CLASS TEST

Sl. : 01JPEE_29062024

MADE EASY

India's Best Institute for IES, GATE & PSUs

Delhi | Bhopal | Hyderabad | Jaipur | Pune | Kolkata

Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

ELECTRICAL ENGINEERING

ELECTRIC CIRCUITS

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

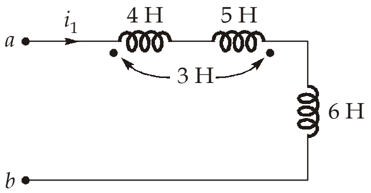
Read the following instructions carefully

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

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

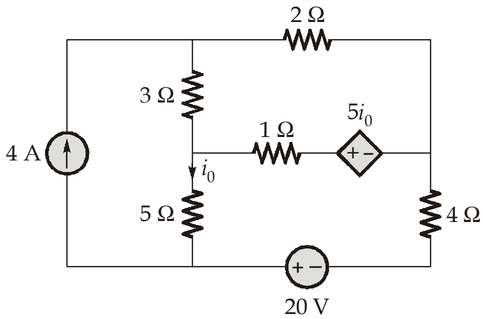
Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 If $i_1 = 2 \cos 500t$ A in the network of given figure, then the value of the maximum energy stored in the network is



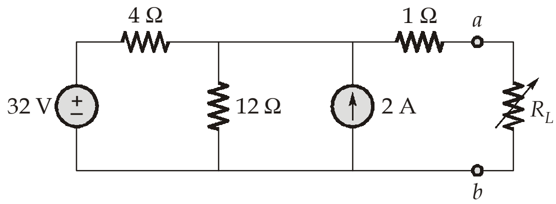
(a) 18 J (b) 16 J
(c) 6 J (d) 42 J

Q.2 For the circuit shown in figure, the current i_0 is



(a) –0.4705 A (b) 8.4705 A
(c) 3.4705 A (d) –2.3705 A

Q.3 For the circuit shown in figure, the Thevenin voltage across the terminals *a* and *b* is



(a) 20 V (b) 30 V
(c) –10 V (d) 15 V

Q.4 If the current through a 0.1 H inductor is $i(t) = 10t\, e^{-5t}$ A, then the energy stored at t = 1 sec is

(a) 91×10^{-6} J
(b) 333×10^{-6} J
(c) 500×10^{-3} J
(d) 227×10^{-6} J

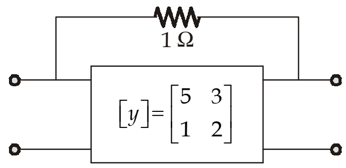
Q.5 A balance abc - sequence Y-connected source with $V_{an} = 100\angle 10°$ V is connected to a Δ-connected balanced load (8 + 4*j*) Ω per phase. The line current I_c is

(a) $33.54\angle 103.43°$ (b) $58.1\angle 103.43°$
(c) $19.36\angle -138.4°$ (d) $41.3\angle 133.43°$

Q.6 The *y*-parameters of a two-port network are

$$[y] = \begin{bmatrix} 5 & 3 \\ 1 & 2 \end{bmatrix} S$$

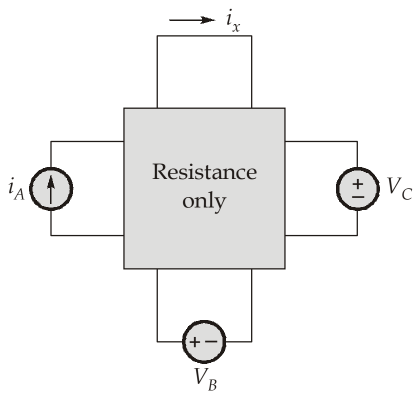
A resistor of 1 Ω is connected across as shown in figure below. The new *y*-parameter would be



(a) $\begin{bmatrix} 6 & 4 \\ 2 & 3 \end{bmatrix} S$ (b) $\begin{bmatrix} 6 & 2 \\ 0 & 3 \end{bmatrix} S$

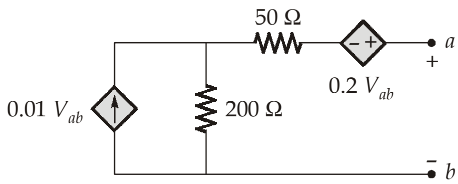
(c) $\begin{bmatrix} 5 & 4 \\ 2 & 2 \end{bmatrix} S$ (d) $\begin{bmatrix} 4 & 4 \\ 2 & 1 \end{bmatrix} S$

Q.7 With sources i_A and V_B on in the circuit of figure and $V_C = 0$, $i_x = 20$ A, with i_A and V_C on and $V_B = 0$, $i_x = -5$ and finally, with all three sources on, $i_x = 12$ A. If the only source V_B is operating, then the value of i_x is



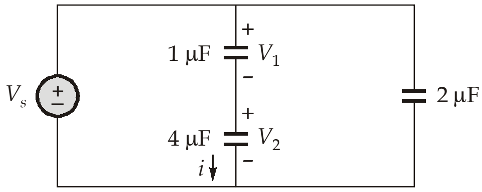
(a) 17 A (b) –8 A
(c) 32 A (d) 7 A

Q.8 The network circuit is shown figure, the value of R_{th} across the terminals a and b is



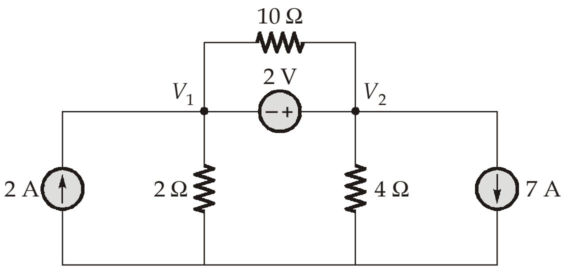
(a) –208.33 Ω (b) 192 Ω
(c) –152 Ω (d) 133.43 Ω

Q.9 For the circuit shown in figure, $v_s = 100e^{-80t}$ and $v_1(0) = 20$ V. The value of $V_1(t)$ for $t \geq 0$ is



