)
15. (c)
16. (a)
17. (a)
18. (c)
19. (b)
20. (a)
21. (None of these)
22. (d)
23. (d)
24. (d)
25. (d)
26. (b)
27. (b)
28. (d)
29. (a)

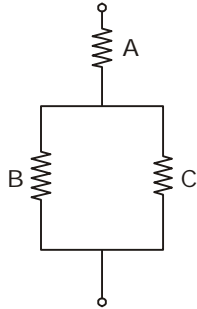
3 Marks

1. (c)

Solutions

1 – Mark

Sol-1:



Resistor are 2, 5 and 10Ω
For maximum resistance B = 2, C = 5, A = 10

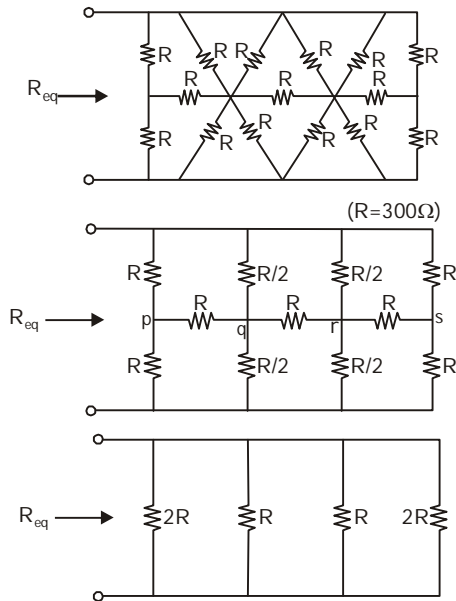
$$R_{\max} = \frac{80}{7}$$

for minimum resistance,
A = 2, B = 5, C = 10

$$R_{\min} = \frac{16}{3}$$

$$\frac{R_{\max}}{R_{\min}} = \frac{(80/7)}{(16/3)} = 2.14$$

Sol-2: (100)

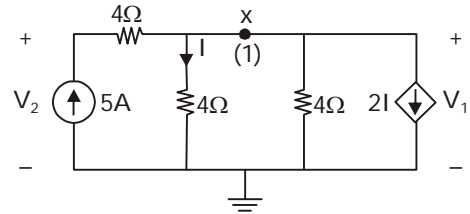


[Here, branch 'pqrs' is removed as no current flows through it, because it forms a balanced bridge]

$$\therefore R_{\text{eq}} = (2R) \parallel (2R) \parallel R \parallel R$$

$$= R \parallel R \parallel R = \frac{R}{3} = 100\Omega$$

Sol-3: (a)



Applying nodal analysis at node (1), we get

$$5 = \frac{x}{4} + \frac{x}{4} + 2I$$

$$\Rightarrow 5 = \frac{2x}{4} + 2 \times \frac{x}{4} \quad [\because x = 4I]$$

$$\therefore x = 5$$

Now, $V_1 = 5V \quad [\because x = V_1]$

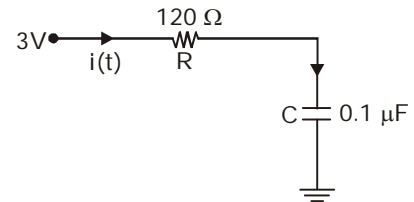
$$V_1 + 5 \times 4 - V_2 = 0$$

[KVL in the outermost loop]

$$\Rightarrow V_2 = 5 + 5 \times 4 = 25 V$$

Sol-4: (c)

Initially capacitor is uncharged. For $t > 0$, the circuit will be :



Current in RC circuit while charging is given by :

$$i(t) = \frac{V_0}{R} e^{-t/RC} \quad \text{where } V_0 = 3V$$

Power delivered by the source = P

$$= 3i(t) \quad [\because P = V \cdot I]$$

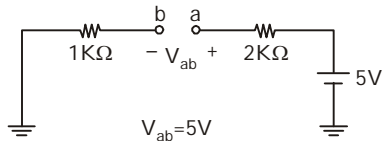
$$\text{Also, Energy} = \int_0^t P dt = \int_0^t 3i(t) dt$$

Capacitor gets fully charged at steady state i.e. $t = \infty$.

$$\begin{aligned} \therefore E &= \int_0^{\infty} 3 \cdot \frac{V_0}{R} e^{-t/RC} dt \\ &= \frac{3V_0}{R} \times \frac{(-1)}{(1/RC)} \left[e^{-t/RC} \right]_0^{\infty} \\ &= -3V_0C \left[e^{-\infty} - e^0 \right] \\ &= -3 \times 3 \times 0.1 \left[0 - 1 \right] \mu\text{J} \\ E &= 0.9 \mu\text{J} \end{aligned}$$

Sol-5: (5)

- For AC input voltage $5\pi \sin(5000t)$, voltage across capacitor (C) at steady state is also sinusoidal, whose average value is zero.
- For DC voltage = 5V, at steady state capacitor behaves as open circuit and inductor behaves as short circuit, therefore circuit is



Average value of voltage across capacitor is $V_{ab} = 5V$.

