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Foreword

Civil Services Preliminary (Engg)

Dear Students,

UPSC Civil Services Prelimary during the period 1993 to 2010 have resulted in large sets of objective type questions in various fields of engineering. It is observed that a very significant proportion of these questions are regularly appearing in ESE, GATE, PSUs and competetive examinations of various state service commissioned electricity boards of the country. These questions are thus very much useful to Electrical and Communication students.

With a view of assisting candidates appearing for examinations of the above type, ACE Academy takes pride in bringing out a complete set of solutions for the civil services priliminary questions.

Most of these questions are conceptual and of high standard. Detailed solutions explaining how the answers are arrived at is presented in additon to answer keys. These will be found useful not only in answering objective type questions but also questions of the conventional type.

The solutions are prepared with utmost care. Inspite of this, if there are errors of any type, we will be grateful to be informed of the same to **aceenggpublications@gmail.com.**

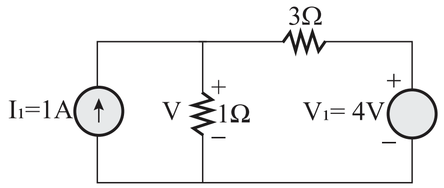
Best wishes to all those who want to go through the following pages.

Y.V. Gopala Krishna Murthy,
M Tech. MIE,
Chairman & Managing Director,
ACE Engineering Publications,
ACE Engineering Academy.

CONTENTS

Chapter 1 Network Elements

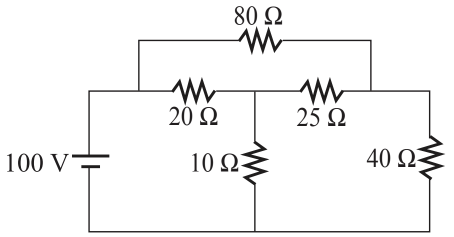
01.



In the dc circuit shown in the above figure, the voltage V across the 1 Ω resistor is **(ICS-93)**

(a) 7/3 V (b) 7/4 V
(c) 5/4 V (d) 1/4 V

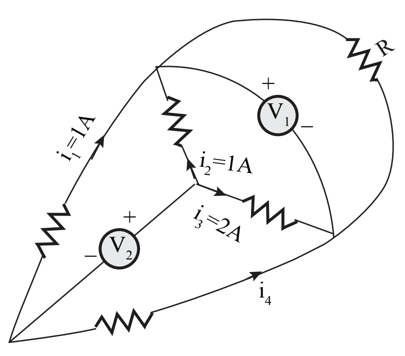
02.



In the dc network shown in the above figure, the current in the 25 Ω resistor will be **(ICS-93)**

(a) 5 A (b) 4 A
(c) 2.5 A (d) zero

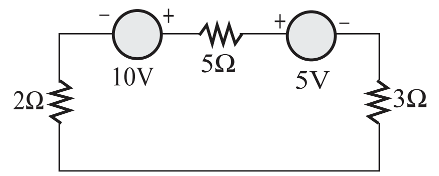
03.



In the circuit shown in the above figure, the value of current i_4 will be **(ICS-93)**

(a) −4 A
(b) −2A
(c) known only if V_1, V_2 and R are known
(d) known only if V_1 and V_2 are known

04.



Consider the above circuit:

If the voltage of each source in the given network is doubled, then which of the following statements would be true?

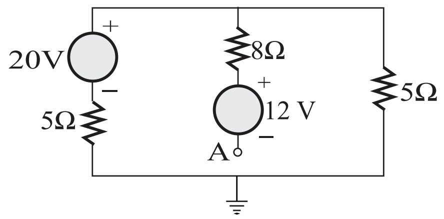
1. Current flowing in the network will be doubled.
2. Voltage across each resistor will be doubled
3. Power absorbed by each resistor will be doubled
4. Power delivered by each source will be doubled.

Select the correct answer using the codes given below: **(ICS-93)**

Codes:

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

05. For the circuit shown in the given figure, the voltage of the terminal A with respect to earth is **(ICS-94)**



(a) – 2.0 V (b) 2.0 V
(c) – 4.0 V (d) 4.0 V

06. The wave form of current flowing, in a pure inductor is as shown in the given figure. (Fig. 1)

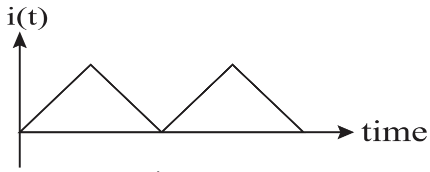
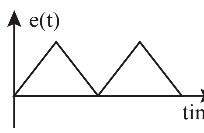
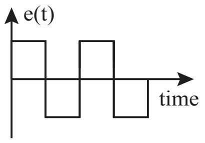
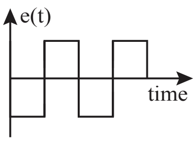


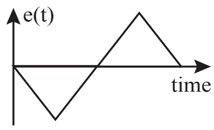
Fig. 1

The wave form of the voltage induced in the inductor will be **(ICS-95)**

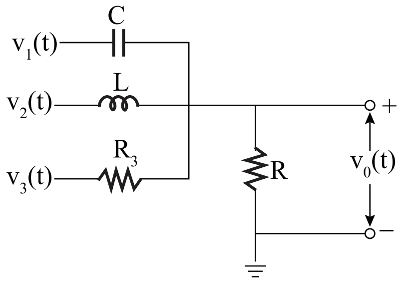
(a)


(b)


(c)


(d)


07. In circuit shown in the given figure, RC is very small and L/R is very large when compared to the time period of the various input signals. Also R << R_3.



The output v_0 (t) is given by **(ICS-96)**

(a) $\frac{dv_1(t)}{dt} + \int v_2(t)\,dt + \frac{R}{R_3} v_3(t)$

(b) $\int v_1(t)\,dt + \frac{dv_2(t)}{dt} + \frac{R}{R_3} \int v_3(t)\,dt$

(c) $RC\frac{dv_1(t)}{dt} + \frac{1}{L/R} \int v_2(t)\,dt + \frac{R}{R_3} v_3(t)$

(d) $RC\int v_1(t)\,dt + \frac{1}{L/R} \int v_2(t)\,dt + \frac{R}{R_3} v_3(t)$

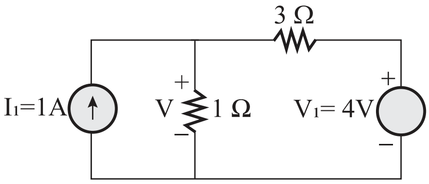
08. Which of the following factor(s) is/are associated with the determination of step response of a time-invariant linear network?
1. Initial conditions of the network
2.Time of application of the input
3. Size of the step input
Select the correct answer using the codes given below: **(ICS-96)**
Codes:
(a) 1, 2 and 3 (b) 1 and 3
(c) 2 and 3 (d) 3 alone

09. A step input as shown in fig. 2 is given to the circuit shown in fig. 1. The output is as shown in fig. 3. The rise time of the circuit response is equal to **(ICS-96)**

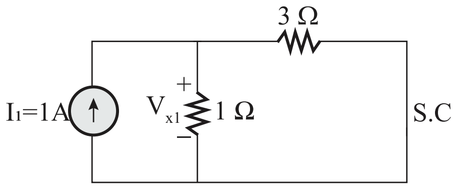
Solutions

01. Ans: (b)

Sol: By superposition theorem

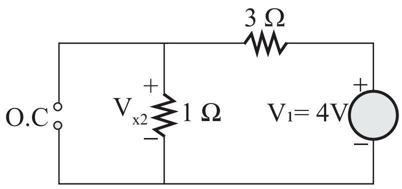


Let I_1 active V_1 is short circuit



$$V_{x_1} = 1 \times 1 \times \frac{3}{1+3} = \frac{3}{4}V$$

Let V_1 active and I_1 is open circuit

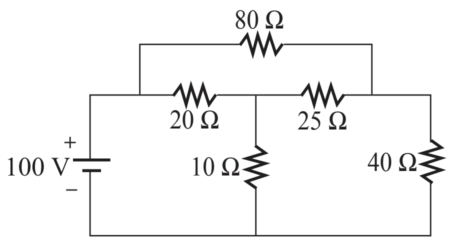


$$V_{x_2} = 4 \times \frac{1}{1+3} = 1V$$

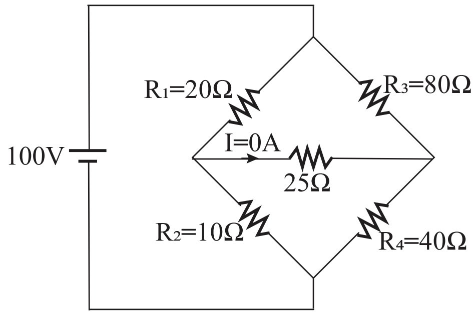
$$V = V_{x_1} + V_{x_2} = \frac{3}{4} + 1 = \frac{7}{4}V$$

