APTITUDE

1. Mr. X speaks ________ Japanese ________ Chinese.

(a) neither / or (b) either / nor

(c) neither / nor (d) also / but

Sol: (c)

Here we will cheake tones.

Mr. X speaks neither Japanese nor Chinese.

2. A sum of money is to be distributed among P, Q, R, and S in the proportion 5 : 2 : 4 : 3, respectively.

If R gets R 1000 more than S, what is the share of Q (in Rs)?

(a) 500 (b) 1000

(c) 1500 (d) 2000

Sol: (d)

P Q R S 1 = 1000 Rs.

5 : 2 : 4 : 3

So, Sharing of Q is = 2 × 1000

= 2000 Rs

3. A trapezium has vertices marked as P, Q, R and S (in that order anticlockwise). The side PQ is parallel to side SR.

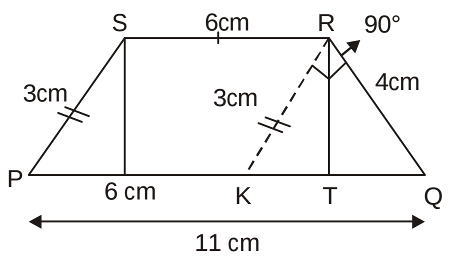
Further, it is given that, PQ = 11 cm, QR = 4 cm, RS = 6 cm and SP = 3 cm.

What is the shortest distance between PQ and SR (in cm)?

(a) 1.80 (b) 2.40

(c) 4.20 (d) 5.76

Sol: (b)



$$\text{Area} = \frac{1}{2}\times B\times H \qquad B \to \text{Base}$$

$$= \frac{1}{2}\times B\times 4 \qquad H \to \text{Height}$$

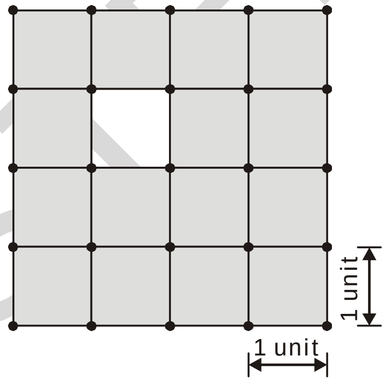
$$= \frac{1}{2}\times 3\times 4$$

$$= 6\text{ cm}^2$$

$$\frac{1}{2}\times 5\times RT = 6\text{ cm}^2$$

$$RT = 2.4\text{ cm}$$

4. The figure shows a grid formed by a collection of unit squares. The unshaded unit square in the grid represents a hole.

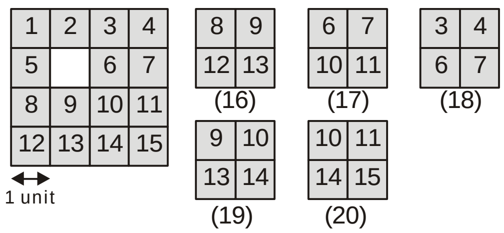


What is the maximum number of squares without a "hole in the interior" that can be formed within the 4 × 4 grid using the unit squares as building blocks?

(a) 15 (b) 20

(c) 21 (d) 26

Sol: (b)

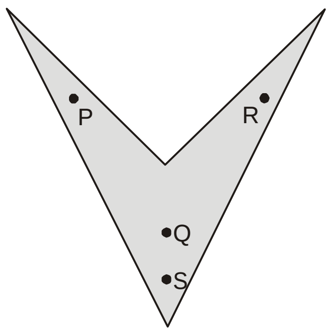


Total number of sqaures without a hole in interior

$$= \underbrace{15}_{\substack{(1\times1)\\ \text{unit}\\ \text{squares}}} + \underbrace{5}_{\substack{(2\times2)\\ \text{unit}\\ \text{squares}}} = 20$$

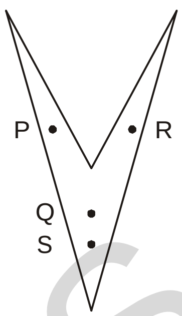
5. An art gallery engages a security guard to ensure that the items displayed are protected. The diagram below represents the plan of the gallery where the boundary walls are opaque. The location the security guard posted is identified such that all the inner space (shaded region in the plan) of the gallery is within the line of sight of the security guard.

