K. K. Wagh Institute of Engineering Education and Research, Nashik

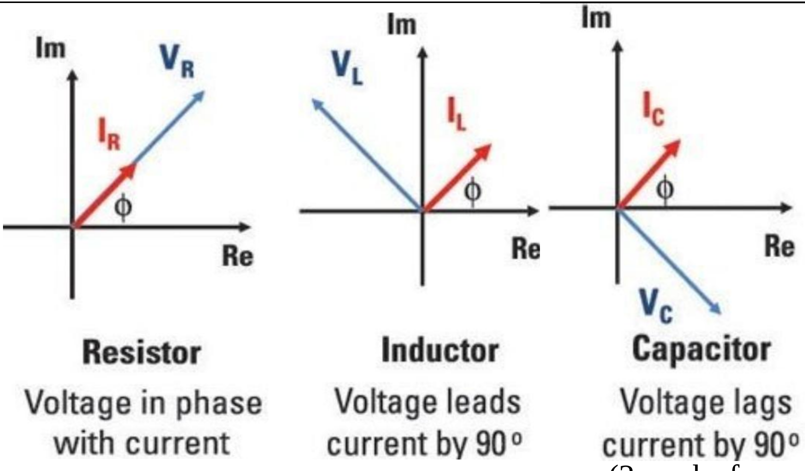
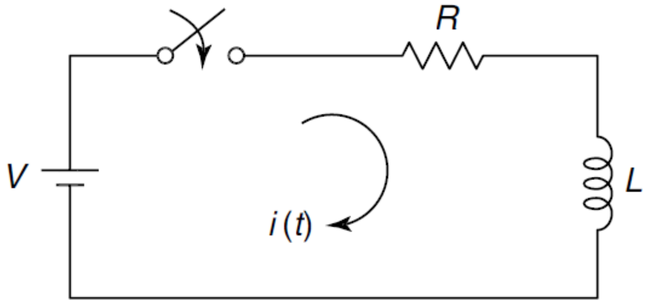
(An Autonomous Institute from A. Y. 2022-23)

Model Answer

End-Sem Examination-I, Winter 2025

Academic Year: 2025-2026	Semester: I
Class: FY	Program: BTech
Branch Code: ETC	Pattern: 2023
Name of Course: Electrical Network	Course Code: 2300118E

Q. No.		Answer Details	Max. Marks
Q.1.		**Voltage Source to Current Source Conversion** An ideal voltage source with a series resistance can be converted into an equivalent current source with a parallel resistance. Voltage Source Representation: • Voltage Source (V_s): The value of the voltage source. • Series Resistance (R_s): The resistance in series with the voltage source. Current Source Representation: • Current Source (I_s): The value of the current source. • Parallel Resistance (R_P): The resistance in parallel with the current source. The relationships are: $I_s = \frac{V_s}{R_s}$, $R_P = R_s$ (3 marks) **Current Source to Voltage Source Conversion** An ideal current source with a parallel resistance can be converted into an equivalent voltage source with a series resistance. current Source Representation: • Current Source (I_s): The value of the current source. • Parallel Resistance (R_P): The resistance in parallel with the current source. Voltage Source Representation: • Voltage Source (V_s): The value of the voltage source. • Series Resistance (R_s): The resistance in series with the voltage source. The relationships are: $V_s = I_s R_P$, $R_s = R_P$ (3 marks)	[12]
Q.2.			

		 (2 marks for each phasor diagram)	
Q.3.	A	The Laplace transform is a mathematical tool that is used to convert the differential equation in the time domain into the algebraic equations in the **frequency domain** or **s-domain.** Mathematically, if $x(t)$ is a time domain function, then its Laplace transform is defined as − $$\mathcal{L}[x(t)] = X(s) = \int_0^{\infty} x(t)e^{-st}dt$$ where, s is a complex **frequency domain parameter,** $\boldsymbol{s = \sigma + j\omega}$, with **real numbers** $\boldsymbol{\sigma}$ **(>0) and** $\boldsymbol{\omega}$. The function **must satisfy** the following condition for its transform to exist: $$\int_0^{\infty} \lvert x(t)\rvert e^{-\sigma t}dt < \infty$$ (4 marks) . $f(t) = e^{-at},\ or,\ e^{-at}u(t)$ $$\mathcal{L}[f(t)] = F(s) = \int_0^{\infty} e^{-at}.e^{-st}dt = \int_0^{\infty} e^{-(s+a)t}dt = \left.\frac{e^{-(s+a)t}}{-(s+a)}\right\|_{t=0}^{t\to\infty}$$ $$= -\frac{1}{(s+a)}\left[\left(e^{-(s+a)t}\right)_{t\to\infty} - \left(e^{-(s+a)t}\right)_{t=0}\right] = \frac{1}{(s+a)}$$ (4 marks)	[8]
	B	 When the switch is closed at t=0, current i(t) starts flowing through the resistor	[8]

and inductor. The KVL equation becomes:

$$V = i(t)R + L\frac{di}{dt}$$ (1 marks)

