GATE 2015 – A Brief Analysis

(Based on student test experiences in the stream of IN on 1st February, 2015-Forenoon session)

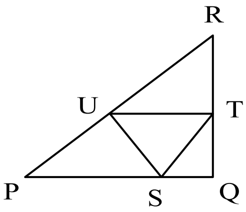
Section wise analysis of the paper

Section Classification	1 Mark	2 Marks	Total no. of Questions
Engineering Mathematics	3	2	5
Network	4	5	9
Signals and Systems	2	5	7
Digital Circuits	3	3	6
Control Systems	1	3	4
Measurement	3	2	5
Analog Circuits	1	5	6
Transducers	5	2	7
Process Control	-	-	-
Communication	1	1	2
Analytical Instrumentation	-	-	-
Optical Instrumentation	1	2	3
Biomedical Instrumentation	1	-	1
Aptitude	5	5	10
Total	30	35	65

Questions from the Paper

Aptitude

1. For the given below figure. PS:QS = 3:1, RT:QT = 5:2, PU: UR = 1:1. If the area of QTS triangle is 20 cm^2, then the area of PQR (in cm^2) is ________.



Key: (280)

Exp: Let area of triangle PQR be 'A'

$$\frac{SQ}{PQ} = \frac{1}{1+3} = \frac{1}{4}$$

$$\frac{QT}{QR} = \frac{2}{2+5} = \frac{2}{7}$$

$$\therefore \text{Area of } \Delta^{le}\, QTS = \frac{1}{2} \times SQ \times QT$$

$$= \frac{1}{2} \times \left(\frac{1}{4}PQ\right) \times \left(\frac{2}{7}QR\right)$$

$$= \frac{1}{4} \times \frac{2}{7} \times \left(\frac{1}{2} \times PQ \times QR\right)$$

$$= \frac{1}{14} \times \text{Area of } \Delta^{le}\, PQR$$

$$\text{given } 20cm^2 = \frac{1}{14} \times A$$

$$\therefore A = 14 \times 20 = 280\,cm^2$$

2. Apparent lifelessness ________ dormant life

(A) harbours (B) leads to (C) supports (D) effects

Key: (A)

Exp: Apparent: looks like

dormant: hidden

Harbour: give shelter

Effect (verb): results in

3. The boy from town was a ________ in the sleepy village

(A) dog out of herb (B) sheep from heap

(C) fish out of water (D) bird from flock

Key: (C)

Exp: From the statement, it appears that boy found it tough to adapt to a very different situation.

4. Tanya is older than Eric

Cliff is older than Tanya

Eric is older than cliff

If the first two statements are true, the third statement is

(A) True (B) False (C) Uncertain (D) Data insufficient

Ans: (B)

5. Five teams have to compete a league with every team playing with every other team exactly once, before going to the next round. How many matches will they have to play to complete league round of matches?

(A) 20 (B) 10 (C) 8 (D) 15

Key: (B)

Exp: For a match to be played, we need 2 teams

No. of matches = No. of ways of selections 2 teams out of 5

$$= {}^{5}C_{2} = 10$$

6. Consider the statements given

Statement 1: No manager is leader

Statement 2: All leaders are executives

Conclusion

(I) No manager is an executive

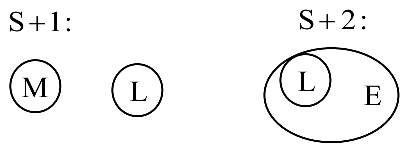
(II) No executive is a manager

(A) Conclusion I follow (B) Conclusion II follows

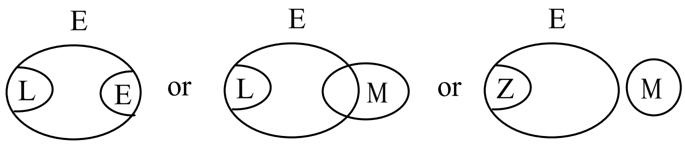
(C) Conclusion I & II follows (D) Neither Conclusion I nor Conclusion II follows

Key: (D)

Exp:



Therefore concluding diagram can be



7. A coin is tossed thrice. Let 'x' be the event head occur in each of first two tosses. Let 'y' be event where tail occurs in third toss, and 'z' be the event tail occurs in two tosses. Based on the above information

(A) X and Y are independent
(B) Y and Z are dependent
(C) Y and Z are independent
(D) X and Z are independent

Key: (D)

Exp: x = {HHT, HHH}

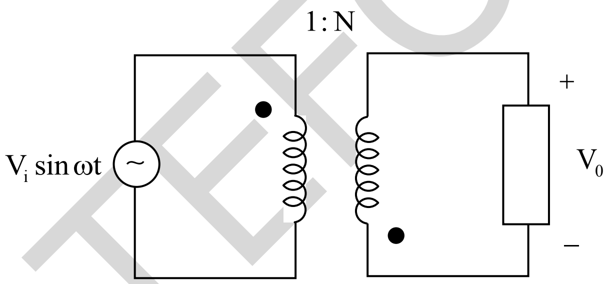
y depends on x

z = {TTH, TTT}

∴ D is the correct choice.