If the security guard does not move around the posted location and has a 360° view, which one of the following correctly represents the set of ALL possible locations among the locations P, Q, R and S, where the security guard can be posted to watch over the entire inner space of the gallery.



(a) P and Q (b) Q
(c) Q and S (d) R and S

Sol: (c)



If person will stand on ‘P’ than he/she can’t see the visibility side of R and vice versa.

But if security guard will be stand at Q and S than he will se whole 360°.

6. Mosquitoes pose a threat to human health. Controlling mosquitoes using chemicals may have undesired consequences. In Florida, authorities have used genetically modified mosquitoes to control the overall mosquito population. It remains to be seen if this novel approach has unforeseen consequences.

Which one of the following is the correct logical inference based on the information in the above passage?

(a) Using chemicals to kill mosquitoes is better than using genetically modified mosquitoes because genetic engineering is dangerous

(b) Using genetically modified mosquitoes is better than using chemicals to kill mosquitoes because they do not have any side effects

(c) Both using genetically modified mosquitoes and chemicals have undesired consequences and can be dangerous

(d) Using chemicals to kill mosquitoes may have undesired consequences but it is not clear if using genetically modified mosquitoes has any negative consequence

Sol: (d)

Using chemicals to kill mosquitoes may have undesired consequence but it is not clear if using genetically modified mosquitoes has any negative consequence.

7. Consider the following inequalities.

(i) $2x - 1 > 7$

(ii) $2x - 9 < 1$

Which one of the following expressions below satisfies the above two inequalities?

(a) $x \leq -4$ (b) $-4 < x \leq 4$
(c) $4 < x < 5$ (d) $x \geq 5$

Sol: (c)

$$\begin{array}{l|l} \Rightarrow \; 2x - 1 > 7 & \quad 2x - 9 < 1 \\ \Rightarrow \; 2x > 8 & \Rightarrow \; 2x < 10 \\ \Rightarrow \; x > 4 & \Rightarrow \; x < 5 \end{array}$$

Combining both inequalities

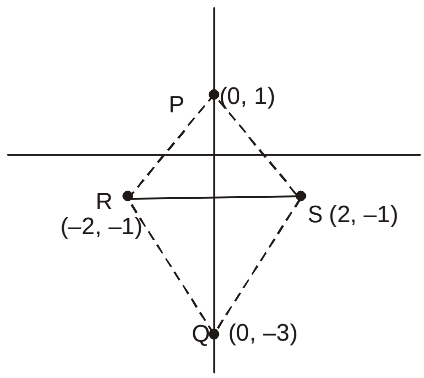
$4 < x < 5$

8. Four points P(0, 1), Q(0, –3), R(–2, –1), and S(2, –1) represent the vertices of a quadrilateral.

What is the area enclosed by the quadrilateral?

(a) 4 (b) $4\sqrt{2}$
(c) 8 (d) $8\sqrt{2}$

Sol: (c)



$$PS = \sqrt{\left(\sqrt{2}\right)^4 + (-2)^2}$$
$$= \sqrt{2+4+2}$$
$$= \sqrt{8}$$
$$SQ = \sqrt{4+4} = \sqrt{8}$$
$$SQ = \sqrt{4+4} = \sqrt{8}$$
$$QS = \sqrt{4+4} = \sqrt{8}$$
$$PQ = \sqrt{16} = 4$$
$$RS = \sqrt{16} = 4$$
$$\text{Area} = \sqrt{8} \times \sqrt{8} = 8 \text{ units}$$

9. In a class of five students P, Q, R, S and T, only one student is known to have copied in the exam. The disciplinary committee has investigated the situation and recorded the statements from the students as given below.

Statement of P: R has copied in the exam.

Statement of Q: S has copied in the exam.

Statement of R: P did not copy in the exam.

Statement of S: Only one of us is telling the truth.

Statement of T: R is telling the truth.

The investigating team had authentic information that S never lies.