02. Ans: (d)

Sol:



Circuit can be redrawn as shown below



As we can see easily given bridge is balanced

$R_1 R_4 = R_3 R_2$

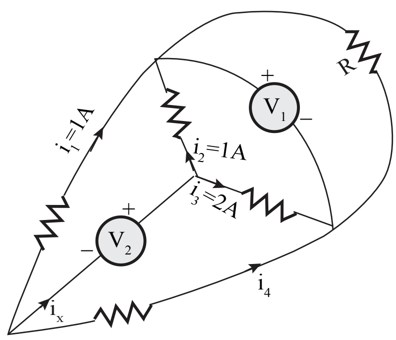
$20 \times 40 = 80 \times 10$

$800 = 800$

Hence current (I) through 25 Ω resister is 0A.

03. Ans: (a)

Sol:



Let i_x is flowing through V_2

$i_x = i_2 + i_3 = 1+2 = 3$ A

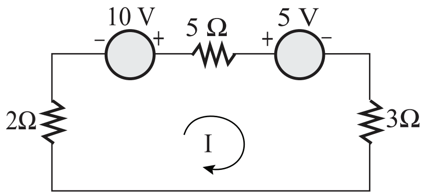
$i_1 + i_x + i_4 = 0$

$1 + 3 + i_4 = 0$

$i_4 = -4A$

04. Ans: (b)

Sol:

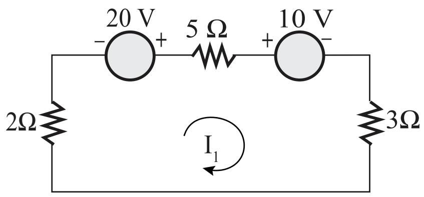


$-10 + 5I + 5 + 3I + 2I = 0$

$10I = 5$

$I = \frac{1}{2}$ A

Now, voltage of each source in the network is doubled



$-20 + 5I_1 + 10 + 3I_1 + 2I_1 = 0$

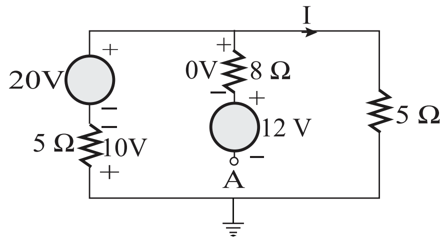
$I_1 = \frac{10}{10} = 1$ A

As current is doubled

1. Voltage across each resistor will be doubled ($\because V \propto I$)
2. Power absorbed by resistors will be four times ($\because P \propto I^2$)
3. Power delivered by sources will be four times ($\because P = VI$)

05. Ans: (a)

Sol:



Let I is the current flowing in the circuit.

$I = \frac{20}{10} = 2A$

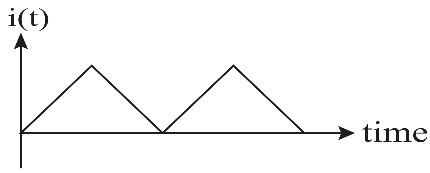
$\therefore$ Potential of 'A' w.r.t. earth is

$0 + 10 - 12 - V_A = 0$

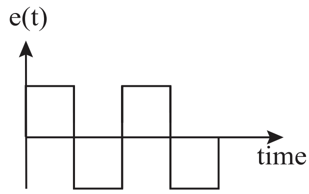
$\Rightarrow V_A = -2$ volts

06. Ans: (b)

Sol: The current wave form

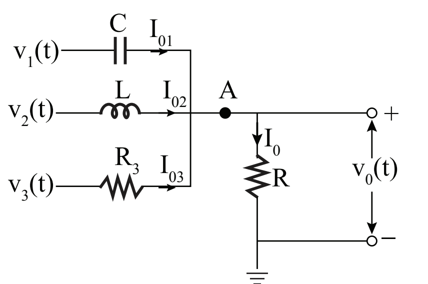


For pure inductor, $V_L = L\frac{di}{dt}$



07. Ans: (c)

Sol: Let I_{01}, I_{02} and I_{03} are flowing as shown below.



$I_{01}(t) = C\frac{d}{dt}[(V_1(t) - V_0(t)]$

$I_{02}(t) = \frac{1}{L}\int\left[V_2(t) - V_0(t)\right]dt$

$$I_{03}(t) = \frac{[V_3(t) - V_0(t)]}{R_3}$$

$$I_0 = \frac{V_0(t)}{R}$$

Applying KCL at node A

$I_0 = I_{01}(t) + I_{02}(t) + I_{03}(t)$

$$\frac{V_0(t)}{R} = C\frac{d}{dt}[(V_1(t) - V_0(t)]$$

$$+ \frac{1}{L}\int\left[V_2(t) - V_0(t)\right]dt$$

$$+ \frac{[V_3(t) - V_0(t)]}{R_3}$$

$$V_0 + RC\frac{d}{dt}V_0(t) + \frac{R}{L}\int V_0(t)\,dt + \frac{R}{R_3}V_0(t)$$

$$= RC\frac{dv_1(t)}{dt} + \frac{R}{L}\int v_2(t)\,dt + \frac{R}{R_3}V_3$$

In Question given RC small, so RC $\frac{d}{dt}V_0(t)$ is small as compared to V_0, similarly we can neglect $\frac{R}{L}\int V_0(t)\,dt$ since $\frac{L}{R}$ is large and also neglect $\frac{R}{R_3}V_0(t)$ since R_3 is very large, so, finally

$$V_0 = RC\frac{d}{dt}V_1(t) + \frac{R}{L}\int V_2(t)\,dt + \frac{R}{R_3}V_3(t)$$

08. Ans: (a)

Sol: The step response of linear time invariant system

y(t) = k u(t)*h(t)

Where k is the size of the step input

The response depend upon

1. Initial conditions of the network
2. Time of application of the input
3. Size of the step input (k).

09. Ans: (d)

Sol: The rise time is the time taken to reach from 10% of output to 90% of the final value.

10. Ans: (b)

Sol: $\frac{d}{dt}u(t) = \delta(t)$ = impulse function

The derivative of the step function is impulse solution.

11. Ans: (b)

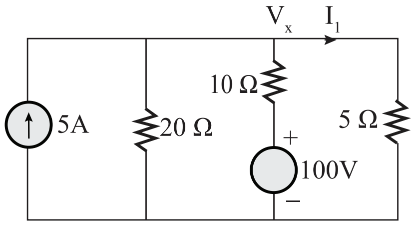
Sol: $R_1 = \frac{4\times 6}{4+6+6} = \frac{24}{16} = \frac{3}{2} = 1.5\Omega$

$R_2 = \frac{4\times 6}{4+6+6} = 1.5\Omega$

$R_3 = \frac{6\times 6}{4+6+6} = \frac{36}{16} = 2.25\Omega$

12. Ans: (a)

Sol:



Apply KCL at point V_x

$$-5 + \frac{V_x}{20} + \frac{(V_x - 100)}{10} + \frac{V_x}{5} = 0$$

$$V_x\left(\frac{1}{20} + \frac{1}{10} + \frac{1}{5}\right) = 5 + 10$$

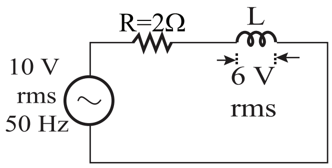
$$\frac{V_x}{20}(1 + 2 + 4) = 15$$

$$V_x = \frac{15\times 20}{7}\text{ V}$$

$$I_1 = \frac{V_x}{5} = \frac{15\times 20}{7\times 5} = 8.57\text{ A}$$

Chapter 4 Sinusoidal Steady State Analysis

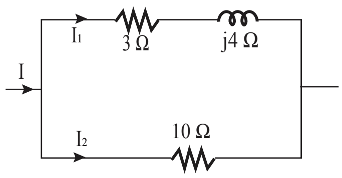
01.



