General Aptitude Part

Q.1 to Q.5 Carry One Mark Each

Question 1

The village was nested in a green spot, _______ the ocean and the hills.

(A) through (B) in

(C) at (D) between

Ans. (D)

Sol. The village was nested in a green spot, **between** the ocean and the hills.

Hence, the correct option is (D).

Question 2

Disagree : Protest :: Agree : _______.

(By word meaning)

(A) Refuse (B) Pretext

(C) Recommend (D) Refute

Ans. (C)

Sol. **Given :** disagree is related with protest in a special manner, as disagree is feeling of our choice and protest is resultant action as when we disagree with something we protest against it. In the same relationship agree will be related to recommend.

Here, agree is our internal feeling and recommend is external resultant action as when we are agreed with something we do recommend.

Hence, the correct option is (C).

Question 3

A 'frabjous' number is defined as a 3 digit number with all digits odd, and no two adjacent digits being the same. For example, 137 is a frabjous number, while 133 is not. How many such frabjous numbers exist?

(D) 125 (B) 720

(C) 60 (D) 80

Ans. (D)

Question 4

Which one among the following statements must be TRUE about the mean and the median of the scores of all candidates appearing for GATE 2023?

(A) The median is at least as large as the mean.

(B) The mean is at least as large as the median.

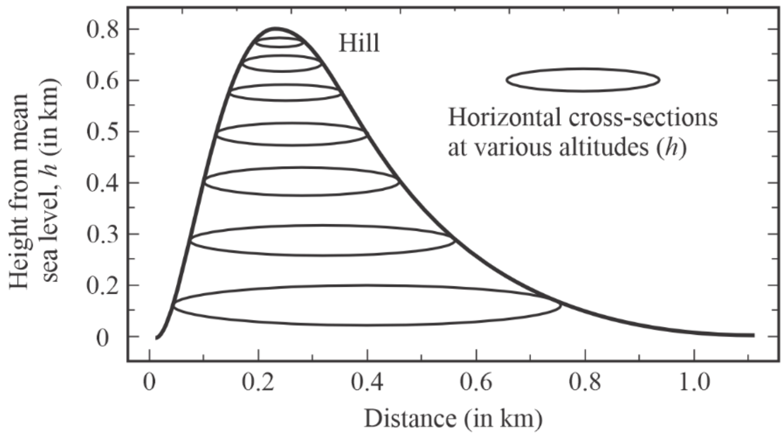
(C) At most half the candidates have score that is larger than the median.

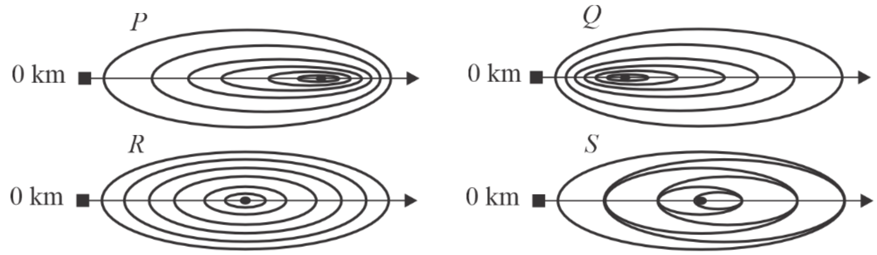
(D) At most half the candidates have a score that is larger than the mean.

Ans. (C)

Question 5

In the given diagram, ovals are marked at different heights (h) of a hill. Which one of the following options P, Q, R and S depicts the top view of the hill?





(A) P (B) Q

(C) R (D) S

Ans. **(B)**

Sol. **Given :** In the diagram ovals (contour lines) are marked at different heights (h) of a hill. The top view of the hill is best depicts by option Q from the figure we can see AB is perpendicular to CD and the slop of the hill is divided in PQ and QR in two parts.

Slop QR is stretching linearly as it down wards and the ovals are widening from line AB towards slop QP, which we can clearly see in the top view diagram of the hill in figure Q.

Hence, the correct option is (B).

Q.6 to Q.10 Carry Two Marks Each

Question 6

Residency is a famous housing complex with many well-established individuals among its residents. A recent survey conducted among the residents of the complex revealed that all of those residents who are well established in their respective fields happen to be academicians. The survey also revealed that most of these academicians are authors of some best-selling books.