Based on the information given above, the person who has copied in the exam is

(a) R (b) P

(c) Q (d) T

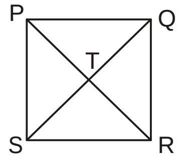
Sol: (b)

Shows cheating done by

P	Q	R	T
↓	↓	↓	↓
R(✓)	P(✓)	P(×)	R(✓)
×	×	×	✓
R(×)	S(×)	P(✓)	

Hence P has copied in the exam.

10. Consider the following square with the four corners and the center marked as P, Q, R, S and T respectively.



Let X, Y and Z represent the following operations:

X: rotation of the square by 180 degree with respect to the S-Q axis.

Y: rotation of the square by 180 degree with respect to the P-R axis.

Z: rotation of the square by 90 degree clockwise with respect to the axis perpendicular, going into the screen and passing through the point T.

Consider the following three distinct sequences of operation (which are applied in the left to right order).

1. XYZZ
2. XY
3. ZZZZ

Which one of the following statements is correct as per the information provided above?

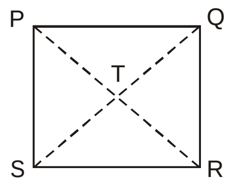
(a) The sequence of operations (1) and (2) are equivalent

(b) The sequence of operations (1) and (3) are equivalent

(c) The sequence of operations (2) and (3) are equivalent

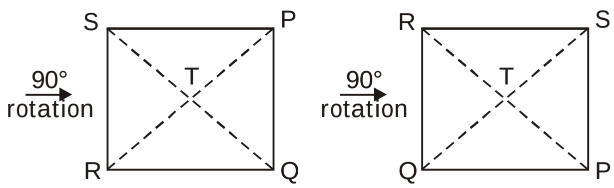
(d) The sequence of operations (1), (2) and (3) are equivalent

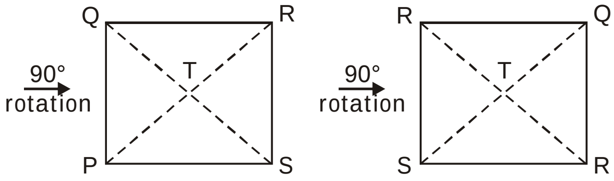
Sol: (b)



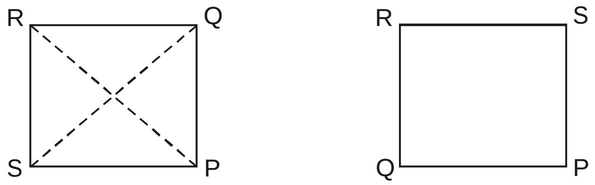
$$x \to S - Q \to 180^\circ$$
$$y \to P - R \to 180^\circ$$
$$z \to 90^\circ\ (T)$$

(3) Operations - ZZZZ

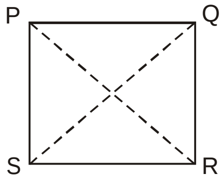




(2) xy



(1) xyzz

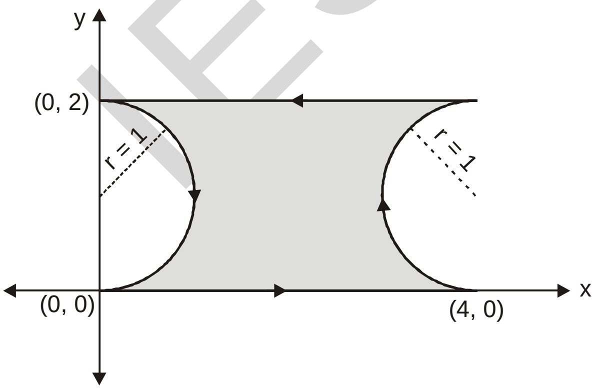


Hence, option (b) is corret

TECHNICAL

11. Consider the two-dimensional vector field $\vec{F}(x,y) = x\vec{i} + y\vec{j}$, where $\vec{i}$ and $\vec{j}$ denote the unit vectors along the x-axis and the y-axis, respectively. A contour C in the x-y plane, as shown in the figure, is composed of two horizontal lines connected at the two ends by two semicircular arcs of unit radius. The contour is traversed in the counter-clockwise sense. The value of the closed path integral