The rms value of the current in the ac circuit as shown in the figure above figure is **(ICS-93)**

(a) 2 A (b) 4 A
(c) 5 A (d) 8 A

02. The total power in the ac circuit shown in the given figure is 1100 W. Match List-I with List-II and select the correct answer using the codes given below the lists: **(ICS-94)**



List-I	**List-II**
A. I_1/I_2	1. 600
B. P_1/P_2	2. 0.3
C. P_1 in W	3. 2.0
D. P_2 in W	4. 500
	5. 1.2

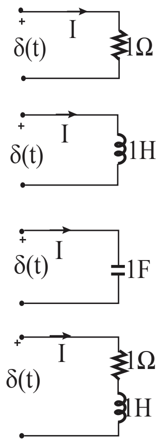
Codes:

	A	**B**	**C**	**D**
(a)	3	5	4	1
(b)	2	3	4	1
(c)	3	5	1	4
(d)	2	3	1	4

03. Lists I and II given below show four elementary circuits and their current response due to unit voltage impulse δ(t). Match List I with List II and select the correct answer using the codes given below the lists **(ICS-94)**

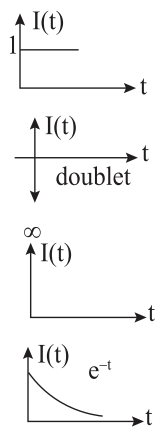
List-I (Elementary circuit)

A. B. C. D.



List-II (Current Response)

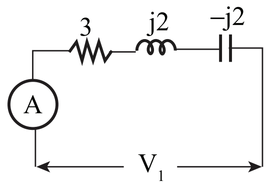
1. 2. 3. 4.



Codes:

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

04. In the ac circuit shown in the given figure when the ammeter reads 10 A, the readings on a voltmeter placed across the entire circuit and then across each element are given below. Match **List I (position of the voltmeter)** with **List II (readings on the voltmeter)** and select the correct answer using the codes given below the lists **(ICS-94)**

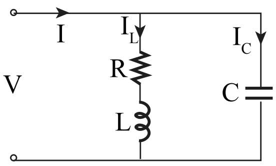


List I	List II
A. V_1	1. 60
B. V_R	2. 20
C. V_L	3. 30
D. V_C	4. 50
	5. 110

Codes:

	A	B	C	D
(a)	5	4	2	1
(b)	5	3	1	2
(c)	4	5	1	2
(d)	4	3	2	1

05. For the given parallel resonant circuit, match List -I with List-II and select the correct answer using the codes given below the lists **(ICS-94)**



List-I

A. I at resonance

B. I_L

C. Dynamic impedance

List-II

1. $\frac{\omega L}{R}$

2. In phase with voltage

3. $\frac{L}{CR}$

4. Lags the applied voltage

Codes:

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

06. Consider the following statements

In a series RLC resonant circuit, the bandwidth is

1. Directly proportional to resonant frequency
2. Inversely proportional to resonant frequency
3. Directly proportional to quality factor
4. Inversely proportional to quality factor

Of these statements **(ICS-94)**

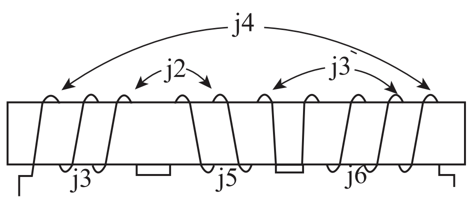
(a) 2 and 3 are correct

(b) 2 and 4 are correct

(c) 1 and 3 are correct

(d) 1 and 4 are correct

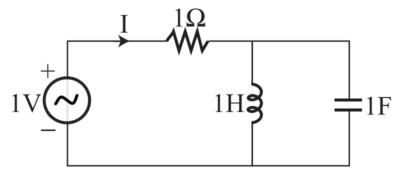
07. The total inductive reactance of the given circuit is **(ICS-94)**



(a) j8 (b) j12

(c) j14 (d) j20

08. If the steady state current in the circuit given in the figure is $i(t) = I\cos(\omega t + \phi)$, then



(a) 50Hz (b) 2π Hz
(c) $\frac{1}{2\pi}$Hz (d) ∞ Hz

54. An iron-cored coil takes 4A at a power factor of 0.5 when connected to a 200V, 50Hz supply. If the equivalent resistance due to copper loss is 20Ω, what is the equivalent resistance corresponding to the core loss?

(ICS-10)

(a) 0Ω (b) 5Ω
(c) 10Ω (d) 15Ω

55. The open loop transfer function of a unity negative feedback system is given as $G(s) = \frac{1}{s+1}$. What is the bandwidth for this system under open loop and closed loop operations respectively in rad/sec?

(ICS-10)

(a) 2 and 1 (b) 1 and 2
(c) 1 and 0.5 (d) 0.5 and 0.5

56. A first order ideal LP (Low Pass) filter is cascaded with a first order ideal high pass filter. Both the filters have the same cutoff frequency. The combined filter is

(ICS-10)

(a) a second order low filter
(b) a second order all pass filter
(c) a second order band-pass filter
(d) not a practical filter

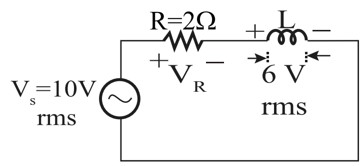
KEY

01. b	02. c	03. b	04. d	05. b
06. d	07. b	08. a	09. d	10. c
11. *	12. c	13. b	14. c	15. d
16. a	17. a	18. c	19. *	20. c
21. c	22. b	23. a	24. d	25. b
26. c	27. a	28. a	29. d	30. d
31. b	32. d	33. a	34. b	35. d
36. c	37. b	38. b	39. a	40. d
41. d	42. b	43. a	44. a	45. b
46. c	47. b	48. b	49. c	50. d
51. a	52. a	53. c	54. b	55. b
56. c				

Solutions

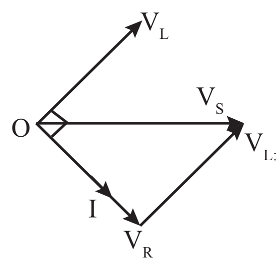
01. Ans: (b)

Sol:



The phasor diagram for the above circuit is as shown below.

V_L = Voltage across inductor



$V_S^2 = V_R^2 + V_L^2$

$10 = \sqrt{V_R^2 + V_L^2}$

$$100 = V_R^2 + (6)^2$$

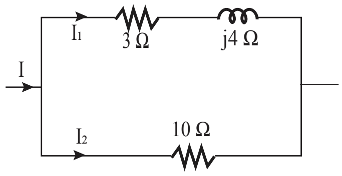
$$V_R^2 = 100 - 36 = 64$$

V_R=8V

$$I_{rms} = \frac{V_R}{R} = \frac{8V}{2\Omega} = 4A$$

02. Ans: (c)

Sol:



Here, $I_1 = \frac{10I}{13+j4}$ and $I_2 = \frac{(3+j4)I}{13+j4}$

$$\Rightarrow \frac{I_1}{I_2} = \frac{10}{\sqrt{9+16}} = \frac{10}{5} = 2$$

$$\Rightarrow \frac{I_1}{I_2} = 2$$

$$P_1 = I_1^2 R_1 = 3I_1^2$$

$$P_2 = (I_2)^2 R_2 = 10(I_2)^2 = 10\left(\frac{I_1}{2}\right)^2 = \frac{10}{4} I_1^2$$

$$\therefore \frac{P_1}{P_2} = \frac{3I_1^2 \times 4}{10 I_1^2} = \frac{12}{10} = 1.2$$