(a) $-60\,e^{-80t} + 80$ V (b) $100\,e^{-80t} - 80$ V
(c) $80\,e^{-60t} - 60$ V (d) $80\,e^{-80t} - 60$ V

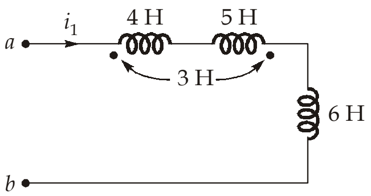
Q.10 For the circuit shown in figure, the node voltage V_2 is,



(a) -3.33 V (b) -7.33 V
(c) -5.33 V (d) -9.33 V

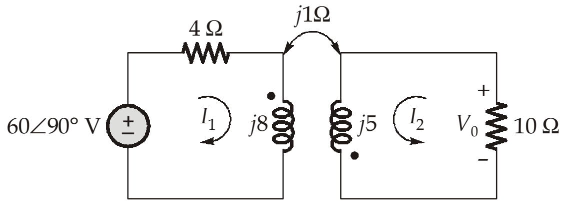
Q. No. 11 to Q. No. 30 carry 2 marks each

Q.11 If $i_1 = 2\cos 500t$ A in the network of given figure, then the value of the maximum energy stored in the network is



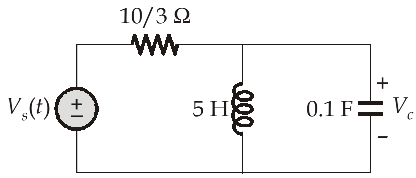
(a) 18 J (b) 16 J
(c) 6 J (d) 42 J

Q.12 For the circuit shown in figure, voltage V_0 across the 10 Ω resistance is



(a) $-6j$ (b) $+8j$
(c) $-16j$ (d) $9j$

Q.13 Consider the circuit shown in figure. Assume that at $t = 0$, –1 A flows through the inductor and +5 V is across the capacitor. If $V_s = 10\,u(t)$ V, then the value of the voltage across the capacitor is



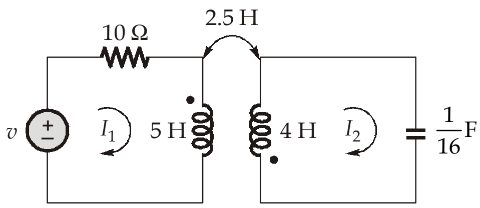
(a) $\left(25e^{-t} - 20e^{-2t}\right)u(t)\,\text{V}$

(b) $\left(17.5e^{-t} - 12.5e^{-2t}\right)u(t)\,\text{V}$

(c) $\left(30e^{t} - 25e^{2t}\right)u(t)\,\text{V}$

(d) $\left(35e^{-t} - 30e^{-2t}\right)u(t)\,\text{V}$

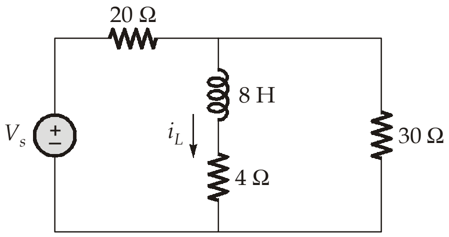
Q.14 The circuit shown in figure, if the voltage $v = 60\cos(4t + 30°)$ V, then the energy stored in the coupled inductors at time $t = 1s$, will be



(a) 20.5 J (b) 28.5 J
(c) 14.5 J (d) 42.5 J

Q.15 A parallel resonant circuit has impedance at $s = -50 \pm j1000s^{-1}$ and a zero at the origin. If C = 1 μF, then the value of L is
(a) 9.89 H (b) 0.997 H
(c) 99.79 H (d) 0.00997 H

Q.16 If $V_s = [-5 + 12\,u(t) + 3\,\delta(t)]$ V for the circuit shown. The expression of $i_L(t)$ for $t > 0$ is,



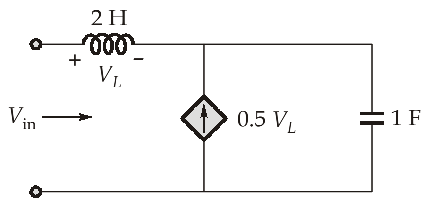
(a) $\left(\frac{21}{80} - \frac{3}{80}e^{-2t}\right)u(t)$

(b) $\left(\frac{31}{81} - \frac{21}{80}e^{-2t}\right)u(t)$

(c) $\left(\frac{51}{80} - \frac{31}{80}e^{-2t}\right)u(t)$

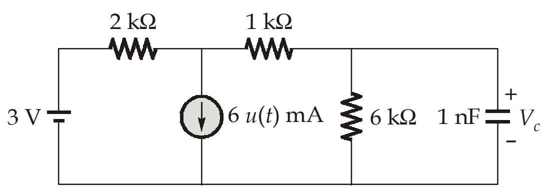
(d) $\left(\frac{3}{80} - \frac{21}{80}e^{-2t}\right)u(t)$

Q.17 The input admittance of the circuit represents a parallel combination of a resistance R and an inductance L. If $\omega = 1$ rad/s then the value of R and L is



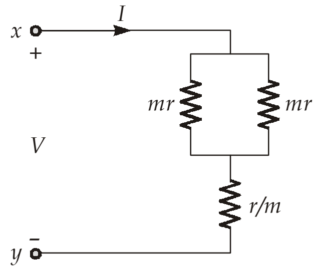
(a) $R = 0.5\ \Omega$, $L = 2$ H
(b) $R = 0.5\ \Omega$, $L = 0.5$ H
(c) $R = 2\ \Omega$, $L = 2$ H
(d) $R = 2\ \Omega$, $L = 0.5$ H