$\oint_c \vec{F}(x,y).(dx\,\vec{i} + dy\,\vec{j})$ is. ________



(a) 0 (b) 1

(c) $8+2\pi$ (d) –1

Sol: (a)

$\oint \vec{F}(x,y)\cdot\left[dx\,\vec{i} + dy\,\vec{j}\right]$

Given $\vec{F}(x,y) = x\vec{i} + y\vec{j}$

$\therefore \quad \int_c xdx + ydy = 0$

Because here vector is conservative.

If the integral function is the total derivative over the closed contoure then it will be zero.

12. Consider a system of linear equations Ax = b, where

$$A = \begin{bmatrix} 1 & -\sqrt{2} & 3 \\ -1 & \sqrt{2} & -3 \end{bmatrix},\ b = \begin{bmatrix} 1 \\ 3 \end{bmatrix}.$$

This system of equations admits ________.

(a) a unique solution for x

(b) infinitely many solutions for x

(c) no solutions for x

(d) exactly two solutions for x

Sol: (c)

$$A = \begin{bmatrix} 1 & -\sqrt{2} & 3 \\ -1 & \sqrt{2} & -3 \end{bmatrix} \text{ and } B = \begin{bmatrix} 1 \\ 3 \end{bmatrix}$$

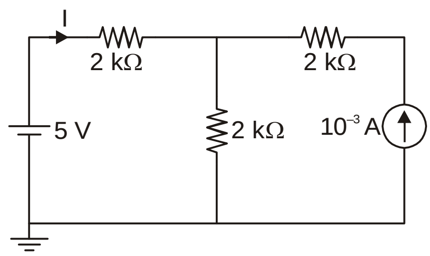
Hence equation will be

$x - \sqrt{2}y + 3z = 1$

$-x + \sqrt{2}y - 3z = 3$

therefore inconsistant solution i.e. there will not be any solution.

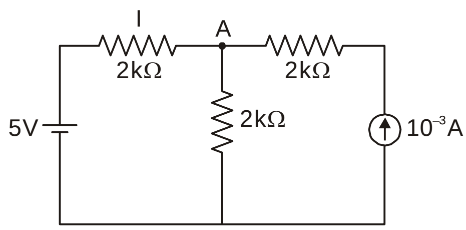
13. The current I in the circuit shown is ________.



(a) 1.25×10^{-3}A (b) 0.75×10^{-3}A

(c) -0.5×10^{-3}A (d) 1.16×10^{-3}A

Sol: (b)



Applying Nodal equation at Node-A

$$\frac{V_A}{2k} + \frac{V_A - 5}{2k} = 10^{-3}$$

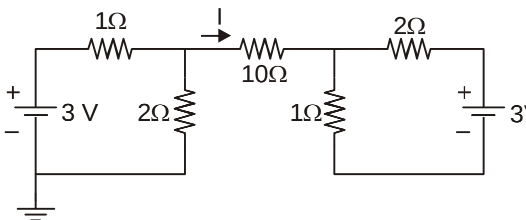
$$\Rightarrow \quad 2V_A - 5 = 2k \times 10^{-3}$$

$$\Rightarrow \quad V_A = \frac{7}{2} V = 3.5\,V$$

Again,

$$I = \frac{5 - V_A}{2k} = \frac{5 - 3.5}{2k} = \frac{1.5}{2k} = \boxed{0.75 \times 10^{-3}\,A}$$

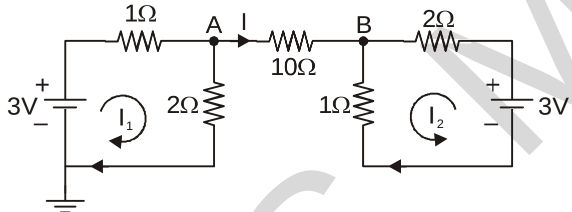
14. Consider the circuit shown in the figure. The current I flowing through the 10 Ω resistor is ________.