Technical

1. Consider the following network. Which of the following represent the output voltage?



(A) $\frac{V_i}{N} \text{Sin}\,\omega t$ (B) $-NV_i \text{Sin}\,\omega t$ (C) $NV_i \text{Sin}\,\omega t$ (D) $-\frac{V_i}{N} \text{Sin}\,\omega t$

Key: (B)

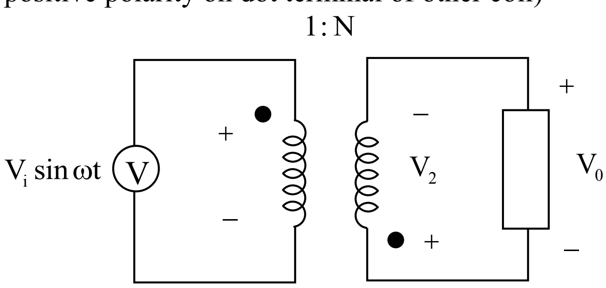
Exp: First mark the mutual voltage polarity using dot convention (when a reference current enters at dot of one coil, it generates positive polarity on dot terminal of other coil)

→ Using Transformer ratio

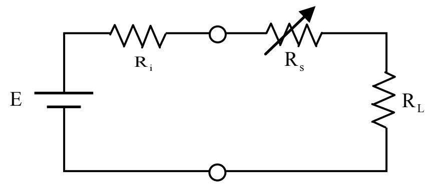
$$\frac{V_2}{V_i} = \frac{N_2}{N_1}$$

$$\Rightarrow V_2 = V_1\left(\frac{N}{1}\right) = NV_i \sin \omega t$$

$$\rightarrow V_o = -V_2 = -NV_i \sin \omega t$$



2. Consider the following network, for which it is known that R_i, R_L are constant, then for what value of variable R_S, there will be maximum power transfer to R_L.

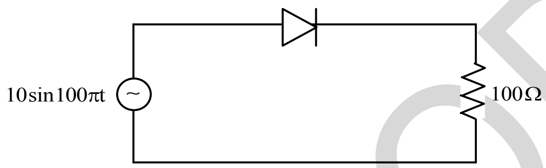


(A) R_i (B) 0 (C) $R_L - R_i$ (D) $R_C + R_S$

Key: (B)

Exp: When load is constant, we should see for what value of resistance current will be maximum and $P_{R_L} = \max$

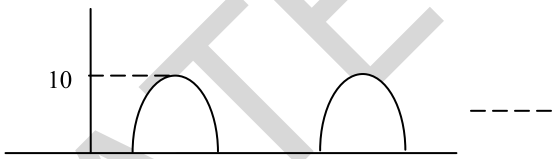
3. For the circuit shown below, the average power dissipated at 100Ω resistor is _______W.



(Assume Diode is ideal)

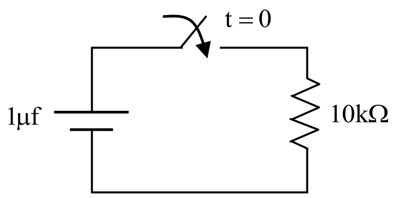
Key: (0.25)

Exp: The voltage waveform at $R = 100\Omega$ is as shown below.



$$P_{avg} = \frac{V_{rms}^2}{R} = \frac{(10/2)^2}{100}$$
$$= 0.25 \text{ Watt}$$

4. In the network shown below capacitor has initial voltage = 10V. Obtain the capacitor voltage (in volts) at t = 10 msec.