Q.18 A network circuit is shown below. The value of V_c at $t = 2\ \mu s$ is



(a) –3.06 V (b) 12.01 V
(c) –14.02 V (d) 6.07 V

Q.19 For the circuit current to be maximum the value of m will be



(a) $\sqrt{2}$ (b) $\sqrt{3}$
(c) $\sqrt{5}$ (d) $\sqrt{7}$

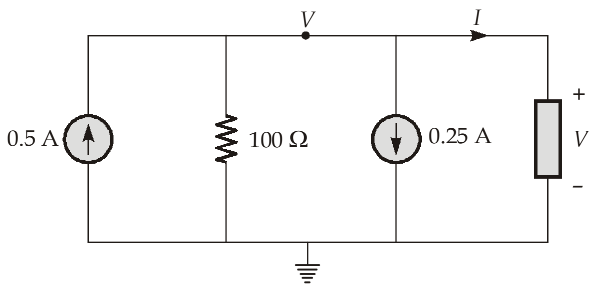
Q.20 A voltage waveform $v(t)$ can be expressed as,

$$v(t) = \begin{cases} 100(1 - e^{-10t})\ \text{V} & \text{for } 0 < t < 1 \\ 100\,e^{-10t}\ \text{V} & \text{for } 1 < t < 2 \end{cases}$$

The rms value of the voltage wave upto t = 2 is

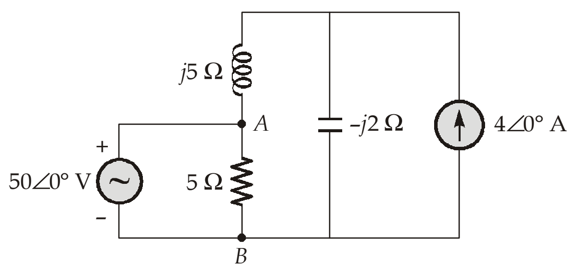
(a) 65.25 V (b) 35.75 V
(c) 31.25 V (d) 19.32 V

Q.21 The power absorbed by the unknown element, if 0.5 A source supplies 1 W to the circuit.



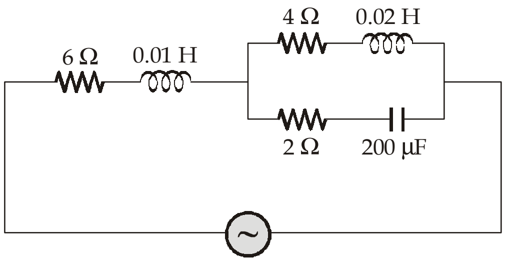
(a) 0.23 W (b) 0.46 W
(c) 0.69 W (d) 0.26 W

Q.22 The voltage V_{AB} for the network shown below:



(a) 0 V (b) 150∠0° V
(c) 50∠0° V (d) 200∠0° V

Q.23 For the circuit shown below:



The input power factor is ______.

(a) 0.899 (b) 0.86

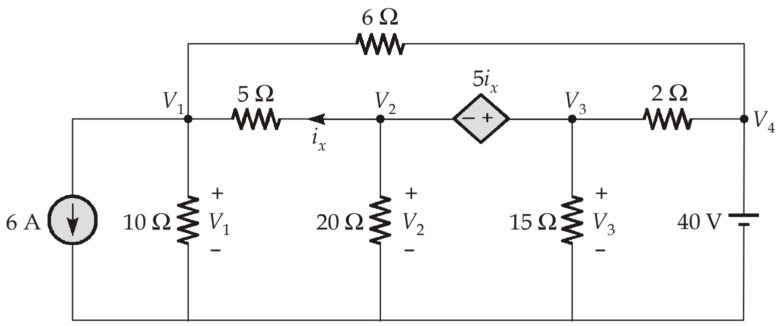
(c) 0.60 (d) 0.30

Q.24 The relative heating effects of two current waves (having same peak value), one sinusoidal and the other, rectangular in shape will be _______.

(a) 1 : 2 (b) $1:\sqrt{2}$

(c) $1:\sqrt{3}$ (d) 1 : 3

Q.25 For the circuit shown below.

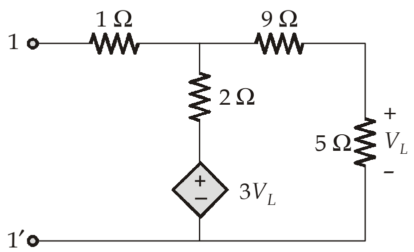


The node voltage V_3 will be _______ V.

(a) 20 V (b) 30 V

(c) 50 V (d) 40 V

Q.26 For the circuit shown below:



Thevenin's equivalent resistance of the circuit given from input terminal 1 – 1′ will be _____ Ω.

(a) 30 Ω (b) 29 Ω

(c) 28 Ω (d) 16 Ω

Q.27 A balanced 3-phase star-connected load draws 10 kW from a three-phase balanced systems of 400 V, 50 Hz while the line current is 75 A (leading power factor) then the capacitance of the load is ______ μF.

(a) 183 (b) 1083
(c) 3149 (d) 361

Q.28 A series RLC circuit resonate at 10 kHz, have a bandwidth of 1 kHz and draw 15.3 W from a 200 V generator operating at the resonant frequency of the current the capacitance of RLC circuit is

(a) 416 pF (b) 610 pF
(c) 2.61 pF (d) 201 pF

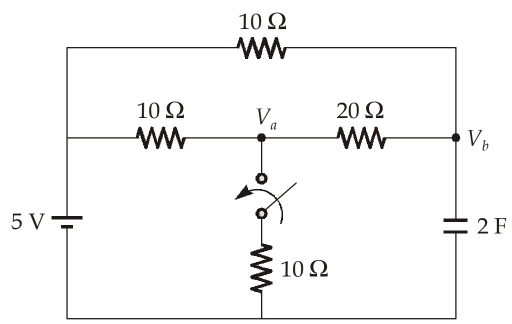
Q.29 A two-port network is described by the equations,

$V_1 = 5I_1 + 2I_2$ and $V_2 = 2I_1 + I_2$

A load impedance (resistive) of 3 Ω is connected at port 2, then the value of input impedance is ______ Ω.

(a) 2 Ω (b) 3 Ω
(c) 4 Ω (d) 5 Ω

Q.30 In the circuit shown below:



Steady state is reached with switch open. At $t = 0$, switch is closed then $V_a(0^+)$ is ______ V.