(a) 1 A (b) 0 A

(c) 0.1 A (d) –0.1 A

Sol: (b)



- Here, there is no any return closed path for Current (I). Hence I = 0.
- Current always flow in loop.

15. The Fourier transform $X(j\omega)$ of the signal $x(t) = \frac{t}{(1+t^2)^2}$ is ______.

(a) $\frac{\pi}{2j}\omega e^{-|\omega|}$ (b) $\frac{\pi}{2}\omega e^{-|\omega|}$

(c) $\frac{\pi}{2j}e^{-|\omega|}$ (d) $\frac{\pi}{2}e^{-|\omega|}$

Sol: (a)

$$x(t) = \frac{t}{(1+t^2)^2}$$

As we know that FT of $te^{-|t|} \xleftrightarrow{FT} \frac{-j4\omega}{(1+\omega^2)^2}$

Duality $\frac{-j4\omega}{(1+t^2)^2} \longleftrightarrow 2\pi(-\omega)e^{-|-\omega|}$

$$\Rightarrow \quad \frac{t}{(1+t^2)^2} \xrightarrow{FT} \frac{-2\pi}{-j4}\omega e^{-|\omega|}$$

$$\Rightarrow \quad \longrightarrow \boxed{\frac{\pi}{j2}\omega e^{-|\omega|}}$$

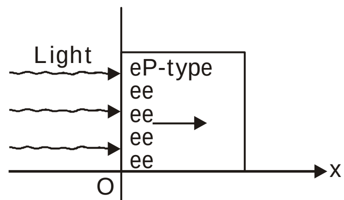
16. Consider a long rectangular bar of direct bandgap p-type semiconductor. The equilibrium hole density is 10^{17} cm^{-3} and the intrinsic carrier concentration is 10^{10} cm^{-3}. Electron and hole diffusion lengths are $2\mu m$ and $1\mu m$, respectively.

The left side of the bar (x = 0) is uniformly illuminated with a laser having photon energy greater than the bandgap of the semiconductor. Excess electron-hole pairs are generated ONLY at x = 0 because of the laser. The steady state electron density at x = 0 is 10^{14} cm^{-3} due to laser illumination. Under these conditions and ignoring electric field, the closest approximation (among the given options) of the steady state electron density at x = 2 μm, is __________.

(a) 0.37×10^{14} cm^{-3} (b) 0.63×10^{13} cm^{-3}

(c) 3.7×10^{14} cm^{-3} (d) 10^{3} cm^{-3}

Sol: (a)



From continuity equation of electrons

$$\frac{dn}{dt} = n\mu_n\frac{dE}{dx} + \mu_n E\frac{dn}{dx} + G_n - R_n + x_n\frac{d^2x}{dx^2} \quad ...(i)$$

0 + 0

[Because $\vec{E}$ is not mentioned hence

$\frac{dE}{dx} = 0 \; [\vec{E} = 0]$

For x > 0, G_n is also zero

$$n = \frac{n_i^2}{N_A} = \frac{10^{20}}{10^{17}} = 10^3$$

$$\because \quad n = n_0 + \delta n$$

$$= 10^3 + 10^{14} = 10^{14}$$

at steady state, $\frac{dn}{dt} = 0$

Hence equation (i) becomes:

$$O = D_n \frac{d^2\delta n}{dx^2} - \frac{\delta n}{\tau_n}$$

$$\Rightarrow \quad \frac{d^2\delta_n}{dx^2} = \frac{\delta_n}{L_n^2} \quad \text{...(ii)}$$

From solving equation (ii)

$$\delta_n(x) = \delta_n(0)e^{-x/L_n}$$

at $\quad x = 2\mu m$

$$\delta_n(2\mu m) = 10^{14}e^{-\frac{2}{2}} = 10^{14}e^{-1}$$

$$= \boxed{0.37 \times 10^{14}}$$

17. In a non-degenerate bulk semiconductor with electron density $n = 10^{16}$ cm^{-3}, the value of $E_C - F_{Fn}$ = 200 meV, where E_C and E_{Fn} denote the bottom of the conduction band energy and electron Fermi level energy, respectively. Assume thermal voltage as 26 meV and the intrinsic carrier concentration is 10^{10} cm^{-3}. For n = 0.5 × 10^{16} cm^{-3}, the closest approximation of the value of ($E_C - E_{Fn}$), among the given options, is __________.