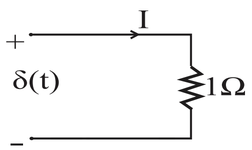
Given, $P_1 + P_2 = 1100$ W

$$\Rightarrow 1.2P_2 + P_2 = 1100 \quad (\because P_1 = 1.2P_2)$$

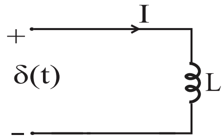
$$\Rightarrow P_2 = \frac{1100}{2.2} = 500W \text{ and } P_1 = 600W$$

03. Ans: (b)

Sol:

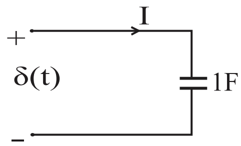


$$\Rightarrow I = \frac{\delta(t)}{1} = \delta(t) \to 3$$



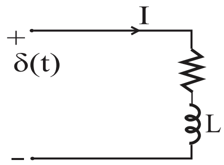
$$\Rightarrow V = L\frac{di}{dt}$$

$$\Rightarrow I = \frac{1}{L}\int V dt \Rightarrow I = u(t) \text{ .... (1)}$$



$$\Rightarrow I = C\frac{dv}{dt} \Rightarrow I = \dot{\delta}(t) \text{ .... (2)}$$

= Doublet function



Taking Laplace transform and applying KVL

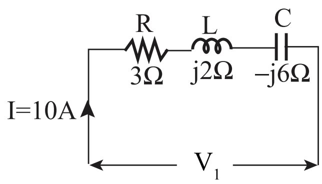
$\Rightarrow -1 + (1 + s)\, I(s) = 0$

$$\Rightarrow I(s) = \frac{1}{s+1}$$

$\Rightarrow I(t) = e^{-t} \to (4)$

04. Ans: (d)

Sol:



$\therefore V_R = IR = 10 \times 3 = 30V$

$V_L = IX_L = 10 \times 2 = 20V$

$V_c = IX_c = 10 \times 6 = 60\ V$

$V_l = \sqrt{V_R^2 + (V_L - V_c)^2}$

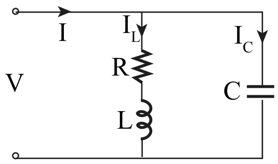
$= \sqrt{30^2 + (20-60)^2}$

$= \sqrt{30^2 + 40^2}$

$= 50V$

05. Ans: (b)

Sol:



$Y = Y_1 + Y_2$

$= \frac{1}{R + j\omega L} + j\omega C$

$= \frac{R - j\omega L}{R^2 + \omega^2 L^2} + j\omega C$

$= \frac{R}{R^2+\omega^2L^2} - j\frac{\omega L}{R^2+\omega^2 L} + j\omega C$

$Y = \frac{R}{R^2+\omega^2L^2} + j\left(\omega C - \frac{\omega L}{R^2+\omega^2L^2}\right)$

At Resonance, $\omega C - \frac{\omega L}{R^2+\omega^2L^2} = 0$

$\Rightarrow C = \frac{L}{R^2+\omega^2L^2}$

$\Rightarrow \omega^2L^2 = \frac{L}{C} - R^2$ ....(1)

Impedance at Resonance is $Z = \frac{R^2+\omega^2L^2}{R}$

$\Rightarrow Z = \frac{R^2 + \frac{L}{C} - R^2}{R}$ (using equation (1))

Dynamic impedance

$\Rightarrow Z = \frac{L}{RC}$

I at resonance will be in phase with voltage

I_L will be lags the applied voltage.

06. Ans: (d)

Sol: For a series RLC circuit

Quality factor $Q = \frac{f_0}{BW}$

f_0 = Resonant frequency

BW = Bandwidth

$\Rightarrow$For constant Q-factor, BW $\propto f_0$

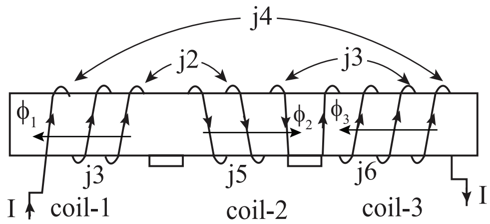
$\rightarrow$ statement –1 true

$\Rightarrow$ Constant f_0, BW $\propto \frac{1}{Q - \text{factor}}$

$\rightarrow$ statement – 4 true

07. Ans: (b)

Sol:



Let current I is flowing as shown in the figure,

The respective fluxes in the coil-1,coil-2 and coil-3 are ϕ_1, ϕ_2 and ϕ_3.

As ϕ_1 and ϕ_2 are in opposite directions coil-1 and coil-2 are in series opposing.

As ϕ_1 and ϕ_3 are in same direction, coil-1 and coil-3 are in series additive.

As ϕ_2 and ϕ_3 are in opposite directions coil-2 and coil-3 are in series opposing.

∴ Total inductive reactance,

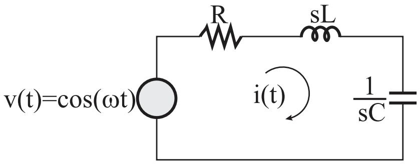
$$X_{L_{eq}} = j3 + j5 + j6 - 2(j2) - 2(j3) + 2(j4)$$

$$\Rightarrow X_{L_{eq}} = j14 - j4 - j6 + j8$$

$$\Rightarrow X_{L_{eq}} = j12 \text{ ohms}$$

08. Ans: (a)

Sol:



$$\therefore I(s) = \frac{V(s)}{R + sL + \frac{1}{sC}}$$

$$\Rightarrow I(s) = V(s) \times \frac{sC}{sCR + s^2LC + 1}$$

$$I(j\omega) = V(j\omega) \times \frac{j\omega C}{1 - \omega^2 LC + j\omega RC}$$

$$\therefore \quad \phi = 90^o - \tan^{-1}\left[\frac{\omega RC}{1 - \omega^2 LC}\right]$$

$$\phi = 90^o - \tan^{-1}\left[\frac{R}{\frac{1}{\omega C} - \omega L}\right]$$

$$\tan^{-1}\left[\frac{R}{\frac{1}{\omega C} - \omega L}\right] = 90^o - \phi$$

Applying 'Tan' on both sides

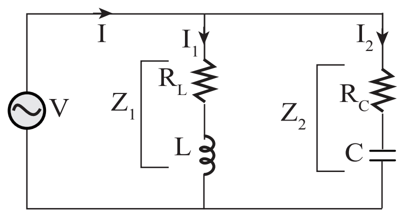
$$\left[\frac{R}{\frac{1}{\omega C} - \omega L}\right] = \cot\phi$$

$$-\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R}$$

$$\phi = \tan^{-1}\left(\frac{\omega L - \frac{1}{\omega C}}{R}\right)$$

09. Ans: (d)

Sol:



Here, $Z_1 = R_L + j\omega L$ and $Z_2 = R_C - j\frac{1}{\omega c}$

∴ Total impedance $Z = Z_1 \| Z_2$

$$= \frac{(R_L + j\omega L)\left(R_c - j\frac{1}{\omega c}\right)}{(R_L + R_c) + j\left(\omega L - \frac{1}{\omega c}\right)}$$

$$= \frac{R_L R_c - j\frac{R_L}{\omega C} + j\omega L R_c + \frac{L}{C}}{(R_L + R_c) + j\left(\omega L - \frac{1}{\omega c}\right)}$$

$$= \frac{R_L R_c - j\frac{R_L}{\omega C} + j\omega L R_c + \frac{L}{C}}{(R_L + R_c) + j\left(\omega L - \frac{1}{\omega c}\right)}$$

$$\times \frac{(R_L + R_c) - j\left(\omega L - \frac{1}{\omega c}\right)}{(R_L + R_c) - j\left(\omega L - \frac{1}{\omega c}\right)}$$

For resonance condition imaginary part = 0

$$\left(R_L R_C + \frac{L}{C}\right)\left(\omega L - \frac{1}{\omega C}\right)$$

$$= (R_L + R_C)\left(\omega L R_C - \frac{R_L}{\omega C}\right)$$

By solving,

Chapter 3 Time Response Analysis

01. In a circuit, the current i (t) has the Laplace transform $I(s) = \frac{3(s+10)}{s(s+12)}$. The final value of i (t) will be **(ICS-93)**