(a) 2 V (b) 3 V
(c) 5 V (d) 8 V

■■■■

CLASS TEST

Sl. : 01JPEE_29062024

MADE EASY

India's Best Institute for IES, GATE & PSUs

Delhi | Bhopal | Hyderabad | Jaipur | Pune | Kolkata

Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

ELECTRIC CIRCUITS

ELECTRICAL ENGINEERING

Date of Test : 29/06/2024

ANSWER KEY

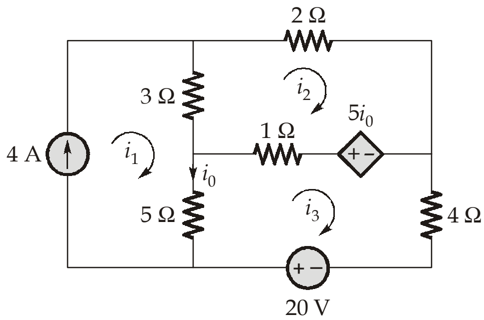
1.	(a)	7.	(a)	13.	(d)	19.	(a)	25.	(b)
2.	(a)	8.	(a)	14.	(a)	20.	(a)	26.	(b)
3.	(b)	9.	(d)	15.	(b)	21.	(b)	27.	(b)
4.	(d)	10.	(c)	16.	(a)	22.	(c)	28.	(b)
5.	(a)	11.	(a)	17.	(c)	23.	(b)	29.	(c)
6.	(b)	12.	(a)	18.	(a)	24.	(a)	30.	(b)

DETAILED EXPLANATIONS

1. (a)

$$\text{Energy stored maximum} = \frac{1}{2}L_{eq}i^2 = \frac{1}{2}\times 9\times 2^2 = 18\text{ J}$$

2. (a)



Apply mesh analysis,

$$i_1 = 4$$

$$i_0 = (i_1 - i_3) = 4 - i_3$$

$$3(i_2 - i_1) + 2i_2 - 5i_0 + (i_2 - i_3) = 0$$

$$6i_2 + 4i_3 = 32 \quad \text{...(i)}$$

$$1(i_3 - i_2) + 5i_0 + 4i_3 - 20 - 5i_0 = 0$$

$$5i_3 - i_2 = 20 \quad \text{...(ii)}$$

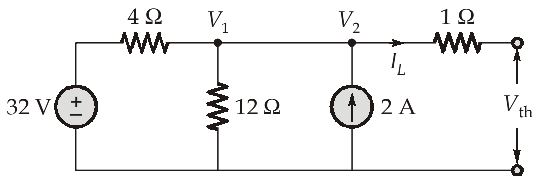
From equation (i) and (ii), we get

$$i_2 = 2.35\text{ A};$$

$$i_3 = 4.4705\text{ A}$$

$$i_0 = 4 - i_3 = -0.4705\text{ A}$$

3. (b)



Apply node analysis,

$$\frac{V_1 - 32}{4} + \frac{V_1}{12} - 2 = 0$$

$$V_1\left(\frac{1}{4} + \frac{1}{12}\right) = 10$$

$$V_1\left(\frac{4}{12}\right) = 10$$

$$V_1 = \frac{120}{4} = 30\text{ V}$$

The thevenin across *a*, *b* it is open circuited,

$$\therefore \quad V_{th} = V_1 = 30\text{ V}$$

4. (d)

$$i(t) = 10t\, e^{-5t}$$

$$\text{Energy stored, } E = \frac{1}{2}Li^2 = \frac{1}{2}\times 0.1 \times (10t\,e^{-5t})^2$$

$$= \frac{0.1}{2}\times 100t^2 e^{-10t} = 5t^2\, e^{-10t}$$

At $t = 1$ sec,
$$E_{1\text{ sec}} = 5 \times 1 \times e^{-10}$$

$$= \frac{5}{e^{10}} = 227 \times 10^{-6} = 227\ \mu\text{J}$$

5. (a)

$$Z_\Delta = (8 + 4j)\ \Omega$$

$$Z_Y = \frac{Z_\Delta}{3} = \left(\frac{8}{3} + \frac{4i}{3}\right)\Omega$$

$$V_{an} = 100\angle 10°\ \text{V}$$

$$V_{cn} = 100\angle 130°\ \text{V}$$

In star;
$$I_{c\text{ line}} = I_{c\text{ phase}} = \frac{100\angle 130°}{(8+4j)/3}$$

$$= 33.54\angle 103.43°\ \text{A}$$

6. (b)

y-parameters of 1 Ω resistor network are $\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$

New y-parameter,

$$= \begin{bmatrix} 5 & 3 \\ 1 & 2 \end{bmatrix} + \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 6 & 2 \\ 0 & 3 \end{bmatrix} S$$

7. (a)

Let,
$$i_x = i_{xA} + i_{xB} + i_{xC}$$

$$i_{xA} + i_{xB} = 20$$

$$i_{xA} + i_{xC} = -5$$

$$i_{xA} + i_{xB} + i_{xC} = 12$$

$$i_{xA} = 3\ \text{A};$$

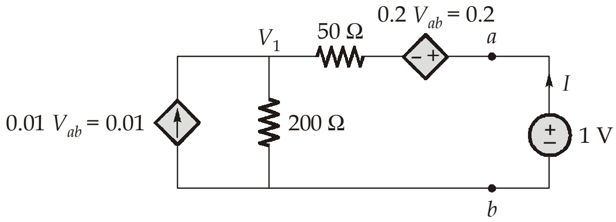
$$i_{xB} = 17\ \text{A};$$

$$i_{xC} = -8\ \text{A}$$

∴ if only source V_B is operating,

then
$$i_x = i_{xB} = 17\ \text{A}$$

8. (a)



$$0.01 = \frac{V_1}{200} + \frac{V_1 - 1 + 0.2}{50}$$

$$0.01 = \frac{V_1}{200} + \frac{V_1}{50} - 0.016$$

$$V_1 = 0.026 \times 40 = 1.04 \text{ V}$$

$$I = \frac{1 - 0.2 - 1.04}{50} = -0.0048 \text{ A}$$

$$R_{th} = \frac{V}{I} = \frac{1}{-0.0048} = -208.33\ \Omega$$

9. (d)