(a) 226 meV (b) 174 meV

(c) 218 meV (d) 182 meV

Sol: **(c)**

Here we have to find the value of $E_c - E_{fn}$

As we know,

$$E_C - E_F = kT\ell n\left(\frac{N_c}{n}\right) \quad \text{...(i)}$$

$$E_C - E_{F1} = kT\ell n\left(\frac{N_c}{n_1}\right) \quad \text{...(ii)}$$

$$E_C - E_{F2} = kT\ell n\left(\frac{N_c}{n_2}\right) \quad \text{...(iii)}$$

Equation (ii) - Equation (iii)

$$(E_c - E_{F1}) - (E_c - E_{F2}) = kT\,\ell n\left[\frac{\frac{N_c}{n_1}}{\frac{N_c}{n_2}}\right] = kT\ell n\,\frac{n_2}{n_1}$$

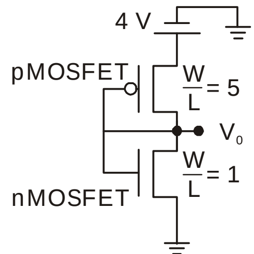
$$\Rightarrow 200\text{meV} - (E_c - E_{F2}) = 26\text{meV} \times \ell n\left(\frac{0.5 \times 10^{16}}{1 \times 10^{16}}\right)$$

$$200\text{mev} - (E_c - E_{F2}) = +26\ \text{mev}\ell n(0.5) = -18$$

$$\Rightarrow \quad (E_c - E_{F2}) = 200 + 8 = 218\ \text{meV}$$

$$= \boxed{218\,\text{meV}}$$

18. Consider the CMOS circuit shown in the figure (substrates are connected to their respective sources). The gate width (W) to gate length (L) ratios $\left(\frac{W}{L}\right)$ of the transistors are as shown. Both the transistors have the same gate oxide capacitance per unit area. For the pMOSFET, the threshold voltage is –1 V and the mobility of holes is 40 cm^2/V.s. For the nMOSFET, the threshold voltage is 1 V and the mobility of electrons is 300 cm^2/V.s. The steady state output voltage V_0 is _________.



(a) equal to 0 V (b) more than 2 V

(c) less than 2 V (d) equal to 2 V

Sol: **(c)**

Figure.

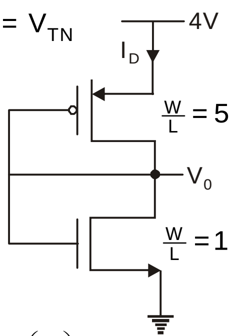
Given data : $|V_{TP}| = 1V = V_{TN}$

CO_x = equal

$\mu_n = 300$

$\mu_P = 40$

$I_{D1} = I_{D2}$



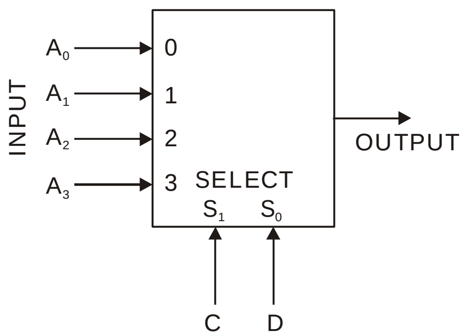
$$\mu_P CO_x\left(\frac{\omega}{L}\right)_1[4 - V_0 - 1]^2 = \mu_n CO_x\left(\frac{\omega}{L}\right)_2[V_0 - 0 - 1]^2$$

$$\Rightarrow \frac{300}{40} \times \frac{1}{5}(V_0 - 1)^2 = (3 - V_0)^2$$

$$\Rightarrow \sqrt{1.5}(V_0 - 1) = 3 - V_0$$

$$\Rightarrow \qquad V_0 = \frac{3+\sqrt{1.5}}{\sqrt{1.5}+1} = \text{less than 2V}$$

19. Consider the 2-bit multiplexer (MUX) shown in the figure. For OUTPUT to be the XOR of C and D, the values for A_0, A_1, A_2, and A_3 are ____________.