In Laplace domain, this becomes
$V/s = I(s)R + LsI(s)$ as the inductor is relaxed initially.

$$V(s) = I(s)(R + Ls)$$

(1 marks)

$$I(s) = \frac{1}{s}\frac{V}{(R+Ls)} = \frac{1}{s}\frac{V/L}{(R/L+s)} = \frac{A}{s} + \frac{B}{s+\frac{R}{L}}$$

Solving for A and B, we get

$$A = sI(s)|_{s=0} = \left.\frac{V/L}{(s+R/L)}\right|_{S=0} = \frac{V/L}{R/L} = \frac{V}{R}$$

$$B = (s + R/L)I(s)\big|_{s=-R/L} = \frac{V/L}{-R/L} = -\frac{V}{R}$$

(4 marks)

So, $I(s) = \frac{V/R}{s} + \frac{-V/R}{s+R/L}$

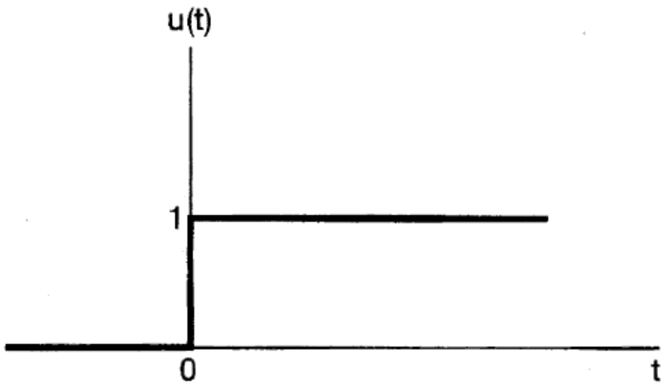
Taking inverse Laplace, we get

$$i(t) = \frac{V}{R}\left(1 - e^{-\frac{R}{L}t}\right)u(t)$$

(2 marks)

	C	$$I(s) = \frac{1}{s}\,\frac{a/b}{(s + c/d)}$$ Using partial fraction expansion, $$I(s) = \frac{1}{s}\,\frac{a/b}{(s + c/d)}$$ $$= \frac{A}{s} + \frac{B}{s + c/d}$$ (2 marks) Solving for A and B, $$sI(s) = A + \frac{Bs}{s + c/d}$$ $$A = sI(s)\big\|_{s=0} = \frac{a/b}{(s + c/d)}\Big\|_{S=0} = \frac{a/b}{c/d} = \frac{ad}{bc}$$ $$(s + c/d)I(s) = \frac{A(s + \frac{c}{d})}{s} + B$$ $$B = (s + c/d)I(s)\big\|_{s=-c/d} = \frac{a/b}{-c/d} = \frac{-ad}{bc}$$ (4 marks) So, $I(s) = \frac{\frac{ad}{bc}}{s} + \frac{\frac{-ad}{bc}}{s+c/d}$ Taking inverse Laplace, we get $$i(t) = \frac{ad}{bc}\left(1 - e^{-\frac{c}{d}t}\right) u(t)$$ (2 marks)	[8]
	D	The unit-step function, denoted by $u(t)$, is a piecewise function that is zero for negative time and one for zero or positive time. The unit-step function is defined as: $$u(t) = \begin{cases} 1 & t > 0 \\ 0 & otherwise \end{cases}$$ (4 marks)	[8]

<table>
<tr>
<td></td>
<td></td>
<td>



It may be noted that the unit-step is discontinuous at t=0.