(a) 0.25 (b) 2.5
(c) 3 (d) infinity

02. Match List I with List II and select the correct answer using the codes given below the Lists: **(ICS-93)**

List I (Condition)

A. R =0

B. $R < 2\sqrt{L/C}$

C. $R = 2\sqrt{L/C}$

D. R $2\sqrt{L/C}$

List II (Transient Current Response)

1. Undamped oscillations
2. Damped oscillations
3. Critically Damped response
4. Non-oscillatory response

Codes:

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

03. With a derivative error feedback control, **(ICS-94)**

(a) a second order system is converted into a first order system
(b) a second order system is converted into a third order system
(c) natural frequency of oscillation changes
(d) damping ratio is increased

04. When a unit-step input is applied, a second order underdamped system has a peak overshoot of OP occurring at t_{max}. If another step input equal in magnitude to the peak overshoot OP is applied at $t = t_{max}$. then the system will settle down at **(ICS-94)**

(a) 1 + OP (b) 1 −OP
(c) OP (d) 1.0

05. Which of the following statements are true of a type I system having unity gain in the forward path and a unity feedback? **(ICS-94)**

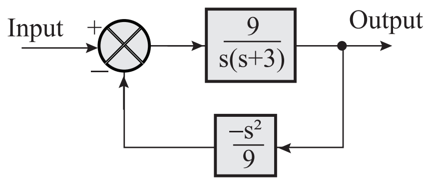
1. Positional error constant K_p is equal to infinity.
2. Acceleration error constant K_a is equal to zero.
3. Steady-state error e_{ss} to a unit step dis placement input is equal to one.

Select the correct answer using the codes given below

Code:

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

06. Consider the control system shown in the following figure and the statements given below the figure. **(ICS-94)**

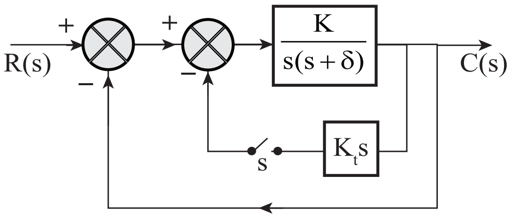


1. The system is of second order.
2. Basically, the system is having positive feedback.
3. The system is of type 1.
4. The dimension of the output is not the same as that of the input

Of these statements
(a) 1 and 2 are correct
(b) 2 and 4 are correct
(c) 2, 3 and 4 are correct
(d) 1, 2 and 3 are correct

07. If I(s) is found to be $\frac{1}{s(s+2)(s+5)}$ then the final value of I (i.e. I at t = ∞) will be **(ICS-95)**
(a) 10 (b) 1.0
(c) 0.667 (d) 0.1

08. The system shown in the given figure, is subjected to a unit ramp input.



On closing the switch 's' **(ICS-95)**
(a) steady state error will increase and damping coefficient ζ will decrease
(b) both steady state error and damping co efficient ζ will increase
(c) both steady state error and damping coef ficient ζ will decrease
(d) steady state error will decrease and damping coefficient ζ will increase

09. Consider the following statements regarding the effect of adding a pole in the open-loop transfer function on the closed-loop step response:
1. It deceases the maximum overshoot.
2. It increases the rise time.
3. It reduces the bandwidth.

Of these statements **(ICS-96)**
(a) 1, 2 and 3 are correct
(b) 1 and 2 are correct
(c) 2 and 3 are correct
(d) 1 and 3 are correct

10. Match List I with List II and select the correct answer using the codes given below the lists:
List-I (Transfer Function) **(ICS-96)**

A. $\frac{1}{(s+\alpha)(s+\beta)}$

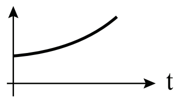
B. $\frac{1}{(s-\alpha)(s-\beta)}$

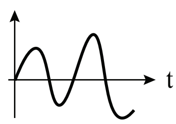
C. $\frac{1}{(s-\alpha+j\beta)(s-\alpha-j\beta)}$

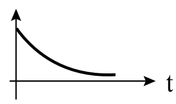
D. $\frac{1}{(s+\alpha+j\beta)(s+\alpha-j\beta)}$

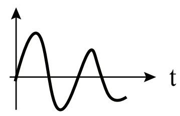
Assume α > 0 and β > 0

List-II (Transient Response)

1.


2.


3.


4.


Codes:

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

11. The error response of a second order system to a step input is obtained as
$E(t) = 1.66\, e^{-8t} \sin(6t + 37^{o})$.
The damping ratio is **(ICS-96)**
(a) 0.4 (b) 0.5
(c) 0.8 (d) 1.0

12. **Assertion (A):** The steady-state error of a type 1 system due to acceleration input is zero.
Reason (R): Type 1 system has a zero positional error constant. **(ICS-96)**

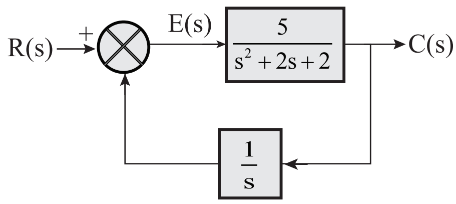
13. The dynamic equation of a second-order system is $2\frac{d^2y}{dt^2} + 4\frac{dy}{dt} + 8y = 8$.
The damping coefficient is **(ICS-97)**
(a) 0.1 (b) 0.25
(c) 0.5 (d) 1.0

14. To improve stability and time response of a control system, poles are often added to the system transfer function. In this context which one of the following pairs is correctly matched? **(ICS-97)**
(a) Zero poles .... makes the system stable and slow responding
(b) One poles .... makes the system less stable and slow responding
(c) Two poles .... makes the system less stable and fast responding
(d) Three poles .... makes the system conditionally stable and fast responding

15. **Assertion (A):** The steady-state error due to step input to a system represented by
$G(s) = \frac{10(1 + 0.5\,s)}{s(1 + s)(1 + 2s)}$ is zero
Reason (R): For a type 1 system, the steady-state error due to step input is zero. **(ICS-97)**

16. The performance specifications for a unity feedback control system having an open-loop transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$ are
1. Velocity error coefficient $K_v > 10\ sec^{-1}$
2. Stable closed-loop operation.
The value of K, satisfying the above specifications, is **(ICS-98)**
(a) $K < 6$ (b) $6 < K < 10$
(c) $K > 10$ (d) None of the above

17. **Assertion (A):** The closed-loop system represented in the given figure is a type-1 system.



Reason (R): Number of poles at the origin possessed by the feedback path decides the type of the closed-loop system **(ICS-98)**

KEY				
01. b	02. a	03. d	04. a	05. b
06. b	07. d	08. b	09. c	10. b
11. c	12. d	13. c	14. b	15. a
16. d	17. a	18. d	19. c	20. a
21. a	22. d	23. c	24. c	25. b
26. d	27. d	28. b	29. *	30. d
31. a	32. c	33. a	34. b	35. d
36. a	37. a	38. b	39. b	40. b
41. c	42. c	43. b	44. a	45. b
46. c	47. b	48. b	49. b	50. a
51. a				

Solutions

01. Ans: (b)

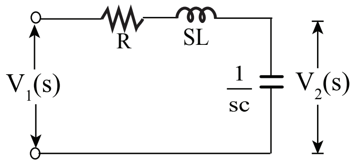
Sol: Final value, $C(\infty) = \underset{t\to\infty}{Lt}\, C(t) = \underset{s\to 0}{Lt}\, sC(s)$

$$C(\infty) = \underset{s\to 0}{Lt} \frac{s\times 3(s+10)}{s(s+12)}$$

$$= \frac{30}{12} = 2.5$$

02. Ans: (a)

Sol: For a series RLC circuit:



$$V_2(s) = \frac{V_1(s).\frac{1}{sC}}{R + sL + \frac{1}{sC}}$$

$$\frac{V_2(s)}{V_1(s)} = \frac{\frac{1}{sC}}{\frac{sCR + s^2LC + 1}{sC}}$$

$$\frac{V_2(s)}{V_1(s)} = \frac{1}{s^2LC + sCR + 1}$$

$$\frac{V_2(s)}{V_1(s)} = \frac{\frac{1}{LC}}{s^2 + s\frac{R}{L} + \frac{1}{LC}} \quad .... (1)$$