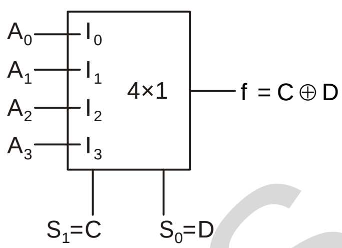
(a) $A_0 = 0,\ A_1 = 0,\ A_2 = 1,\ A_3 = 1$

(b) $A_0 = 1,\ A_1 = 0,\ A_2 = 1,\ A_3 = 0$

(c) $A_0 = 0,\ A_1 = 1,\ A_2 = 1,\ A_3 = 0$

(d) $A_0 = 1,\ A_1 = 1,\ A_2 = 0,\ A_3 = 0$

Sol: (c)



$$f = \bar{C}\bar{D}\underbrace{\cancel{I_0}}_{0} + \bar{C}DI_1 + C\bar{D}I_2 + CD\underbrace{\cancel{I_3}}_{0}$$

$$[C \oplus D]$$

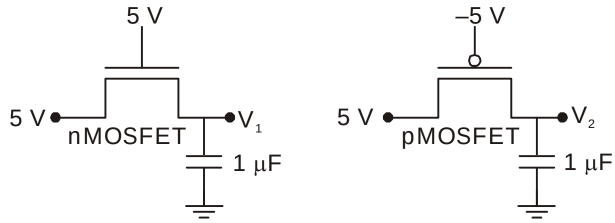
For this

$$A_0 = 0 = A_3$$

and $\quad A_1 = A_2 = 1$

Hence option (c)

20. The ideal long channel nMOSFET and pMOSFET devices shown in the circuits have threshold voltages of 1 V and –1 V, respectively. The MOSFET substrates are connected to their respective sources. Ignore leakage currents and assume that the capacitors are initially discharged. For the applied voltages as shown, the steady state voltages are ______________.



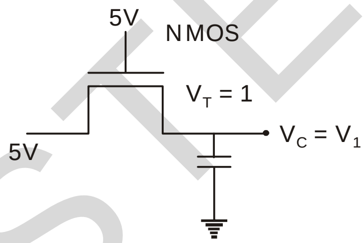
(a) $V_1 = 5\text{ V},\ V_2 = 5\text{ V}$

(b) $V_1 = 5\text{ V},\ V_2 = 4\text{ V}$

(c) $V_1 = 4\text{ V},\ V_2 = 5\text{ V}$

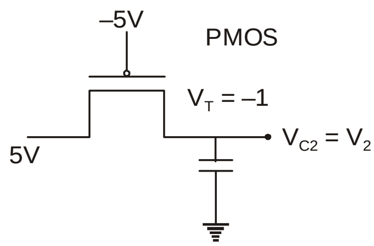
(d) $V_1 = 4\text{ V},\ V_2 = -5\text{ V}$

Sol: (c)



$$V_{C1} = \min(V_G - V_T, V_D)$$
$$= \min(4, 5)$$

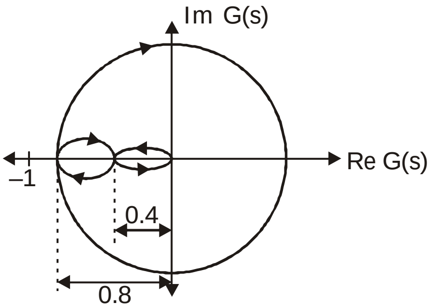
$$\boxed{V_{c1} = 4V}$$



$$V_{5G} > |V_{TP}|$$
$$V_{C2} + 4 > 1$$
$$\Rightarrow \quad V_{C2} > -4$$
$$V_{5D} > 0$$
$$V_{C2} \geq 5V$$