(4 marks)

Laplace Transform of the Unit-Step Function
The Laplace transform of the unit-step function can be found using the definition of the Laplace transform:

$$\mathcal{L}[u(t)] = \int_0^\infty u(t)e^{-st}\,dt = \int_0^\infty e^{-st}\,dt = \left.\frac{e^{-st}}{-s}\right|_0^\infty = 0 - \left(-\frac{1}{s}\right) = \frac{1}{s}$$

(4 marks)

</td>
<td></td>
</tr>
<tr>
<td>Q.4.</td>
<td>A</td>
<td>

The **short-circuit admittance parameters**, also known as Y-parameters, are used to describe the electrical behavior of linear two-port networks using admittance (the inverse of impedance).
These parameters are particularly useful when dealing with high-frequency circuits and can be measured when all ports are short-circuited except the one where the measurement is taken.

(2 marks)

For a two-port network with input port (1) and output port (2), the Y-parameters are defined as follows:

- y_{11}: Input admittance with output port short-circuited.
- y_{12}: Reverse transfer admittance with input port short-circuited.
- y_{21}: Forward transfer admittance with output port short-circuited.
- y_{22}: Output admittance with input port short-circuited.

(2 marks)

Currents I_1 and I_2 are related to voltages V_1 and V_2 as:

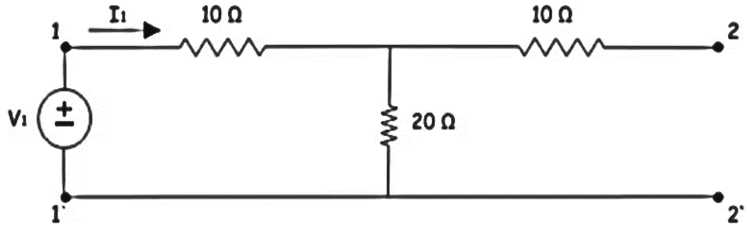
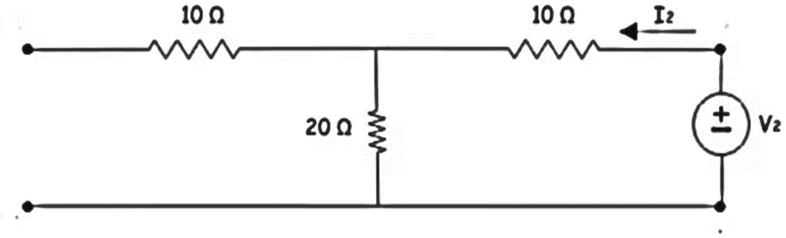
$$I_1 = y_{11}V_1 + y_{12}V_2$$
$$I_2 = y_{21}V_1 + y_{22}V_2$$

Which is represented in matrix form as:

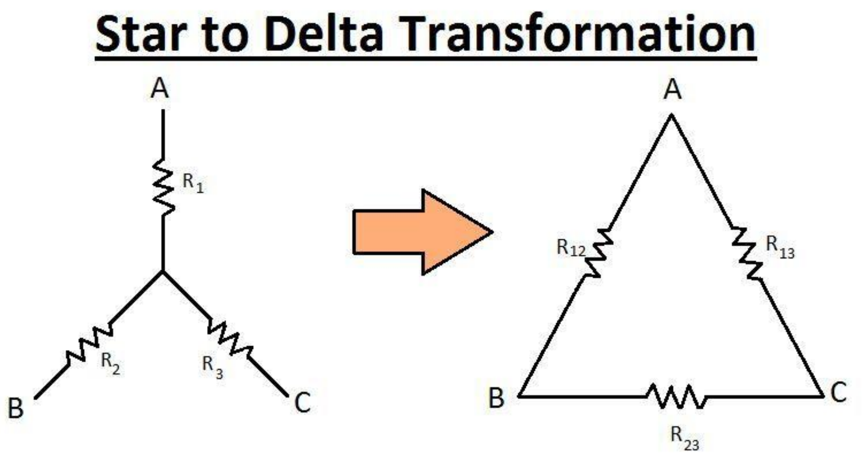
$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

(4 marks)