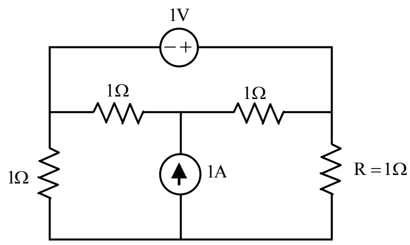
Key: (3.67)

Exp: It is a source free Network where capacitor violtage

$$V_c(t) = V_0 e^{-t/\tau}; t > 0$$
$$= 10e^{-100t}$$
$$V_c\left(10\times10^{-3}\right) = 10e^{-\left[100\times10\times10^{-3}\right]} = 3.67V$$

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

5. In the network shown below, find the current (in Amperes) through the resistance 'R'.



Key: (1)

Exp: Using supermesh analysis

Mesh 1, 3 form super mesh

$2I_1 - I_2 + 2I_3 - I_2 = 0$

$\Rightarrow 2I_1 - 2I_2 + 2I_3 = 0$ … (1)

Writing KCL at Q

$I_1 - I_3 = -1$ … (2)

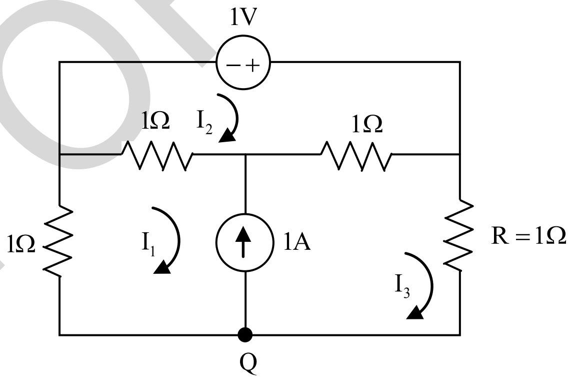
Writing KCL on mesh 2

$2I_2 - I_1 - I_3 = 1$ … (3)

Solution Equation 1, 2, 3

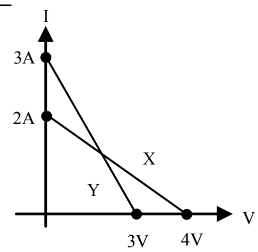
$I_1 = 0, I_2 = I_3 = 1A$

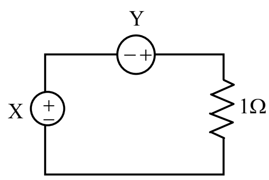
Current through R is $I_3 = 1A$



Note: Strictly saying it is an ambiguous question as the direction of current is not mentioned, so it could be –1A as well.

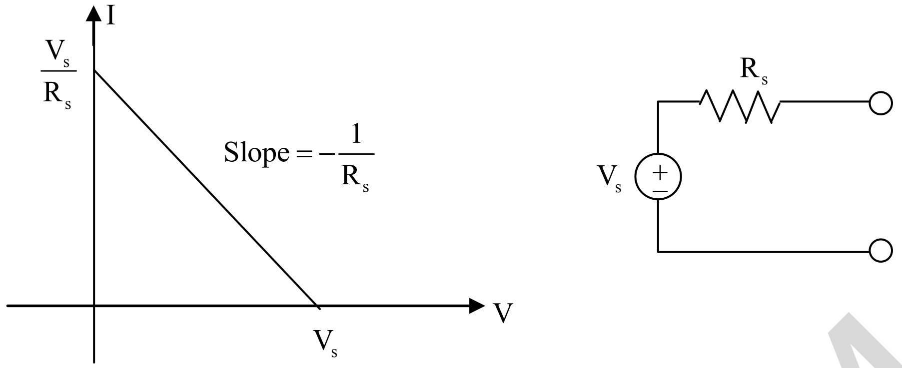
6. The transfer characteristic of two non ideal voltage source are given in figure. If these are connected in the circuit as shown below, then the current through 1Ω register is ________ A.





Key: (1.75)

Exp: The transfer characteristic curve and the circuit of a non ideal source is given below.



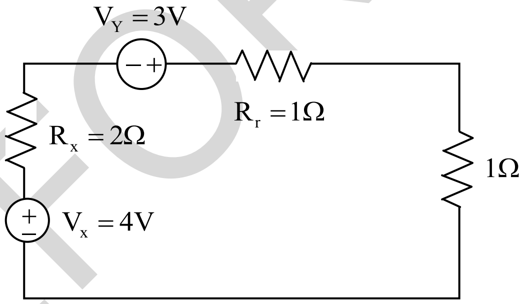
Comparing the curve of X and Y we can conclude that