Based only on the information provided above, which one of the following statements can be logically inferred with certainty?

(A) Some residents of the complex who are well established in their fields are also authors of some best-selling books.

(B) All academicians residing in the complex are well established in their fields

(C) Some authors of best-selling books are residents of the complex who are well-established in their fields

(D) Some academicians residing in the complex are well established in their fields.

Ans. (D)

Sol. Residency is a famous housing complex with many well-established individuals among its residents. A recent survey conducted among the residents of the complex revealed that all of those residents who are well established in their respective fields happen to be academicians. From this information we can easily inferred that "Some academicians residing in the complex are well established in their fields" option (D) is correct.

Option (C) cannot be inferred with certainty as it is not a necessary condition some residents who are established in their field cannot be the authors of any book.

Option (B) can also not be inferred as it is clearly mention in the passage, all those residents who are well established in their respective field are academicians and vice-versa cannot be certainly inferred.

Option (A) can also not be inferred as "some authors of bestselling books are residents of the complex who are wells established in their fields." Are academicians which is not mention in option.

Hence, the correct option is (D).

Question 7

Ankita has to climb 5 stairs starting at the ground, while respecting the following rules :

1. At any stage, Ankita can move either one or two stairs up.
2. At any stage, Ankita cannot move to a lower step.

Let $F(N)$ denote the number of possible ways in which Ankita can reach the N^{th} stair.

For example, $F(1)=1, F(2)=2, F(3)=3.$

The value of $F(5)$ is _______.

(A) 8 (B) 7
(C) 6 (D) 5

Ans. (A)

Question 8

The information contained in DNA is used to synthesize proteins that are necessary for the functioning of life. DNA is composed of four nucleotides: Adenine (A), Thymine (T), Cytosine (C), and Guanine (G). The information contained in DNA can then be thought of as a sequence of these four nucleotides: A, T, C, and G. DNA has coding and non-coding regions. Coding regions where the sequence of these nucleotides are read in groups of three to produce individual amino acids—constitute only about 2% of human DNA. For example, the triplet of nucleotides CCG codes for the amino acid glycine, while the triplet GGA codes for the amino acid proline. Multiple amino acids are then assembled to form a protein.

Based only on the information provided above, which of the following statements can be logically inferred with certainty?

(i) The majority of human DNA has no role in the synthesis of proteins.
(ii) The function of about 98% of human DNA is not understood.

(A) only (i) (B) only (ii)
(C) both (i) and (ii) (D) neither (i) nor (ii)

Ans. (C)

Sol. (i) The majority of human DNA has no rule in the synthesis of proteins can be inferred with certainty, as "the information contained in DNA is used to synthesis proteins is given in the passage. Apart from this there in no information in passage that how much part of human DNA has role in the synthesis of proteins.