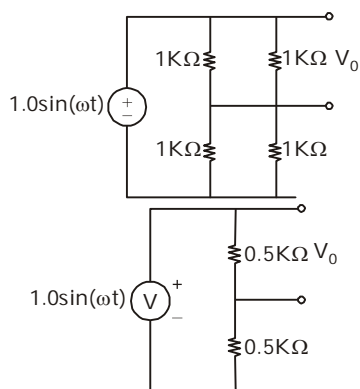
Sol-6: (0.5)

At very high frequencies, capacitor behaves as short-circuit.

$$\therefore X_C = \frac{1}{j\omega C}$$

When $\omega \rightarrow \infty$, $X_C \rightarrow 0$ [short circuit]

When all capacitors are replaced by short-circuit.



By voltage division rule

$$V_0 = \frac{0.5}{0.5+0.5} V$$

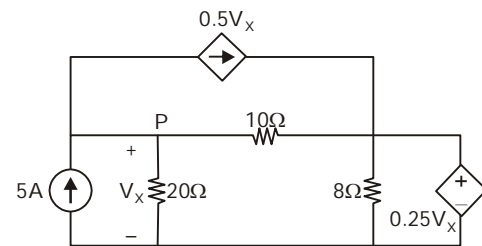
$$V_0 = \frac{V}{2}$$

$$V_0 = \frac{1}{2} [1.0 \sin(\omega t)]$$

$$V_0 = 0.5 \sin(\omega t)$$

$$(V_0)_{\text{peak}} = 0.5 \text{ Volts}$$

Sol-7: (8)



Apply KCL at point P

$$\frac{V_x}{20} + \frac{V_x - 0.25V_x}{10} + 0.5V_x = 5$$

$$V_x \left(\frac{1}{20} + \frac{75}{1000} + \frac{1}{2} \right) = 5$$

$$V_x \left(\frac{1}{20} + \frac{3}{40} + \frac{1}{2} \right) = 5$$

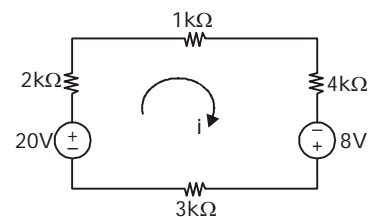
$$V_x \left(\frac{2+3+20}{40} \right) = 5$$

$$V_x \left(\frac{5}{8} \right) = 5$$

$$\therefore V_x = 8 \text{ Volts}$$

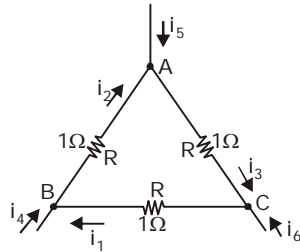
Sol-8: (2.8)

Transforming current sources into voltage sources, we get



$$i = \frac{20+8}{(2+1+4+3)k} = 2.8 \text{ mA}$$

Sol-9: (a)



Given,

$$R = 1\Omega, i_1 = 2A, i_4 = -1A, i_5 = -4A$$

Applying KCL at node B,

$$i_4 + i_1 - i_2 = 0$$

$$i_2 = i_1 + i_4 = 2 - 1 = 1A$$

Applying KCL at node A,

$$i_5 + i_2 - i_3 = 0$$

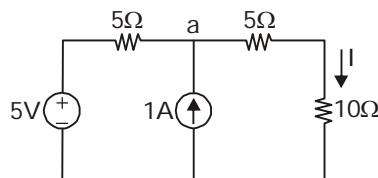
$$i_3 = i_2 + i_5 = 1 - 4 = -3A$$

Applying KCL at node C,

$$i_3 + i_6 - i_1 = 0$$

$$i_6 = i_1 - i_3 = 2 - (-3) = 5A$$

Sol-10: (0.5)



Applying KCL at node a,

$$\frac{V_a - 5}{5} + \frac{V_a}{15} - 1 = 0$$

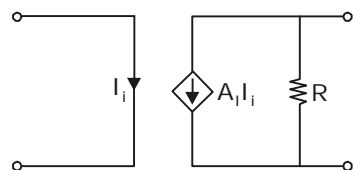
$$3(V_a - 5) + V_a = 15$$

$$4V_a = 30$$

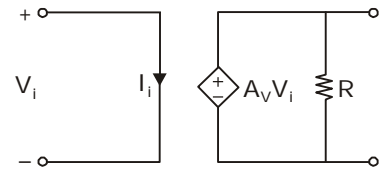
$$V_a = 7.5V$$

$$\therefore I = \frac{V_a}{15} = \frac{7.5}{15} = 0.5A$$

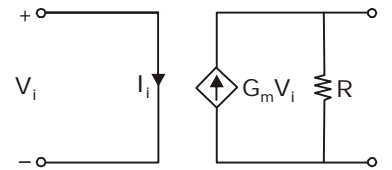
Sol-11: (c)