X: $V_x = 4V,\ R_x = 2\Omega$

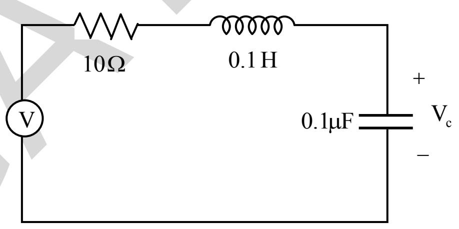
Y: $V_y = 3V,\ R_y = 1\Omega$

When we connect these the circuit becomes,

$$I_{1\Omega} = \frac{4+3}{2+1+1} = 1.75A$$



7. If the following circuit is under resonance, then the voltage across capacitor V_c is ________ V.



Key: (100)

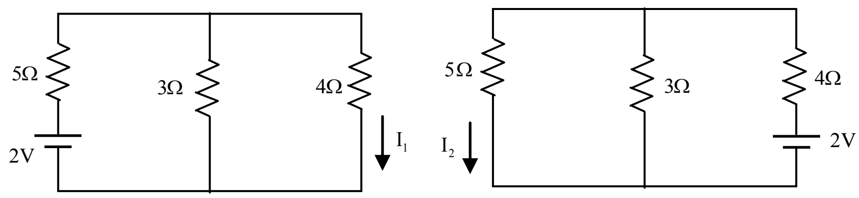
Exp: Under series resonance condition, voltage across L, C is Q times of the supply voltage.

$$V_C = QV$$

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{0.1}{0.1\times10^{-6}}} = 100$$

$$V_c = QV = (100)(1) = 100V$$

8. In the network given below, $\left|\frac{I_1}{I_2}\right| =$ ________.



Key: (1)

Exp: By reciprocity theorem, $I_1 = I_2$

So $\left|\frac{I_1}{I_2}\right| = 1$

9. The Transfer function $H(s) = \frac{s^2 - bs + c}{s^2 + bs + c}$ represents

(A) High pass filter (B) Low pass filter
(C) Band pass filter (D) All pass filter

Key: (D)

Exp: We can see that the poles and zeros are symmetrical about origin, all pole lie on left half of s-plane, and all zero on right half of s-plane. This represents an all pass filter.

10. The following arrangement is made to measure the value of R using V-I method. It is known that the worst case error induced by voltmeter is 2% and ammeter is 1% then the maximum error in measurement of R is _________ %.

Key: (3)

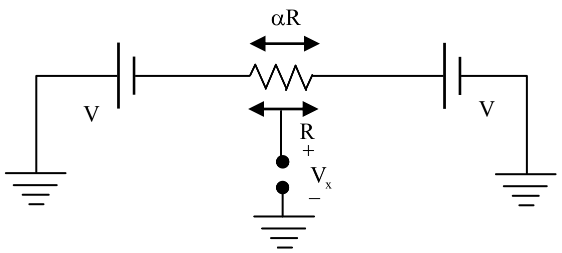
Exp: $R_x = \frac{V_x}{I_x} = \frac{V_x \pm 2\%}{I_x \pm 1\%} = R_x \pm 3\%$

11. Which of the following bridge is best suited for measurement of resistance whose value lies in the range 0.001Ω to 0.1Ω

(A) Maxwell Bridge (B) Schering Bridge
(C) Kelvin Double Bridge (D) Owens Bridge

Key: (C)

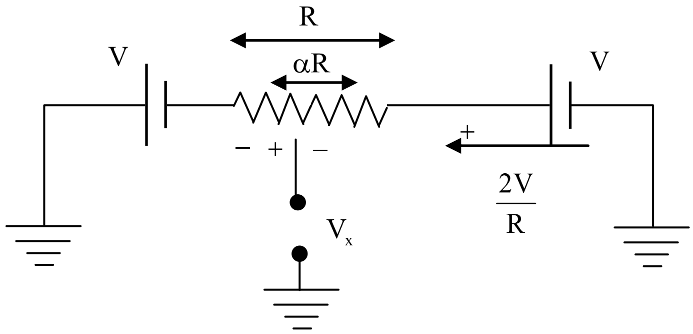
12. In the potentiometer shown below determine the value of V_A.



(A) $V(1-2\alpha)$ (B) $V(1-\alpha)$ (C) αV (D) $V(2-\alpha)$

Key: (A)

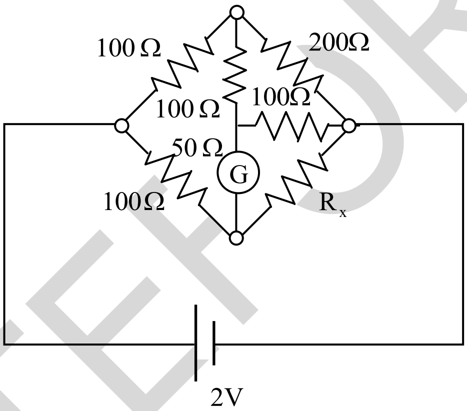
Exp:



Writing KVL as per the current direction

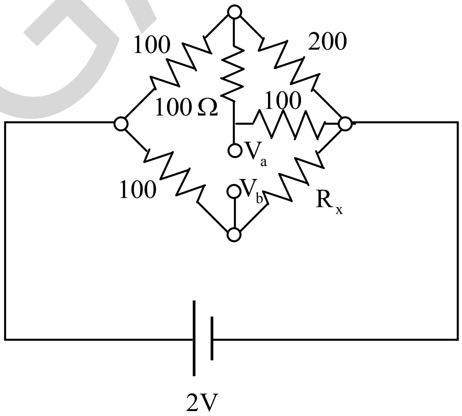
$$V_x + (\alpha R)\frac{2V}{R} - V = 0$$

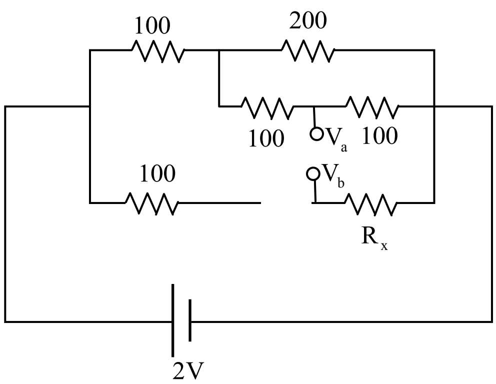
13. If the current passing through galvanometer is zero, then value of R_X is ________Ω. .



Key: (33.33)

Exp: When the current through galvanometer is 0 then its 2 end voltage are same or we can say the open circuit voltage across galvanometer is 0.





By voltage division, $V_a = 0.5V$

$$V_b = \left(\frac{2}{100+R_x}\right)R_x$$

$V_a = V_b$

$$\frac{1}{2} = \frac{2R_x}{100+R_x}$$

$$\Rightarrow 100 + R_x = 4R_x$$

$$\Rightarrow R_x = \frac{100}{3} = 33.33\Omega$$

14. Let 3+4j is a zero of 4^{th} order FIR filter, then which of following is not a zero of filter?

(A) $\frac{3}{25} - j\frac{4}{25}$ (B) $3-4j$

(C) $\frac{3}{25} + j\frac{4}{25}$ (D) $\frac{1}{2} - j\frac{1}{4}$

Key: (D)

Exp: The property of a FIR filter is that if Z_o is a zero then the remaining zeros are

$$\frac{1}{Z_0}, \quad [Z_0]^*, \quad \left[\frac{1}{Z_0}\right]^*$$

$$\downarrow \quad \downarrow \quad \downarrow$$

$$\left[\frac{3}{25} - j\frac{4}{25}\right], \quad [3-4j], \quad \left[\frac{3}{25} + j\frac{4}{25}\right]$$

So option D is not matching with any of this.

15. The time period of signal

$2\cos\frac{2\pi t}{3} + \cos\pi t$ is ______ sec.

Key: (6)

Exp: $\omega_0 = \frac{H.C.F(2\pi,\pi)}{L.C.M(3,1)} = \frac{\pi}{3}$

$$\frac{2\pi}{T} = \frac{\pi}{3} \Rightarrow T = 6 \text{ sec}$$

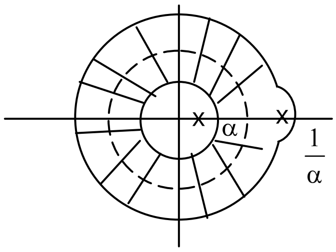
16. If $x(n) = \alpha^{|n|};\ 0 < |\alpha| < 1$, then the ROC of x(n) is

(A) $\alpha < |Z| < \frac{1}{\alpha}$ (B) $|Z| > \alpha$ (C) $|Z| < \frac{1}{\alpha}$ (D) $|Z| > 1$

Key: (A)

Exp: $x(n) = \alpha^{|n|} = \alpha^n u(n) + \left(\frac{1}{\alpha}\right)^n u(-n-1)$

$|z| > \alpha \; ; \; |z| < \frac{1}{\alpha}$



17. The impulse response of a discrete time LTI system is $h(n) = \dfrac{\sin\frac{\pi}{6}n}{\pi n}$ and the input to the system is $x(n) = \dfrac{\sin \omega_c n}{\pi n}$, then its output is

(Assume $\omega_c > \pi/6$)