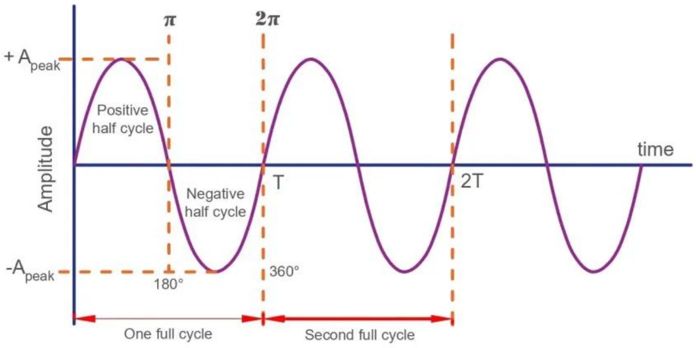
</td>
<td>[8]</td>
</tr>
</table>

	B	Steps for z-parameters : 1. Connect a supply V_1 at port 1, to make a current I_1 flow at port 1-1'  This gives, $I_1 = \frac{V_1}{30}, \quad V_2 = 20I_1$ $z_{11} = \left(\frac{V_1}{I_1} \mid I_2 = 0\right) = 30\ \Omega$ $z_{21} = \left(\frac{V_2}{I_1} \mid I_2 = 0\right) = 20\ \Omega$ 2. Connect a supply V_2 at port 2, to make a current I_2 flow at port 2-2'.  $I_2 = \frac{V_2}{30}, \quad V_1 = 20I_2$ $z_{12} = \left(\frac{V_1}{I_2} \mid I_1 = 0\right) = 20\ \Omega$ $z_{22} = \left(\frac{V_2}{I_2} \mid I_1 = 0\right) = 30\ \Omega$ (4 marks) Now convert z-parameters to y-parameters as $\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} \frac{z_{22}}{z_{11}z_{22} - z_{12}z_{21}} & \frac{-z_{12}}{z_{11}z_{22} - z_{12}z_{21}} \\ \frac{-z_{21}}{z_{11}z_{22} - z_{12}z_{21}} & \frac{z_{11}}{z_{11}z_{22} - z_{12}z_{21}} \end{bmatrix}$ $\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} \frac{30}{900 - 400} & \frac{-20}{900 - 400} \\ \frac{-20}{900 - 400} & \frac{30}{900 - 400} \end{bmatrix}$ $\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} 0.06 & -0.04 \\ -0.04 & 0.06 \end{bmatrix} \Omega^{-1}$ (4 marks)	[8]
	C	**Hybrid parameters**, or **h-parameters**, are used to describe the behavior of linear two-port networks, often in transistor modeling and small-signal analysis. The term "hybrid" comes from the fact that these parameters are a mix of impedance, admittance, and dimensionless ratios, making them versatile for various applications.	[8]

		The h-parameters are defined as follows: • h_{11}: Input impedance with output port short-circuited • h_{12}: Reverse voltage gain with input port open-circuited • h_{21}: Forward current gain with output port short-circuited • h_{22}: Output admittance with input port open-circuited The relationship between the voltages and currents in terms of h-parameters is given by: $V_1 = h_{11}I_1 + h_{12}V_2, \qquad I_2 = h_{21}I_1 + h_{22}V_2$ $\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$ (4 marks) where: • h_{11}: Input impedance with output short-circuited $(V_2 = 0)$. $h_{11} = \left. \frac{V_1}{I_1} \right\|_{V_2=0}$ • h_{12}: Reverse voltage gain with input open-circuited $(I_1 = 0)$. $h_{12} = \left. \frac{V_1}{V_2} \right\|_{I_1=0}$ • h_{21}: Forward current gain with output short-circuited $(V_2 = 0)$. $h_{21} = \left. \frac{I_2}{I_1} \right\|_{V_2=0}$ • h_{22}: Output admittance with input open-circuited $(I_1 = 0)$. $h_{22} = \left. \frac{I_2}{V_2} \right\|_{I_1=0}$ (4 marks)	

	D	$Z = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ $\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} \frac{z_{22}}{z_{11}z_{22} - z_{12}z_{21}} & \frac{-z_{12}}{z_{11}z_{22} - z_{12}z_{21}} \\ \frac{-z_{21}}{z_{11}z_{22} - z_{12}z_{21}} & \frac{z_{11}}{z_{11}z_{22} - z_{12}z_{21}} \end{bmatrix}$ $\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} \frac{4}{1*4-2*3} & \frac{-2}{1*4-2*3} \\ \frac{-3}{1*4-2*3} & \frac{1}{1*4-2*3} \end{bmatrix}$ $= \begin{bmatrix} \frac{4}{-2} & \frac{-2}{-2} \\ \frac{-3}{-2} & \frac{1}{-2} \end{bmatrix} = \begin{bmatrix} -2 & 1 \\ 1.5 & 0.5 \end{bmatrix} \Omega^{-1}$	[8]
Q.5	A	 $\boldsymbol{R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3}}$ $\boldsymbol{R_{13} = R_1 + R_3 + \frac{R_1 R_3}{R_2}}$ $\boldsymbol{R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1}}$ (2 marks for figure) (2 marks for each equation)	[8]