$$C_{eq} = 1 \,||\, 4 = \frac{4}{5} = 0.8\ \mu\text{F}$$

$$i = C_{eq}\frac{dv}{dt} = 0.8\frac{d}{dt}(100e^{-80t}) \times 10^{-6}$$

$$= 0.8 \times 100 \times (-80)e^{-80t} \times 10^{-6}$$

$$= -6.4\, e^{-80t} \text{ mA}$$

$$v_1(t) = \frac{1}{C_1}\int_0^t i\,dt + V_1(0)$$

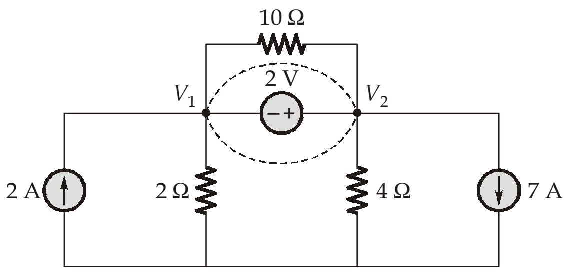
$$= \frac{1}{1 \times 10^{-6}}\int_0^t -6.4e^{-80t}\,dt \times 10^{-3} + 20$$

$$= \frac{-6.4}{10^{-3}} \times \left.\frac{e^{-80t}}{-80}\right|_0^t + 20$$

$$v_1(t) = 80(e^{-80t} - 1) + 20$$

$$= (80e^{-80t} - 60) \text{ V}$$

10. (c)



Using supernode method,

$$-2+\frac{V_1}{2}+\frac{V_2}{4}+7 = 0$$

$$2V_1 + V_2 = -20$$

$$V_1 - V_2 = -2$$

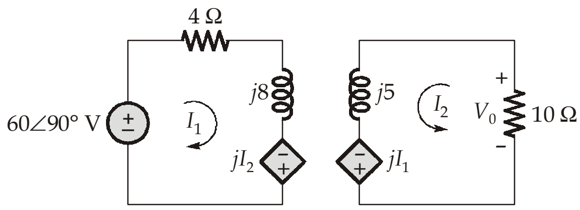
$$V_1 = -7.33 \text{ V}$$

$$V_2 = -5.33 \text{ V}$$

11. (a)

$$\text{Energy stored maximum} = \frac{1}{2}L_{eq}i^2 = \frac{1}{2}\times 9\times 2^2 = 18 \text{ J}$$

12. (a)



Apply KVL,

$$(10 + j5)I_2 - jI_1 = 0$$

$$I_1 = \frac{(10+j5)}{j}I_2 = (5-10j)I_2$$

$$-60j + (4 + 8j)I_1 - jI_2 = 0$$

$$(4 + 8j)(5 - 10j)I_2 - jI_2 = 60j$$

$$I_2 = 0.6\angle 90°$$

$$V_0 = -10 \times I_2$$

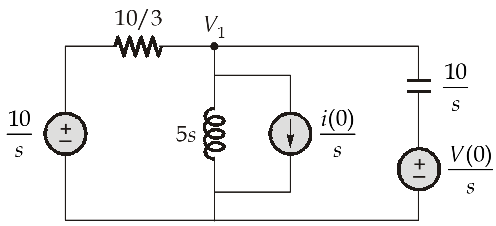
$$= -10 \times 0.6j = -6j$$

13. (d)

$$i(0) = -1 \text{ A}$$

$$V(0) = 5 \text{ V}$$

Apply node analysis



$$\frac{\left(V_1-\frac{10}{s}\right)}{\frac{10}{3}}+\frac{V_1}{5s}-\frac{1}{s}+\frac{\left(V_1-\frac{5}{s}\right)}{\left(\frac{10}{s}\right)} = 0$$

$$V_1\left(\frac{3}{10}+\frac{1}{5s}+\frac{s}{10}\right)-\frac{10\times 3}{s\times 10}-\frac{1}{s}-\frac{5}{s}\times\frac{s}{10} = 0$$

$$V_1\left(\frac{3s+2+s^2}{10s}\right) = \left(\frac{3}{s}+\frac{1}{s}+\frac{0.5s}{s}\right)$$

$$V_1 = \frac{10s}{(s^2+3s+2)}\times\frac{(0.5s+4)}{s}$$

$$V_1 = \frac{(5s+40)}{s^2+3s+2} = \frac{5(s+8)}{(s+1)(s+2)}$$

$$V_1 = 5\left(\frac{7}{s+1}-\frac{6}{s+2}\right)$$

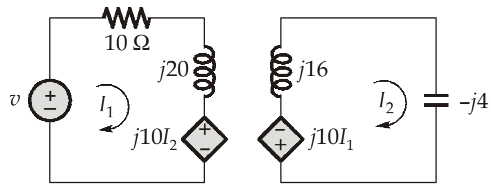
$$v_1(t) = \left(35e^{-t}-30e^{-2t}\right)u(t)$$

14. (a)

$$X_{L1} = j\omega L = j4 \times 5 = j20\ \Omega$$
$$X_{L2} = j\omega L_2 = j4 \times 4 = j16\ \Omega$$

$$X_C = \frac{1}{j\omega C} = \frac{16}{j4\times 1} = -j4\Omega$$

$$X_m = j\omega M = j \times 4 \times 2.5 = j10\ \Omega$$



$$-60\angle 30° + (10+20j)I_1 + j10I_2 = 0 \quad ...(i)$$

$$(j16-j4)I_2 + j10I_1 = 0$$

$$I_1 = -1.2I_2 \quad ...(ii)$$

$$-(10+j20)\times 1.2I_2 + j10I_2 = 60\angle 30°$$

$$I_2 = 3.25\angle 160.6\ \text{A}$$

$$I_2 = 3.25\cos(4t+160.6°)$$

$$I_1 = 3.9\cos(4t-19.4°)$$

At $t = 1$ sec, $4t = 4\text{ rad} = 229.18°$

$$I_2 = 2.82\ \text{A}$$

$$I_1 = -3.38\ \text{A}$$

Total energy stored in the coupled inductor is

$$E = \frac{1}{2}L_iI_i^2 + \frac{1}{2}L_2I_2^2 + MI_1I_2$$

$$E = \frac{1}{2}\times 5\times(-3.38)^2 + \frac{1}{2}\times 4\times(2.82)^2 - 2.5\times 3.38\times 2.82 = 20.5\ \text{J}$$