(A) $\left[\dfrac{\sin\frac{\pi n}{6}}{\pi n}\right]^2$

(B) $\left[\dfrac{\sin\frac{\pi n}{6}}{\pi n}\right] \cdot \left[\dfrac{\sin \omega_c n}{\pi n}\right]$

(C) $\left[\dfrac{\sin \omega_c}{\pi n}\right]$

(D) $\left[\dfrac{\sin\frac{\pi n}{6}}{\pi n}\right]$

Key: (D)

Exp: $\left[\dfrac{\sin \alpha n}{\pi n}\right] \times \left[\dfrac{\sin \beta n}{\pi n}\right] = \left[\dfrac{\sin \gamma n}{\pi n}\right]$

where $\gamma = \min(\alpha, \beta)$

Output $g(n) = x(n) * h(n)$

In frequency domain they will be multiplied.

18. A signal n(t) having maximum frequency f_m , then the maximum frequency of $x^2(t)$ is

(A) f_m (B) $2f_m$ (C) $4f_m$ (D) $8f_m$

Key: (B)

Exp: Multiplication in time domain corresponds to convolution in frequency domain

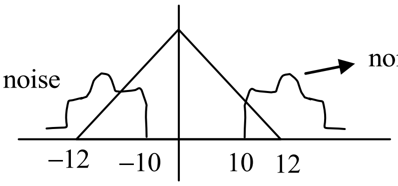
$x^2(t) \to x(f) * x(f)$

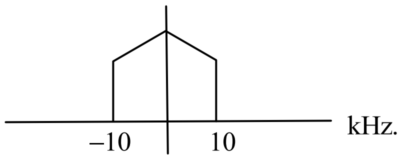
Using limit property of convolution $x^2(t)$ have maximum frequency $2f_m$.

19. A signal is band limited to 12 kHz. A portion of it i.e. from 10 kHz to 12 kHz is corrupted by effect of additive noise. The theoretical Nyquist frequency required to recover the uncorrupted part of signal is _______ KHz.

Key: (20)

Exp:





20. The transfer function of a open -loop control system is $\frac{s^2+6s+10}{s^2+2s+2}$, then the angle of arrival is

(A) $\pm\frac{\pi}{4}$ (B) $\pm\frac{\pi}{3}$ (C) $\pm\frac{\pi}{2}$ (D) $\pm\frac{5\pi}{6}$

Key: (A)

Exp: Angle of arrival is calculated on a complex zero and it is given by,

$\phi_a = 180 - \angle GH$ (at a + ve imaginary zero)

$$G(s) = \frac{(s+3+i)(s+3-i)}{(s+1+i)(s+1-i)}$$

$$G(-3+i) = \frac{[-3+i+3+i][-3+i+3-i]}{[-3-i+1+i][-3+i+1-i]} = \frac{[2i]}{[-2+2i][-2]}$$

$$\angle G(-3+i) = 90^o - \left[180^o - \tan^{-1}\frac{2}{2}\right] - \left[180^o\right]$$

$$= 90^o - 180^o + 45^o - 180^o = 135^o$$

$$\phi_a = 180° - 135° = 45° = \pi/4$$

Other angle will be same with opposite sign $\pm\pi/4$

21. The transfer function of a second order control system is $\frac{1}{s^2+1}$ then % overshoot at its step response is _______ %.

Key: (100)

Exp: Comparing the denominator, $\xi = 0$

$$\%\text{ Overshoot} = e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}} \times 100 = 100$$

22. Consider the A and B matrix for a control system, then the value of α so that the system is not controllable is ______.

$$A = \begin{bmatrix} 1 & 2 \\ \alpha & 0 \end{bmatrix} \quad B = \begin{bmatrix} 1 \\ +1 \end{bmatrix}$$

Key: (3)

Exp: For a system to be uncontrollable, its controllability determinant should be equal to zero.

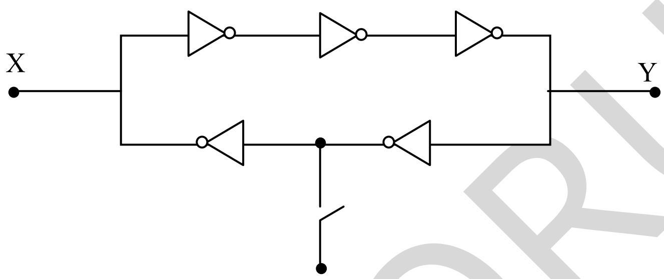
$$Q_c = |B\ AB| = 0$$

$$AB = \begin{bmatrix} 1 & 2 \\ \alpha & 0 \end{bmatrix}_{2\times 2} \begin{bmatrix} 1 \\ +1 \end{bmatrix}_{2\times 1} = \begin{bmatrix} 3 \\ \alpha \end{bmatrix}$$