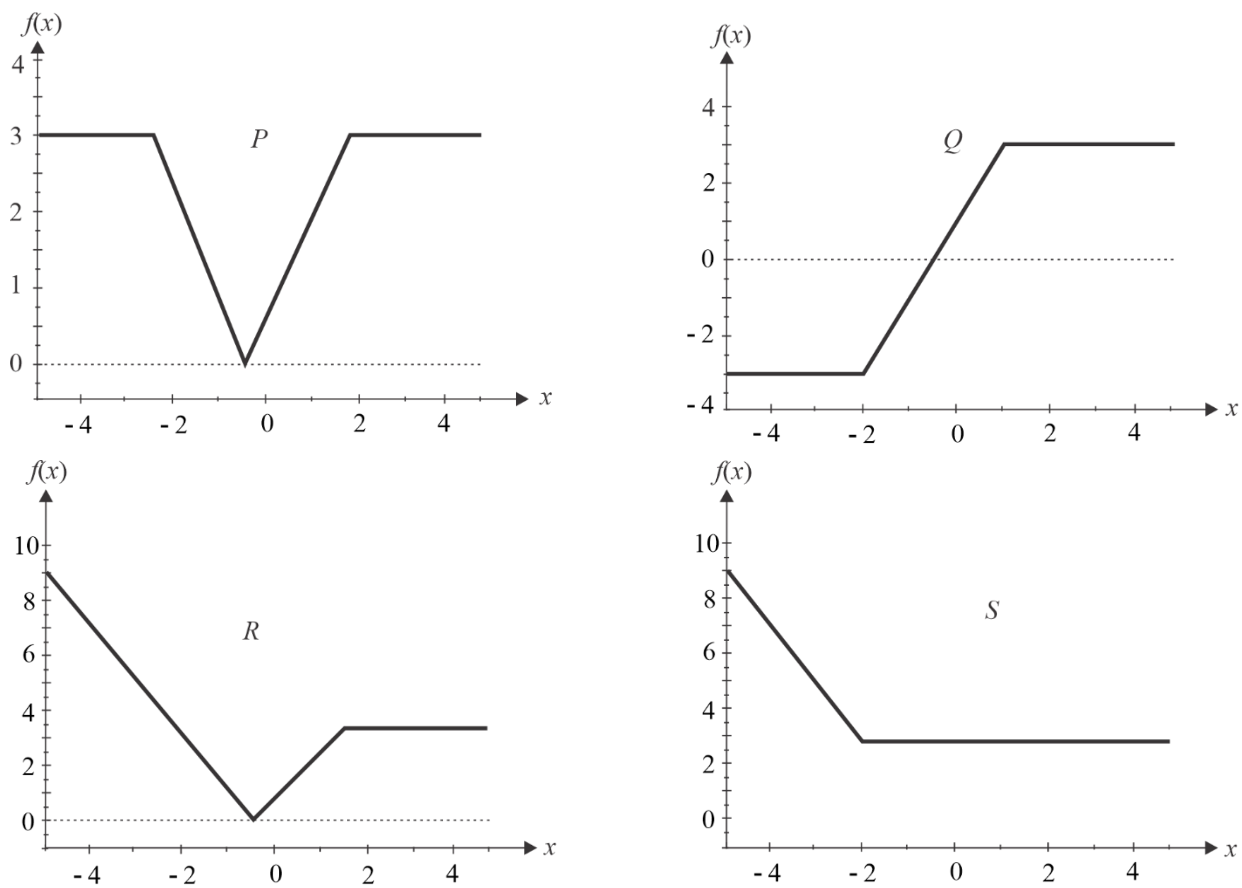
(ii) The function of about 98% of human DNA is not understood can be inferred with certainty as "DNA has coding and non-coding regions. Coding regions constitute only about 2% of human DNA" is given in the passage and we have no information about non-coding region of DNA in the passage.

Hence, the correct option is (D).

Question 9

Which one of the given figures *P*, *Q*, *R* and *S* represents the graph of the following function?

$$f(x) = \big||x+2| - |x-1|\big|$$



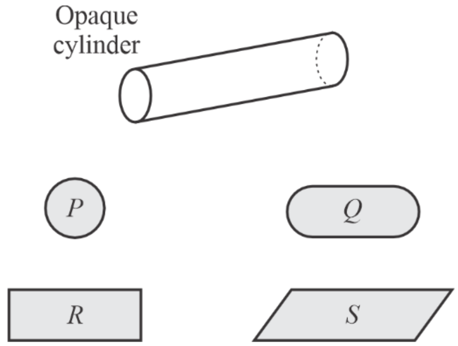
(A) *P* (B) *Q*

(C) *R* (D) *S*

Ans. (A)

Question 10

An opaque cylinder (shown below) is suspended in the path of a parallel beam of light, such that its shadow is cast on a screen oriented perpendicular to the direction of the light beam. The cylinder can be reoriented in any direction within the light beam, Under these conditions, which one of the shadows *P*, *Q*, *R* and *S* is NOT possible?



(A) *P* (B) *Q*

(C) *R* (D) *S*

Ans. (D)

Sol. Given : An opaque cylinder is suspended in the path of a parallel beam of light such that its shadow is cast on a screen oriented perpendicular to the direction of light beam.

The cylinder can be reoriented in any direction within the light beam. Under these conditions shadow S is not possible.

Hence, the correct option is (D).