15. (b)

$$\text{T.F.} = \frac{s}{(s+50)^2+(1000)^2} = \frac{s}{s^2+100s+100.25\times 10^4}$$

$$s^2+\frac{1}{RC}s+\frac{1}{LC} = 0$$

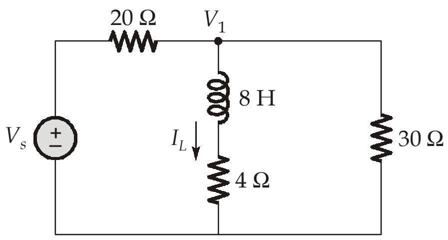
$$\frac{1}{RC} = 100;$$

$$\frac{1}{LC} = 100.25\times 10^4 = \frac{1}{L\times 1\times 10^{-6}}$$

$$L = 0.9975\text{ H}$$

16. (a)

$$V_S(s) = \frac{-5}{s}+\frac{12}{s}+3 = \left(\frac{7}{s}+3\right)$$



$$\frac{(V_1-V_s)}{20}+\frac{V_1}{8s+4}+\frac{V_1}{30} = 0$$

$$V_1\left(\frac{1}{20}+\frac{1}{8s+4}+\frac{1}{30}\right) = \frac{1}{20}\left(\frac{7+3s}{s}\right)$$

$$V_1\left(\frac{24s+12+60+16s+8}{60(8s+4)}\right) = \frac{1}{20s}(7+3s)$$

$$V_1 = \frac{7+3s}{20s}\times\frac{60(8s+4)}{(40s+80)}$$

$$= \frac{3}{s}\frac{(7+3s)(8s+4)}{(40s+80)}$$

$$I_L = \frac{3}{s}\frac{(7+3s)(8s+4)}{(40s+80)(8s+4)} = \frac{3}{s}\times\frac{(7+3s)}{40(s+2)}$$

$$I_L = \frac{3}{40}\left[\frac{7}{2s}+\frac{-1}{2(s+2)}\right]$$

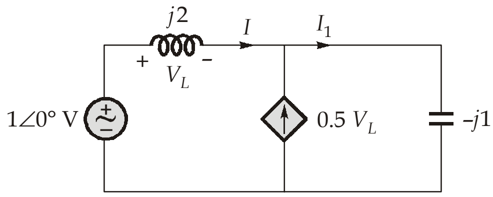
$$i_L(t) = \frac{3}{40}\left(\frac{7}{2}-\frac{1e^{-2t}}{2}\right)u(t)$$

$$i_L(t) = \left(\frac{21}{80}-\frac{3}{80}e^{-2t}\right)u(t)$$

17. (c)

$$X_L = \omega L = 2$$

$$X_C = \frac{1}{1} = 1$$



$$I = 0.5\ V_L + I_1$$
$$= -0.5 \times (j2)I + I_1$$
$$I = -jI + I_1$$

$$I(1 + j) = \frac{(1 - j2I)}{-j1}$$

$$I(-j + 1) = (1 - j2I)$$
$$I(1 + j) = 1$$

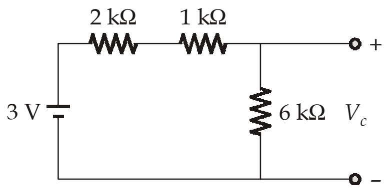
$$I = \left(\frac{1}{2} - \frac{j}{2}\right)$$

$$Y_{in} = I \times 1 = \left(\frac{1}{2} + \frac{1}{j2}\right) s$$

$$R = 2,\ L = 2$$

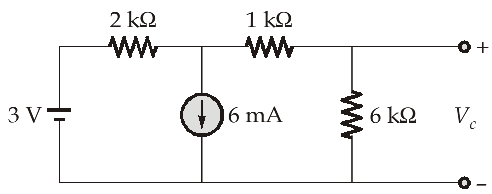
18. (a)

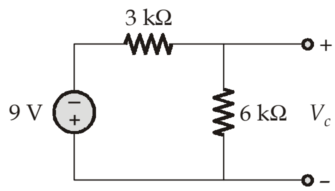
At $t < 0$,



$$V_c(0^-) = 3 \times \frac{6}{(6+3)} = \frac{18}{9} = 2\ \text{V}$$

At $t > 0$,





$$v_c(\infty) = \frac{6}{9}\times(-9) = -6 \text{ V}$$

$$v_c(t) = -6 + (2 + 6)e^{-t/\tau}$$

$$\tau = \frac{18}{9}\times 1 = 2\ \mu\text{s}$$

$$V_c(t) = -6 + 8e^{-\frac{t}{2}}$$

$$V_c(2\ \mu\text{s}) = -6 + 8e^{-1} = -3.06 \text{ V}$$

19. (a)

The equivalent resistance across x-y is

$$R_{x\text{-}y} = \frac{mr}{2}+\frac{r}{m} = \frac{m^2r+2r}{2m}$$

It may be noted that I will be maximum when $R_{x\text{-}y}$ will be minimum,

$$\frac{\delta R_{x-y}}{\delta m} = 0$$

i.e., $2m\,(2mr) - 2(m^2r + 2r) = 0$

i.e., $m = \sqrt{2}$

20. (a)

$$(V_{\text{rms}})^2 = \frac{1}{T}\left[\int_0^{t_1} v^2 dt + \int_{t_1}^{T} v^2 dt\right]$$