$$Q_c = |B\ AB| \rightarrow \begin{vmatrix} 1 & 3 \\ 1 & \alpha \end{vmatrix} = 0$$

$$\Rightarrow \alpha - 3 = 0 \Rightarrow \alpha = +3$$

23. Consider the following circuit, the switch is momentarily closed. Which of following is true?



(A) Only X will latch (B) Only Y will latch

(C) Both X, Y will latch (D) Both X, Y will toggle

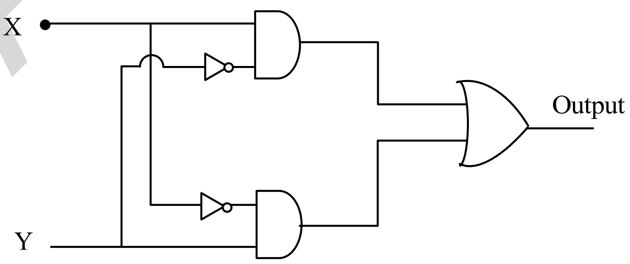
Key: (D)

Exp: The above circuit is a stable multivibrator circuit, where odd numbers of inverter are there in the loop. In such a circuit, irrespective of the position of output, it always toggles.

$\rightarrow$ Latching means X and Y will be fixed to same value, in this case it is not possible.

24. In the logic circuit shown below, obtain the output expression.

(A) $\bar{X}Y + X\bar{Y}$ (B) $XY + \bar{X}\bar{Y}$ (C) $X + \bar{X}Y$ (D) $X + \bar{X}Y + XY$



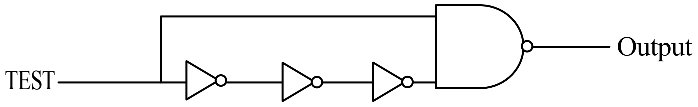
Key: (A)

Exp: Output of upper AND gate is $X\bar{Y}$

Output of lower AND gate is $\bar{X}Y$

Output of OR gate is $X\bar{Y} + \bar{X}Y$.

25. In the logic circuit shown below, all the logic gates have identical delay. Which of the following is a true statement regarding output?



The test signal makes a transition from 0 to 1 at t = 0

(A) Output is high
(B) Output is low
(C) Output is first low to high then low
(D) Output is first high to low then high

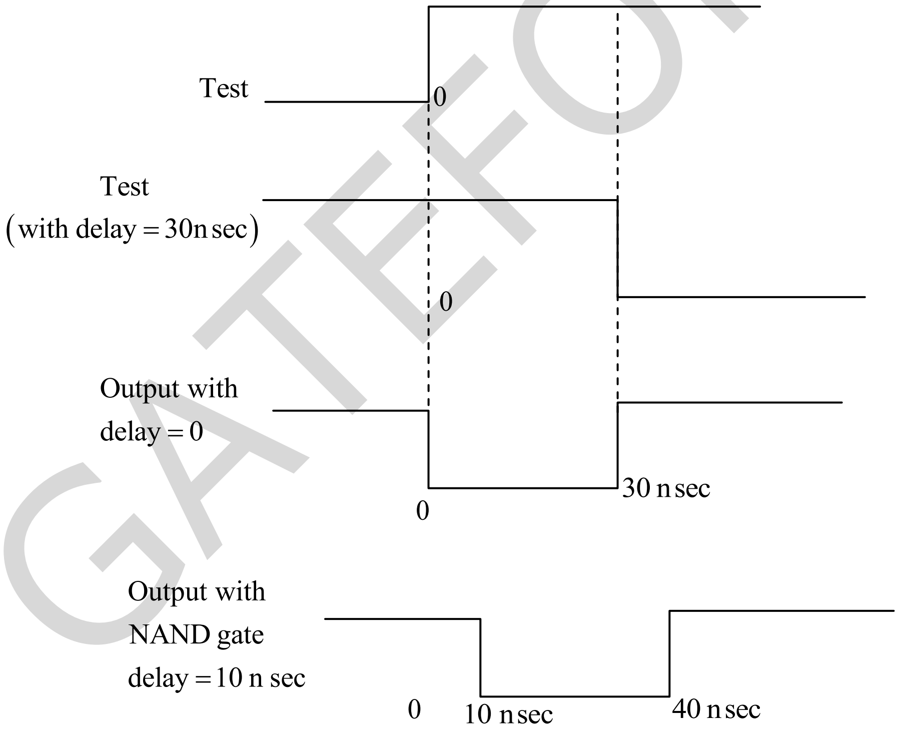
Key: (D)

Exp: For analysis point of view assume delay of each gate is 10 msec. However we can take any value.