Standard second order transfer function

$$T.F = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2} \quad .... (2)$$

Compare eqn. (1) with eqn (2)

$$\omega_n = \frac{1}{\sqrt{LC}}$$

$$2\zeta\omega_n = \frac{R}{L}$$

$$\zeta = \frac{R}{2}\sqrt{\frac{C}{L}}$$

(i) if $R = 0 \Rightarrow \zeta = 0$ (undamped)

(ii) if $R = 2\sqrt{\frac{L}{C}} \Rightarrow \zeta = 1$ (critical damped)

(iii) if R $2\sqrt{\frac{L}{C}}$ ζ 1 ⇒ (under damped)

(iv) if $R > 2\sqrt{\frac{L}{C}} \Rightarrow \zeta > 1$ (over damped)

04. Ans: (a)

Sol: The closed loop second order system, H(s)

$$H(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

Unit step u(t) is initially applied and $M_p u(t - t_p)$ is applied at $t = t_p$

$\therefore r(t) = u(t) + M_p u(t - t_p)$

$$R(s) = \frac{1}{s} + \frac{M_p e^{-st_p}}{s}$$

$$c(s) = H(s)R(s)$$

$$= \left[\frac{1}{s} + \frac{M_p e^{-t_p s}}{s}\right]\left[\frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}\right]$$

$$c(\infty) = \underset{s\to 0}{Lt}\ s\ c(s)$$

(From final value theorem)

$$c(\infty) = \underset{s\to 0}{Lt}\, s \times \left[\frac{1+M_p e^{-t_{ps}}}{s}\right] \times \left[\frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}\right]$$

$$c(\infty) = 1 + M_p$$

05. Ans: (b)

Sol: For a type -I system, $K_p = \infty$ and $K_a = 0$

07. Ans: (d)

Sol: Given $I(s) = \dfrac{1}{s(s+2)(s+5)}$

According to final value theorem

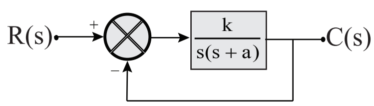
$$\underset{t\to\infty}{Lt}\ I(t) = \underset{s\to 0}{Lt}\ s \times I(s)$$

$$= \underset{s\to 0}{Lt}\ s \times \frac{1}{s(s+2)(s+5)}$$

$$= 0.1$$

08. Ans: (b)

Sol: Before switch is closed:



Damping ratio, ζ:

C.E is $s^2 + as + k = 0$

$$\zeta = \frac{a}{2\sqrt{k}} \ ....\ (1)$$

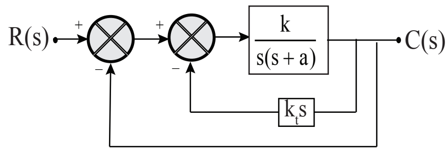
e_{ss} for unit ramp input:

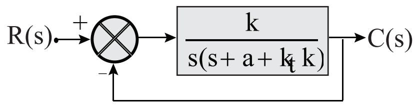
$$e_{ss} = \underset{s\to 0}{Lt}\left[\frac{s \times \frac{1}{s^2}}{1+\frac{k}{s(s+a)}}\right]$$

$$e_{ss} = \underset{s\to 0}{Lt}\left[\frac{1}{s+\frac{k}{s+a}}\right]$$

$$e_{ss} = \frac{a}{k} \ ......(2)$$

After switch closed:





Damping ratio, ζ:

C.E is $s^2 + (a + k_t k)s + k = 0$

$$\zeta = \frac{a+k_t k}{2\sqrt{k}} \ ....\ (3)$$

e_{ss} for unit ramp input:

$$e_{ss} = \underset{s\to 0}{Lt}\left[\frac{s \times \frac{1}{s^2}}{1+\frac{k}{s(s+a+k_t k)}}\right]$$

$$e_{ss} = \frac{a+k_t k}{k}$$

$$e_{ss} = \frac{a}{k} + k_t \ ....(4)$$

From (1) & (3), we can say that damping ratio, ζ is increases.

From (2) & (4), we can say that steady state error is increases.

09. Ans: (c)

Sol: We know that, addition of a pole will decreases the stability.

⇒ ζ decreases

⇒ % M_p increases.

Hence 1st statement is wrong.

If ζ decreases, then θ will be increased.

Raise time $t_r = \frac{\pi - \theta}{\omega_d}$.

With increased θ, raise time is also increased.

Hence 2nd statement is correct.

If stability decrease, then bandwidth will decrease.

10. Ans: (b)

Sol: A. $\frac{1}{(s+\alpha)(s+\beta)}$

Poles = $-\alpha, -\beta$ are real and lies left side.

So system is stable.

Hence A $\rightarrow$ 3.

B. $\frac{1}{(s-\alpha)(s-\beta)}$

Poles = $+\alpha, +\beta$ are lies right side of S-plane.

So system is unstable

Hence B $\rightarrow$ 1.

C. $\frac{1}{(s-\alpha)+j\beta)(s-\alpha-j\beta)}$

Poles = $\alpha \pm j\beta$ are complex conjugate and lies on right side of s-plane.

Hence C $\rightarrow$ 2.

D. $\frac{1}{(s+\alpha+j\beta)(s+\alpha-j\beta)}$

$\Rightarrow$ Poles = $-\alpha \pm j\beta$ are complex and lies on left side of s-plane

Hence D $\rightarrow$ 4.

11. Ans: (c)

Sol: The error response of a second order system to a step input, e(t)

$$e(t) = \frac{e^{-\zeta\omega_n t}}{\sqrt{1-\zeta^2}}.\sin\left[\left(\omega_n\sqrt{1-\zeta^2}\right)t + \cos^{-1}\zeta\right]$$

.... (1)

The given error response is compare with (1).

$\cos^{-}\zeta = 37^o$

$\zeta = \cos 37^o$

$\zeta = 0.8$

12. Ans: (d)

Sol: Consider type 1 system

$G(s)H(s) = \frac{K}{s(1+sT_1)........}$

Assertion (A): For acceleration input

$$K_a = \underset{s\to 0}{Lt}\, s^2 G(s)H(s)$$

$$K_a = \underset{s\to 0}{Lt}\, s^2 \frac{K}{s(1+sT_1)....} = 0$$

$$S.S.E = \frac{1}{K_a} = \frac{1}{0} = \infty \text{ But given zero.}$$

So Assertion (A) is wrong.

Reason (R): Positional error constant

$$K_p = \underset{s\to 0}{Lt}\, G(s)H(s)$$

$$K_p = \underset{s\to 0}{Lt} \frac{K}{s(1+sT_1)} = \infty$$

$$S.S.E = \frac{1}{1+K_p} = \frac{1}{1+\infty} = 0$$

Hence reason (R) is correct.