B



Average Value = Area under one cycle= $v_{avg} = \frac{1}{2\pi}\int_0^{2\pi} v\, d(\omega t) = 0$

RMS or Effective Value = $v_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} v^2 d(\omega t)} = \frac{A_{peak}}{\sqrt{2}}$

(2 marks for figure)
(3 marks for each equation)

[8]

C

The **impulse function**, often denoted by $\delta(t)$, is a mathematical function with unique properties that make it useful in signal processing, control systems, and communications. The impulse function, also known as the Dirac delta function, is not a traditional function but rather a generalized function or "distribution" that is used to model an idealized instantaneous impulse.

Definition of Impulse Function

The impulse function $\delta(t)$ is defined by the following properties:

1. It is zero everywhere except at $t = 0$.
2. The area under $\delta(t)$ is equal to 1, i.e.,

$$\int_{-\infty}^{\infty} \delta(t)\, dt = 1$$

3. It represents an infinitely high, infinitely narrow spike at $t = 0$, with an area of 1, which is useful for modeling instantaneous events.

In practical terms, the impulse function is often used to "sample" a value of another function at a specific point in time, which is fundamental in systems analysis.

(4 marks)

Important properties of $\delta(t)$:

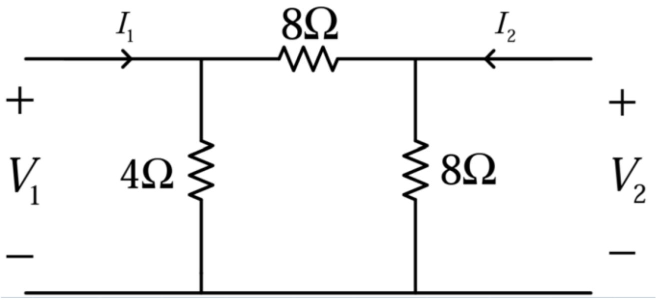
1. $\int_{-\infty}^{\infty} \delta(t)\, dt = 1$
2. Total area under $\delta(t) = 1$
3. The function has zero value everywhere els
4. $\int_{-\infty}^{\infty} f(t)\delta(t)\, dt = f(0)$
5. $\int_{-\infty}^{\infty} f(t)\delta(t-a)\, dt = f(a)$

Total

(4 marks)

D

OR



V2

Steps :

1. Connect a supply V_1 at port 1, to make a current I_1 flow at port 1.
2. The total resistance of the circuit R, seen from port 1 will be the parallel combination of resistance 4 ohm and two series resistances of 8 ohms each. Thus R = 4 || 16 = 16/5 ohms.
3. Also, the current division rule gives the current through resistance 16 ohm as $I = \frac{4}{16+4} I_1 = \frac{1}{5} I_1\ A$. This gives voltage across 8-ohm resistance V_2 as $V_2 = 8 * \frac{1}{5} I_1 = \frac{8}{5}\ I_1$.

This gives,

$$z_{11} = \left(\frac{V_1}{I_1} | I_2 = 0\right) = 16/5\ \Omega$$

$$z_{21} = \left(\frac{V_2}{I_1} | I_2 = 0\right) = 8/5\ \Omega$$

(4 marks)

4. Connect a supply V_2 at port 2, to make a current I_2 flow at port 2
5. The total resistance of the circuit R, seen from port 2 will be the parallel combination of resistance 8 ohm and two resistances in series of 8 ohm and 4 ohm (=12 ohm). Thus R = 8 || 12 = 24/5 ohms.
6. Also, the current division rule gives the current through resistance 8 ohm as $I = \frac{12}{12+8} I_2 = \frac{12}{20} I_2 = \frac{3}{5} I_2\ A$. This gives voltage across 8-ohm resistance V_2 as $V_2 = 8 * \frac{1}{5} I_1 = \frac{8}{5}\ I_1$.

$$z_{12} = \left(\frac{V_1}{I_2} | I_1 = 0\right) = 8/5\ \Omega$$

$$z_{22} = \left(\frac{V_2}{I_2} | I_1 = 0\right) = 24/5\ \Omega$$

(4 marks)