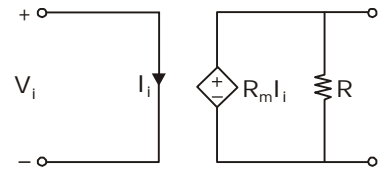
Current controlled current source



Voltage controlled voltage source

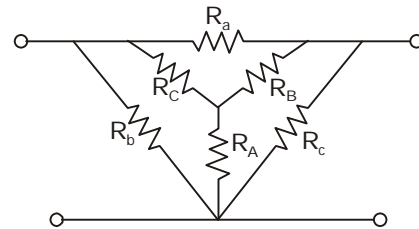


Voltage controlled current source



Current controlled voltage source

Sol-12: (b)



To convert delta to star

$$R'_c = \frac{R_a R_b}{R_a + R_b + R_c}$$

if they are factor by k so

$$R'_c = \frac{kR_a kR_b}{kR_a + kR_b + kR_c}$$

$$R'_c = \frac{kR_a R_b}{R_a + R_b + R_c}$$

$$R'_c = k R_c$$

So they are also factored by k.

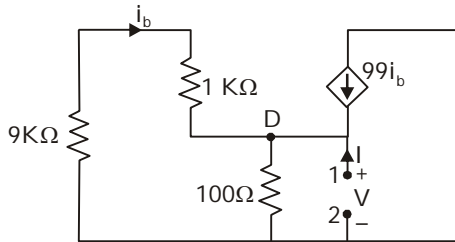
Sol-13: (b)

The average power delivered to a complex impedance $R \pm jX$ is given by

$$P_{avg} = I_{rms}^2 R$$

$$= \left(\frac{5}{\sqrt{2}} \right)^2 \times 4 = 50 \text{ W}$$

Sol-14: (a)



Let voltage across 1, 2 is V and current through it is I .

$$V = -i_b(9000+1000)$$

$$V = -10000i_b$$

Applying KCL at point D

$$i_b + I + 99i_b = \frac{V}{100}$$

$$I - \frac{V}{100} = \frac{V}{100}$$

$$I = \frac{V}{50}$$

And the impedance equivalent will be given by

$$\frac{V}{I} = Z = 50\Omega$$

Sol-15: (c)

Energy dissipated = $V \cdot I \cdot t$ Joules [V in volts, I in ampere, t in seconds]

Here, the graph of $V - t$ is given. The area under $V - t$ graph will give the product of V & t . [V in Volts and t in seconds]

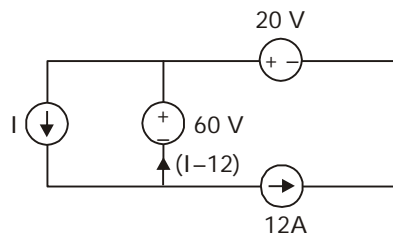
\therefore Energy dissipated = [Area under graph] $\times I$

$$= \frac{1}{2} \times (12+10) \times 10 \times 60 \times 2 \text{ Joules}$$

$$= 11 \times 10 \times 60 \times 2 \text{ Joules}$$

$$\text{Energy Dissipated} = 13.2 \text{ kJ}$$

Sol-16: (a)

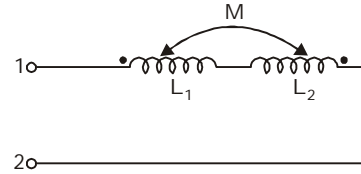


For absorbing power by 60 V,

$$I - 12 < 0$$

$$\text{So } I < 12A$$

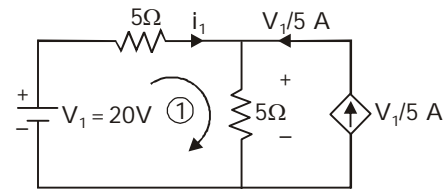
Sol-17: (d)



Since the flux in both coil is opposing, so mutual inductance will be negative compared to self inductance.

$$\begin{aligned} \text{Net inductance} &= L_1 - M + L_2 - M \\ &= L_1 + L_2 - 2M \end{aligned}$$

Sol-18: (a)



Apply KVL in loop ①,

$$V_1 - 5i_1 - 5\left(i_1 + \frac{V_1}{5}\right) = 0$$

$$\therefore i_1 = 0 \text{ A}$$

So, voltage across 5Ω resistor

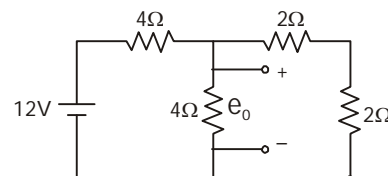
$$= 5 \times 4 = 20 \text{ V}$$

So power delivered by current source

$$= 20 \times 4 = 80 \text{ Watts}$$

Note : If current in a resistor flows from low voltage to high voltage then it is delivering power (applicable for both voltage source or current source).

Sol-19: (c)



$$R_{eq} = 4 \parallel 4 + 4 = 6\Omega$$

$$I = \frac{12}{6} = 2A$$

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