13. Ans: (c)

Sol: $2\frac{d^2y}{dt^2} + 4\frac{dy}{dt} + 8y = 8$

$2s^2y(s) + 4sy(s) + 8y(s) = 8 \times (s)$

$$\frac{y(s)}{x(s)} = \frac{8}{2s^2+4s+8}$$

$$T.F = \frac{4}{s^2+2s+4}$$

$\omega_n = 2$ rad/sec

Chapter 2 Transmission & Distribution

01. The open and short-circuit impedances of a transmission line at 1.5 kHz are 900 $\angle -40°$ ohms and 400 $\angle -10°$ ohms respectively. Its characteristic impedance in ohms, will be **(ICS-93)**

(a) $1300\angle -50°$ (b) $500\angle -30°$
(c) $600\angle -25°$ (d) $50\angle -20°$

02. If a circular line of radius R has around its periphery n equally spaced points, then the GMD among them will be **(ICS-93)**

(a) $R(n)^{1/n}$ (b) $R(n)^{1/(n-1)}$
(c) $R(n)^{1/2}$ (d) R(n)

03. A medium line with parameters A, B, C, D is extended by connecting a short line of impedance Z in series. The overall ABCD parameters of the series combination will be **(ICS-93)**

(a) A, AZ, C + D/Z, D
(b) A, AZ + B, C, CZ+D
(c) A + BZ, B, C + DZ, D
(d) AZ, B, C/Z, D

04. The time taken for a surge to travel a 600 km long overhead transmission line is **(ICS-93)**

(a) 6 s (b) 1 s
(c) 0.02 s (d) 0.002 s

05. Match List I (load) with List II (relationship) in respect of forward current i_f and the reflected current i_r at the receiving end of the transmission line. Select the correct answer using the codes given below the Lists: **(ICS-93)**

List I	List II
A. Open-circuit	1. $i_r = 0$
B. Short-circuit	2. $i_r = -i_f$
C. $R_L = Z_0$	3. Partial reflection
D. $R_L < Z_0$	4. $i_r = i_f$

Codes:

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

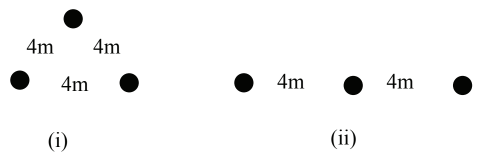
06. The function of the earth wire in an extra high voltage line is to **(ICS-93)**

(a) prevent earth fault
(b) provide a safety measure for any high flying object
(c) provide a shield to the phase conductors from direct lightning stroke
(d) provide mechanical strength to the towers

07. The self-inductance of a long cylindrical conductor due to its internal flux linkages is k H/m. If he diameter of the conductor is doubled, then the self-inductance of the conductor due its internal flux linkages would be **(ICS-94)**

(a) 0.5 kH/m (b) kH/m
(c) 1.414 kH/m (d) 4 kH/m

08. Two arrangements of conductors are proposed for a 3-phase transmission line: one with equilateral spacing of 4 m and the other, a flat with 4 m between the conductors as shown in the given figure. **(ICS-94)**



The conductor diameter in each case is 2 cm. Assuming that the line is transposed in both cases. Which one of the following statements would be true?

(C_n = capacitance in F/m line to neutral,
L = inductance in H/m per phase) **(ICS-94)**

(a) $C_{n1} = C_{n2}$ and $L_1 > L_2$
(b) $C_{n1} > C_{n2}$ and $L_1 < L_2$
(c) $C_{n1} < C_{n2}$ and $L_1 > L_2$
(d) $C_{n1} > C_{n2}$ and $L_1 > L_2$

09. For a given power delivered, if the working voltage of a distributor line is increased to n times, the cross-sectional area A of the distributor line, would be reduced to **(ICS-94)**

(a) $\frac{1}{n}A$ (b) $\frac{1}{n^2}A$
(c) $\frac{1}{2n^2}A$ (d) $\frac{1}{2n}A$

10. When bundle conductors are used in place of single conductors, the effective inductance and capacitance will respectively **(ICS-94)**

(a) increase and decrease
(b) decrease and increase
(c) decrease and remain unaffected
(d) remain unaffected and increase

11. A balanced 3-phase, 3-wire supply feeds balanced stat connected resistors . If one of the resistor is disconnected, then the percentage reduction in load will be **(ICS-94)**

(a) $33\frac{1}{3}$ (b) 50
(c) $66\frac{2}{3}$ (d) 75

12. A long overhead transmission line is terminated by its characteristic impedance. Under this operating condition, the ratio of the voltage to the current at different points along the line will **(ICS-94)**

(a) progressively increase from the sending-end to the receiving-end
(b) progressively increase from the receiving-end to the sending-end
(c) remain the same at the two ends, but be higher between the two ends being maximum at the centre of the line
(d) remain the same at all points

13. For a transmission line with negligible losses, the lagging reactive power (VAR) delivered at the receiving-end, for a given receiving-end voltage, is directly proportional to the **(ICS-94)**

(a) square of the line voltage drop
(b) line voltage drop
(c) line inductive reactance
(d) line capacitive reactance

14. Earth wire on EHV overhead transmission line is provided to protect the line against **(ICS-94)**

98. The capacitance of a 3-core cable between any two conductors with sheath earthed is C μF. What is the per phase capacitance of the cable? **(ICS-10)**

(a) $\frac{C}{3}$ (b) $\frac{2C}{3}$

(c) 2 C (d) $\frac{C}{2}$

99. If δ is the loss angle of the cable, then what is the power factor of the cable? **(ICS-10)**

(a) cos δ (b) sin δ

(c) tan δ (d) independent of δ

KEY

01. c	02. b	03. b	04. d	05. a
06. c	07. b	08. b	09. a	10. b
11. b	12. d	13. b	14. a	15. a
16. d	17. b	18. a	19. c	20. b
21. d	22. b	23. c	24. a	25. a
26. b	27. d	28. b	29. b	30. c
31. b	32. b	33. c	34. a	35. b
36. c	37. a	38. a	39. b	40. a
41. c	42. a	43. b	44. a	45. d
46. a	47. a	48. d	49. c	50. a
51. c	52. a	53. b	54. b	55. b
56. c	57. b	58. a	59. a	60. c
61. d	62. b	63. b	64. a	65. c
66. a	67. a	68. c	69. b	70. b
71. c	72. d	73. c	74. a	75. a
76. b	77. c	78. c	79. c	80. c
81. b	82. *	83. b	84. a	85. c
86. c	87. a	88. a	89. c	90. d
91. d	92. c	93. d	94. d	95. d
96. c	97. b	98. c	99. b	

Solutions

01. Ans: (c)

Sol: Characteristic impedance is given as

$$Z_c = \sqrt{Z_{sc}.Z_{oc}}$$

where

Z_{sc} - short circuit impedance.

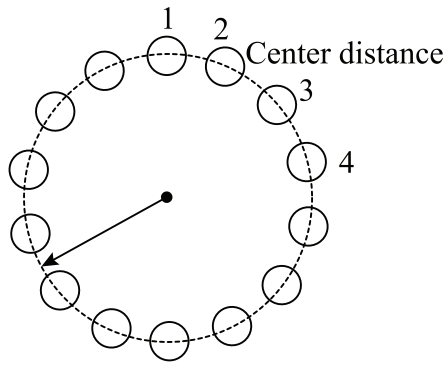
Z_{oc} - open circuit impedance.

$$= \sqrt{900\angle -40 \times 400\angle -10^{o}}$$

$$= 600\angle -25°$$

02. Ans: (b)

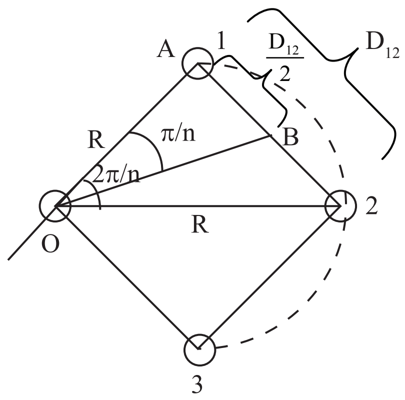
Sol:



GMD among sub-conductors is given by

$$GMD = \sqrt{GMD_1 \times GMD_2 \times GMD_3 \times ... \times GMD_6}$$

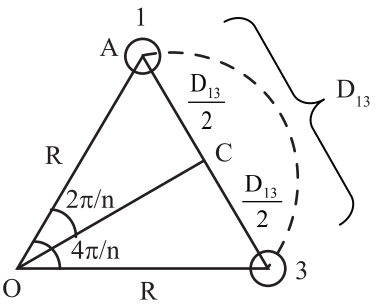
$$GMD_1 = \left[D_{12} \times D_{13} \times D_{14} \times ....D_{1n}\right]^{\frac{1}{n-1}}$$



From the ΔOAB $\sin\frac{\pi}{n} = \frac{D_{12}/2}{R}$

$D_{12} = 2R\sin\frac{\pi}{n}$

From ΔOAC



$\sin\frac{2\pi}{n} = \frac{D_{13}/2}{R}$

$D_{13} = D_{13} = 2R\sin\frac{2\pi}{n}$

Similarly $D_{14} = 2R\sin\frac{3\pi}{n}$

$D_{15} = 2R\sin\frac{4\pi}{n}$ ....