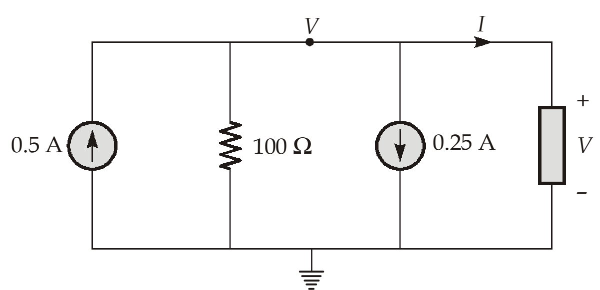
$$= \frac{1}{2}\left[\int_0^1 10^4(1-2e^{-10t}+e^{-20t})\,dt + \int_1^2 10^4 e^{-20t}\,dt\right]$$

$$= (5000)\left[[(t+0.2e^{-10t}-0.05e^{-20t})\Big|_0^1 - \left(\frac{1}{20}\right)e^{-20t}\Big|_1^2\right]$$

$$= (5000)\ [1 + 0.2e^{-10} - 0.2 + 0.05 - 0.05\ e^{-40}]$$

$\therefore$ $V_{\text{rms}} = 65.25 \text{ V}$

21. (b)



Voltage across 0.5 A current source is

$$V = \frac{\text{Power}}{\text{Current}} = \frac{1\text{ W}}{0.5\text{ A}} = 2\text{ V}$$

Applying nodal analysis at node

$$0.5 = \frac{V}{100} + 0.25 + I$$

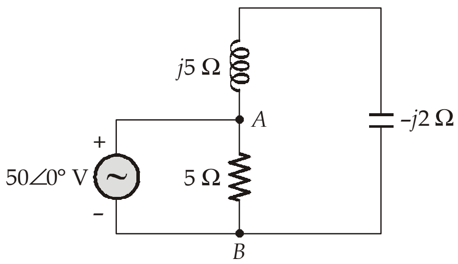
$$0.5 = \frac{2}{100} + 0.25 + I$$

$$I = 0.23\text{ A}$$

Power absorbed by unknown element = 0.23 × 2 = 0.46 W

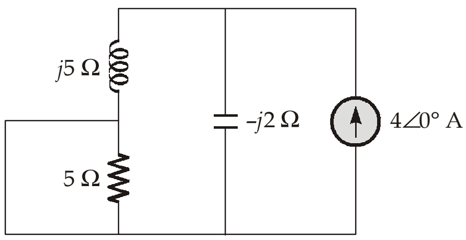
22. (c)

Step-I: When the 50∠0° V source is acting alone.



$$V'_{AB} = 50\angle 0° + 0\text{ V} = 50\angle 0°\text{ V}$$

Step-II: When the 4∠0° A source is acting alone.



$$V''_{AB} = 0\text{ V}$$

By superposition theorem, $V_{AB} = V'_{AB} + V''_{AB}$

$$= 50\angle 0° = 50\angle 0°\text{ V}$$

23. (b)

$$X_{L1} = 2\pi \times 50 \times 0.01 = 3.14\ \Omega$$
$$X_{L2} = 2\pi \times 50 \times 0.02 = 6.28\ \Omega$$

$$X_C = \frac{1}{2\pi \times 50 \times 200 \times 10^{-6}} = 15.92\ \Omega$$

$$\bar{Z}_1 = 6 + j3.14\ \Omega$$

$$\bar{Z}_2 = 4 + j6.28\ \Omega$$

$$\bar{Z}_3 = 2 - j15.92\ \Omega$$

$$\bar{Z} = \bar{Z}_1 + \frac{\bar{Z}_2\,\bar{Z}_3}{\bar{Z}_2 + \bar{Z}_3}$$

$$= (6+j3.14) + \frac{(4+j6.28)\,(2-j15.92)}{(4+j6.28)+(2-j15.92)} = 17.27\angle 30.75°\ \Omega$$

Power factor $= \cos\phi = \cos(30.75°) = 0.86$ (lagging)

24. **(a)**

RMS value of the rectangular wave = I_m

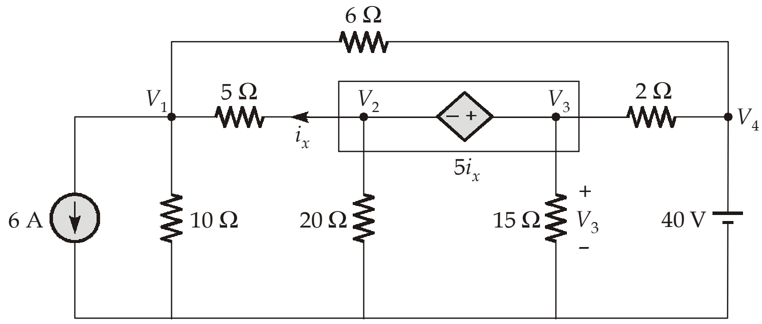
RMS value of sinusoidal current wave = $\dfrac{I_m}{\sqrt{2}}$

Heating effect due to rectangular current wave = $I_m^2 RT$

Heating effect due to sinusoidal current wave = $\left(\dfrac{I_m}{\sqrt{2}}\right)^2 RT$

$$\text{Relative heating effects} = \left(\frac{I_m}{\sqrt{2}}\right)^2 RT : I_m^2\, RT = 1:2$$

25. **(b)**



Nodes 2 and 3 form a super node:

$$V_3 = 5i_x + V_2$$

$$= 5\left[\left(\frac{V_2 - V_1}{5}\right)\right] + V_2 = 2V_2 - V_1$$

Applying KCL at node 1,

$$6 + \frac{V_1}{10} + \frac{V_1 - V_2}{5} + \frac{V_1 - V_4}{6} = 0$$

$$6 + \frac{V_1}{10} + \frac{V_1}{5} - \frac{V_2}{5} + \frac{V_1 - 40}{6} = 0$$

$$\frac{7}{15}V_1 - \frac{1}{5}V_2 = \frac{2}{3} \qquad \ldots(3)$$

Applying KCL for the super node:

$$\frac{V_2 - V_1}{5} + \frac{V_2}{20} + \frac{V_3}{15} + \frac{V_3 - V_4}{2} = 0$$

$$\frac{V_2 - V_1}{5} + \frac{V_2}{20} + \frac{(2V_2 - V_1)}{15} + \frac{(2V_2 - V_1) - 40}{2} = 0$$