→ By referring the circuit the upper input to the NAND gate is direct test signal.

The lower input to NAND gate is TEST but with a delay of 30 nsec.

→ Assuming the delay of NAND gate is 0. First draw output waveform (ideal case) then shift that by 10 msec. i.e. introduce the delay.



So we can clearly say that initial output change from high to low, then it changes from low to high and then finally at steady state output is 1.

Note: Saying output is high (option A) will be wrong here. We are not interested to find steady state output.

26. Evaluate the integral $\oint \frac{dz}{z^2}$ where the contain is unit circle taken in clockwise direction.

(A) $2\pi i$ (B) 0 (C) $-2\pi i$ (D) $4\pi i$

Key: (B)

Exp: Residue at $z = 0$ is 0 so by C.J.T $\oint \frac{dz}{z^2} = 2\pi i \times 0 = 0$

27. A square matrix of order n has rank r then the no.of linearly independent solution.

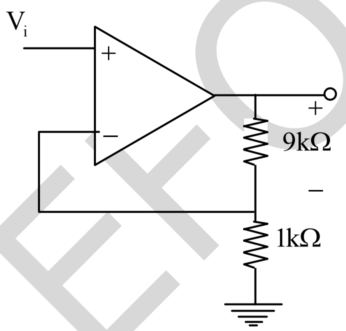
(A) n (B) r (C) $n-r$ (D) $n+r$

Key: (C)

28. For the op-amp circuit shown below, assume that the open loop transfer function is $A = \frac{10^4}{1+10^{-3}s}$.

The bandwidth of circuit is

(A) 10^3 (B) 10^4 (C) 10^5 (D) 10^6



Key: (D)

Exp: Closed loop transfer function A_{CL}

$$A_{CL} = \frac{A_{OL}}{1+A_{OL}\beta}$$

Here $A_{OL} = \frac{10^4}{1+10^{-3}s}$, $\beta = \frac{R_i}{R_i+R_f} = \frac{1}{9+1} = 0.1$

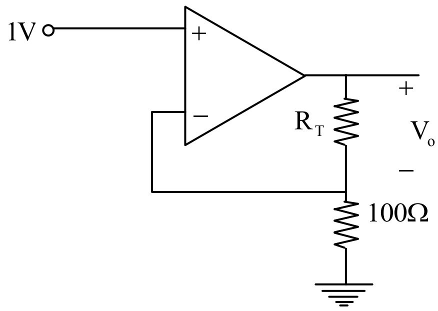
$$A_{CL} = \frac{\frac{10^4}{1+10^{-3}s}}{1+\frac{10^4 \times 0.1}{1+10^{-3}s}} = \frac{10^4}{1+10^{-3}s+10^3}$$

$$= \frac{10}{10^{-3}+10^{-6}s+1} \approx \frac{10}{1+\frac{s}{10^6}}$$

→ In a first order transfer function $\frac{k}{1+s\tau}$ the bandwidth of system is given by $1/\tau$

$B.W = 10^6$

29. In the circuit given below, R_T represent the resistance of a thermistor whose relation with temperature is described by $R_T = R_o[1+\alpha T]$. Assume $R_o = 100\Omega$, $\alpha = 0.0039/°C$, $T = 100°C$ and obtain V_o (in Volts)?



Key: (1.39)

Exp: Using the above information

$$R_T = R_o[1+\alpha T]$$
$$= 100[1+0.0039\times 100] = 139\Omega$$

$\rightarrow$ Since it is a non inverting amplifier its output voltage w.r.t ground is

$$\left(1+\frac{R_f}{R_i}\right)V_i = \left(1+\frac{139}{100}\right) = 2.39V$$

$\rightarrow$ But here V_o is not w.r.t ground, it is across R_T

So $V_o = 2.39 - 1 = 1.39V$

30. The instrument used for measurement of flow is

(A) Pirani gauge
(B) Orifice plate
(C) Bourdon tube
(D) Strain gauge

Key: (B)

31. In pH measurement, the relation between potential and temperature is

(A) $E \propto T^2$
(B) $E \propto \frac{1}{T^2}$
(C) $E \propto T$
(D) $E \propto \frac{1}{T}$

Key: (C)