$$\boxed{V_{C2} = 5V}$$

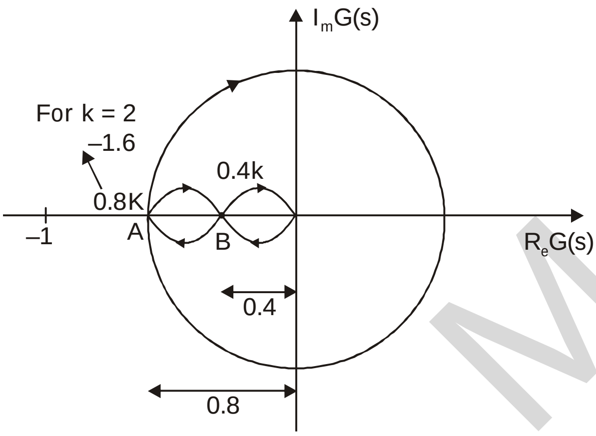
21. Consider a closed-loop control system with unity negative feedback and KG(s) in the forward path, where the gain K = 2. The complete Nyquist plot of the transfer function G(s) is shown in the figure. Note that the Nyquist contour has been chosen to have the clockwise sense. Assume G(s) has no poles on the closed right-half of the complex plane. The number of poles of the closed-loop transfer function in the closed right-half of the complex plane is ________.



(a) 0 (b) 1

(c) 2 (d) 3

Sol: (c)



For K = 2, point A will be –0.8 × 2 = –1.6

Hence $N = -2$

$P = 0$

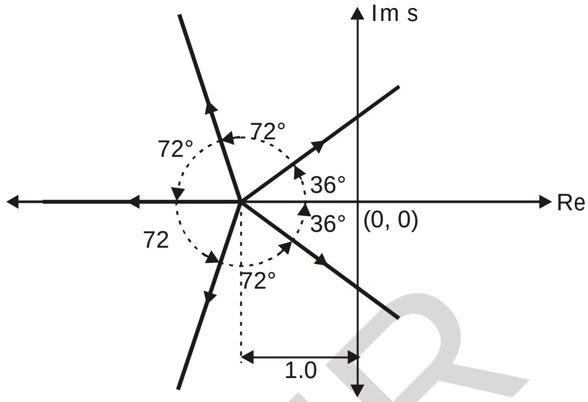
(By default Nyquist contoure is considered in clockwise direction)

$\boxed{P - N = 2}$

Number of closed loop pole in right side of the complex plane.

22. The root-locus plot of a closed-loop system with unity negative feedback and transfer function KG(s) in the forward path is shown in the figure. Note that K is varied from 0 to ∞.

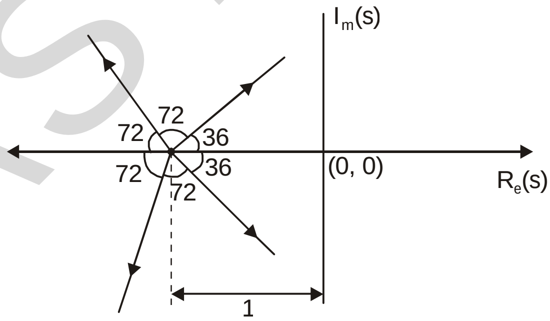
Select the transfer function G(s) that results in the root-locus plot of the closed-loop system as shown in the figure.



(a) $G(s) = \dfrac{1}{(s+1)^5}$ (b) $G(s) = \dfrac{1}{s^5+1}$

(c) $G(s) = \dfrac{s-1}{(s+1)^6}$ (d) $G(s) = \dfrac{s+1}{s^6+1}$

Sol: (a)



Here 5 Root Locus branches are diverging from same point, this can possible only when if we have 5 poles in the system at the same point because Root Locus branch departs from open loop pole and

Number of Root Locus branches = Number of open loop poles or Number of zero (Whichever is greater).

Here, there are 5 multiple Real poles, and matching with option (A).

23. The frequency response H(f) of a linear time-invariant system has magnitude as shown in the figure.

Statement I: The system is necessarily a pure delay system for inputs which are bandlimited to $-\alpha \le f \le \alpha$.

Statement II: For any wide-sense stationary input process with power spectral density $S_X(f)$, the output power spectral density $S_Y(f)$ obeys $S_Y(f) = S_X(f)$ for $-\alpha \le f \le \alpha$.