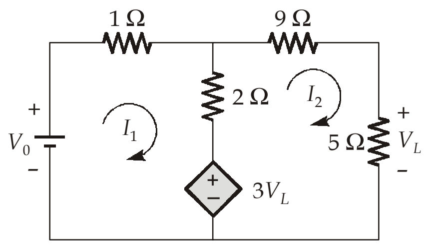
$$-\frac{23}{30}V_1 + \frac{83}{60}V_2 = 20 \quad \text{...(4)}$$

Solving equation (3) and (4),

$$V_1 = 10 \text{ V}$$
$$V_2 = 20 \text{ V}$$
$$V_3 = 2V_2 - V_1$$
$$= 40 - 10 = 30 \text{ V}$$

26. (b)

Let us apply a voltage source V_0 at the input terminals such that the current in the loops be I_1 and I_2.



Obviously, $V_L = R_L I_2 = 5I_2$

∴ The dependent voltage source is $3V_L = 15I_2$

Again applying KVL in loop-1,

$$V_0 = 3I_1 + 15I_2 - 2I_2$$
$$= 3I_1 + 13I_2 \quad \text{...(1)}$$

In loop-2,

$$0 = -2I_1 + (2 + 9 + 5)\, I_2 - 3V_L$$
$$0 = -2I_1 + 16I_2 - 15I_2$$
$$I_2 = 2I_1 \quad \text{...(2)}$$
$$V_0 = 3I_1 + 13 \times 2I_1$$
$$V_0 = 29I_1$$
$$\frac{V_0}{I_1} = R_{\text{input}} = 29\ \Omega$$

27. (b)

$$Z_{ph} \text{ (Phase impedance)} = \frac{V_{ph}}{I_{ph}} = \frac{400}{75\sqrt{3}} = 3\ \Omega$$

$$\left[\text{In star connection } I_{ph} = I_{\text{line}}, V_{ph} = \frac{V_L}{\sqrt{3}}\right]$$

$$\frac{\text{Power}}{\text{Phase}} = I_{ph}^2 R_{ph}$$

$$\frac{10 \times 10^3}{3} = (75)^2 R_{ph}$$

$\therefore \quad R_{ph} = \frac{10\times1000}{3\times75\times75} = 0.6\ \Omega$

$\therefore \quad X_{ph} = \sqrt{Z_{ph}^2 - R_{ph}^2} = \sqrt{3^2-(0.6)^2} = 2.94\ \Omega$

As the current is leading, X_{ph} must be capacitive.

$\therefore \quad X_c = 2.94\ \Omega$

or, $\quad \frac{1}{\omega C} = 2.94\ \Omega$

$\therefore \quad C = \frac{1}{2.94\times2\pi f} = \frac{1}{2.94\times2\times\pi\times50} = 1083\ \mu F$

28. (b)

For a series RLC circuit operating at resonance,

$$V_R = V = 200\ V$$

$$P_R = \frac{V^2}{R}$$

$$15.3 = \frac{(200)^2}{R}$$

$$R = \frac{200\times200}{15.3} = 2.61\ k\Omega$$

$$Q = \frac{f_0}{\Delta f} = \frac{10}{1} = 10$$

Now, $\quad Q = \frac{\omega_0 L}{R}$

$$10 = \frac{2\pi(10^4)(L)}{2.61\times10^3}$$

$\therefore \quad L = 416\ mH$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$10^4 = \frac{1}{2\pi\sqrt{416\times10^{-3}C}}$$

$$C = 610\ pF$$

29. (c)

$V_1 = 5I_1 + 2I_2 \quad \text{...(1)}$

$V_2 = 2I_1 + I_2 \quad \text{...(2)}$

and $\quad V_2 = -I_2R_L = -3I_2 \quad \text{...(3)}$

From equation (2) and (3),

$$-3I_2 = 2I_1 + I_2$$

or, $\quad -4I_2 = 2I_1$

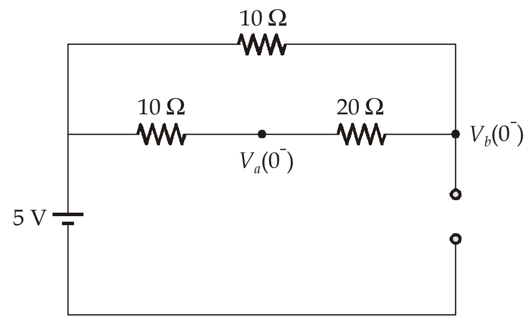
$$I_2 = -\frac{I_1}{2} \text{ put this value in equation (1)}$$

$$V_1 = 5I_1 + 2\left(-\frac{I_1}{2}\right) = 4I_1$$

$$\therefore \quad Z_{in} = \frac{V_1}{I_1} = 4\ \Omega$$

30. (b)

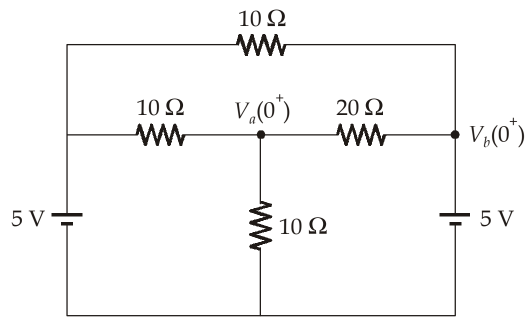
At $t = 0^-$, the network attains steady state condition. Hence, the capacitor acts as an open-circuit.



$$V_b(0^-) = 5\text{ V}$$

At $t = 0^+$, the capacitor acts as a voltage source of 5 V,

$$V_b(0^+) = 5\text{ V}$$



Writing KCL equation at $t = 0^+$

$$\frac{V_a(0^+) - 5}{10} + \frac{V_a(0^+)}{10} + \frac{V_a(0^+) - 5}{20} = 0$$

$$0.25\ V_a(0^+) = 0.75$$

$$V_a(0^+) = 3\text{ V}$$

■■■■