$D\,D_{1n} = 2R\sin\frac{(n-1)\pi}{n}$

$D_{12} \times D_{13} \times \text{..........} \times D_{1n}$

$= 2R\sin\frac{\pi}{n} \times 2R\sin\frac{2\pi}{n} \times 2R\sin\frac{3\pi}{n} \times \text{......} \times 2R\sin\frac{(n-1)\pi}{n}$

$= R^{n-1}\left[2\sin\frac{\pi}{n} \times 2\sin\frac{2\pi}{n} \times 2\sin\frac{3\pi}{n} \times \text{.....} \times 2\sin\frac{(n-1)\pi}{n}\right]$

$n = 2 \Rightarrow 2\sin\frac{\pi}{2} = 2$

$n = 3 \Rightarrow 2\sin\frac{\pi}{3} \times 2\sin\frac{2\pi}{3} = 3$

$n = 4 \Rightarrow 2\sin\frac{\pi}{4} \times 2\sin\frac{2\pi}{4} \times 2\sin\frac{3\pi}{4} = 4$

$2\sin\frac{\pi}{n} \times 2\sin\frac{2\pi}{n} \times \text{....} \times 2\sin\frac{(n-1)\pi}{n} = n$

$D_{12}\,D_{13} \text{ .... } D_{1n} = R^{(n-1)}n$

$GMD_1 = \left[D_{12} \times D_{13} \times D_{14} \times \text{.......} \times D_{1n}\right]^{\frac{1}{n-1}}$

$= \left[R^{n-1}n\right]^{\frac{1}{n-1}} = R\left[n\right]^{\frac{1}{n-1}}$

$GMD_1 = R\left[n\right]^{\frac{1}{n-1}}$

GMD of each sub conductor will be same so that overall GMD is any one of the conductor

$GMD = GMD_1$

$= R(n)^{\frac{1}{n-1}}$

03. Ans: (b)

Sol: Medium line and short line are cascaded together the resultant ABCD parameters as follows

$$\begin{bmatrix} A_0 & B_0 \\ C_0 & D_0 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}\begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} A & AZ+B \\ C & CZ+D \end{bmatrix}$$

04. Ans: (d)

Sol: The time taken by the wave to reach end of the line is $T = \dfrac{\text{length of transmission line}}{\text{velocity of wave propagation}}$

$$T = \frac{600\text{ km}}{3\times 10^5\text{km/s}}$$

$$= 0.002\text{ s}$$

05. Ans: (a)

Sol: $\because \dfrac{i_r}{i_f} = \dfrac{Z_0 - R_L}{R_L + Z_0}$

$$i_r = -i_f\left[\frac{R_L - Z_0}{R_L + Z_0}\right]$$

Where, R_L is the receiving end load impedance, and Z_0 is the characteristic impedance of the line,

(a) open circuited line, $R_L = \infty$

$\Rightarrow i_r = -i_f$

(b) short circuited line, $R_L = 0$

$\Rightarrow i_r = i_f$

(c) $R_L = Z_0$

$\Rightarrow i_r = 0$ (no reflected wave)

(d) $R_L > Z_0$

$$\Rightarrow \frac{i_r}{i_f} = \frac{R_L - Z_0}{R_L + Z_0} = \frac{Z_0 - R_L}{Z_0 + R_L}$$

$Z_0 - R_L$ is positive and $(Z_0 - R_L) < (Z_0 + R_L)$

Hence, $\dfrac{i_r}{i_f} < 1$ (partial reflection)

06. Ans: (c)

Sol: The function of the earth wire in an extra high voltage line is to provide a shield to the phase conductor from direct lightening stroke.

07. Ans: (b)

Sol: $L_a = \dfrac{\mu_0\mu_r}{8\pi} + \dfrac{\mu_0\mu_r}{2\pi}\ln\left(\dfrac{1}{r}\right) - \dfrac{\mu_0\mu_r}{2\pi}\ln\left(\dfrac{1}{d}\right)$

$L_{self} = L_{self}$ due to $\psi_{int} + L_{self}$ Due to ψ_{ext}

$$= \frac{\mu_0\mu_r}{8\pi} + \frac{\mu_0\mu_r}{2\pi}\ln\left(\frac{1}{r}\right)$$

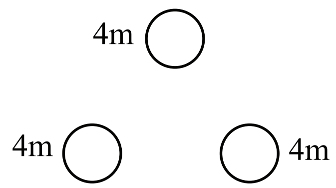
$$L_{mutual} = L_{\text{mutual due to ext}} = \frac{\mu_0\mu_r}{2\pi}\ln\left(\frac{1}{d}\right)$$

Ans: kH/m

($\because$ 1st term is independent of diameter)

08. Ans: (b)

Sol: (i)

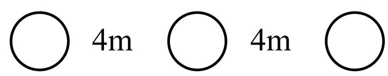


L_1 C_{n1}

After Transposition

$$GMD_1 = \sqrt[3]{4\times4\times4} = 4$$

(ii)



L_2 C_{n2}

After Transposition

$$GMD_2 = \sqrt[3]{4\times4\times8} = 5.021\text{ m}$$

$GMD_1 < GMD_2$

$L_1 < L_2$

$C_{n1} > C_{n2}$

09. Ans: (a)

Sol: Given data,

$V_2 = nV_1$

Then for same power delivered,

$V_1I_1 = V_2I_2 \Rightarrow nV_1 = nV_1I_2$

$\Rightarrow I_1 = nI_2$

For same current density, J

$I_1 = J.a_1$ (a_1 is the area)

$I_2 = J.a_2$

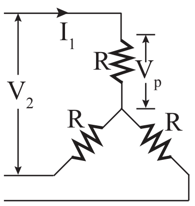
$\Rightarrow a_1 = n.a_2 \Rightarrow a_2 = \frac{1}{n}a_1$

10. Ans (b)

Sol: Bundling of conductors will lead to an increase in the Geometric mean radius (GMR) of the conductors and an increase in GMR leads to decrease in the inductance and increase in capacitance of the line.

11. Ans: (b)

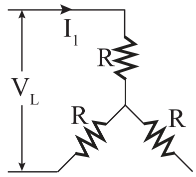
Sol: Loss of one resistor will lead to two resistors in series across the supply.



For a balanced (Y) load,

$$P_1 = 3I_1^2R = 3\left(\frac{V_p}{R}\right)^2 R = 3\left(\frac{V_L}{\sqrt{3}R}\right)^2 R$$

$$P_1 = \frac{V_L^2}{R}$$



Loss of one phase

$$P_2 = 2I_2^2R = 2\left(\frac{V_L}{2R}\right)^2 R$$

$$= \frac{V_L^2}{2R}$$

$$\text{Now, } \Delta P = \frac{P_1 - P_2}{P_1} = \frac{\frac{V_L^2}{R} - \frac{V_L^2}{2R}}{\frac{V_L^2}{R}} \times 100$$

$= 50\%$

12. Ans: (d)

Sol: For a transmission line, at any point impedance Z(x) where x is the distance from the receiving end is given as,

$$\frac{V(x)}{I(x)} = Z(x)$$

and $V(x) = V_L\cosh(\gamma x) + I_LZ_0\sinh(\gamma x)$

$$I(x) = I_L\cosh(\gamma x) + \frac{V_L}{Z_0}\sinh(\gamma x)$$

$$Z(x) = Z_0\left[\frac{Z_L\cosh(\gamma x) + Z_0\sinh(\gamma x)}{Z_0\cosh(\gamma x) + Z_L\sinh(\gamma x)}\right]$$

if line is terminated with its characteristic impedance then, $Z_L = Z_0$

$Z(x) = Z_0$

13. Ans: (b)

Sol: $\because Q_R = \frac{|V_s||V_R|}{X}\cos\delta - \frac{|V_R|^2}{X}$

For $\cos\delta \approx 1$