Technical Part

Q.11 to Q.35 Carry One Mark Each

Question 11 **[Engineering Mathematics, Linear Algebra]**

Choose solution set *S* corresponding to the systems of two equations

$$x-2y+z=0$$

$$x-z=0$$

Note : R denotes the set of real numbers

(A) $S=\left\{\alpha\begin{pmatrix}1\\1\\1\end{pmatrix}\middle|\alpha\in R\right\}$

(B) $S=\left\{\alpha\begin{pmatrix}1\\1\\1\end{pmatrix}+\beta\begin{pmatrix}1\\0\\1\end{pmatrix}\middle|\alpha,\beta,\in R\right\}$

(C) $S=\left\{\alpha\begin{pmatrix}1\\1\\1\end{pmatrix}+\beta\begin{pmatrix}2\\1\\2\end{pmatrix}\middle|\alpha,\beta,\in R\right\}$

(D) $S=\left\{\alpha\begin{pmatrix}1\\0\\1\end{pmatrix}\middle|\alpha\in R\right\}$

Ans. (A)

Sol. Given : System of equations are : $x-2y+z=0$ and $x-z=0$

The equations can be written in matrix form as,

$$\begin{bmatrix} 1 & -2 & 1 \\ 1 & 0 & -1 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

On applying the row operation $R_2 \leftarrow R_2 - R_1$, we get

$$\begin{bmatrix} 1 & -2 & 1 \\ 0 & 2 & -2 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

The modified equations are,

$x - 2y + z = 0$ ...(i)

$2y - 2z = 0$ ....(ii)

At $z = \alpha$,

$2y - 2\alpha = 0$

$y = \alpha$

$x - 2\alpha + \alpha = 0 \Rightarrow x = \alpha$

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} \alpha \\ \alpha \\ \alpha \end{bmatrix} = \alpha \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$

Hence, the correct option is (A).

Question 12 **[Measurement]**

Inductance of a coil is measured as 10 mH, using an LCR meter, when no other objects are present near the coil. The LCR meter uses a sinusoidal excitation at 10 kHz. If a pure copper sheet is brought near the coil, the same LCR meter will read _____.

(A) Less than 10 mH

(B) 10 mH

(C) More than 10 mH

(D) Less than 10 mH initially and then stabilizes to more than 10 mH

Ans. (A)

Question 13 **[Measurement]**

Which of the following flow meters offers the lowest resistance to the flow?

(A) Turbine flow meter (B) Orifice flow meter

(C) Venturi meter (D) Electromagnetic flow meter

Ans. (D)

Question 14

Pair the quantities (p) to (s) with the measuring devices (i) to (iv)

(i)	Linear Variable Differential Transformer (LVDT)	(p)	Torque

(ii)	Thermistor	(q)	Pressure
(iii)	Strain gauge	(r)	Linear position
(iv)	Diaphragm	(s)	Temperature

(A) (i)-(r), (ii)-(s), (iii)-(q), (iv)-(p)
(B) (i)-(p), (ii)-(s), (iii)-(r), (iv)-(q)
(C) (i)-(r), (ii)-(s), (iii)-(p), (iv)-(q)
(D) (i)-(q), (ii)-(s), (iii)-(p), (iv)-(r)

Ans. (C)

Question 15

Capacitance 'C' of a parallel plate structure is calculated as 20 pF using $C = \frac{\varepsilon_0 \varepsilon_r A}{d}$, where ε_0 is the permittivity of free space, ε_r is the relative permittivity of the dielectric, A is the overlapping area of the electrodes and d is the distance between them. The value of C is then measured using an LCR meter. If the meter is assumed to be ideal and in produces no error due to cable capacitance, which one of the following needing is likely to be correct?

(A) 20.5 pF
(B) 20 pF
(C 19.5 pF
(D) 10 pF

Ans. (A)

Question 16 **(Digital Electronics)**

The table shows the present state $Q(t)$, next state $Q(t+1)$, and the control input in a flip flop. Identify the flip-flop.

$Q(t)$	$Q(t+1)$	Input
0	0	0
0	1	1
1	0	1
1	1	0

(A) T flip-flop
(B) D flip-flop
(C) SR flip-flop
(D) JK flip-flop

Ans. (A)

Sol. **Given :** Table of present state $Q(t)$, next state $Q(t+1)$ and control input is shown below,

$Q(t)$	$Q(t+1)$	Input
0	0	0
0	1	1
1	0	1
1	1	0

From the given table, $Q(t+1) = Q(t) \oplus \text{Input}$ ...(i)

Comparing equation (i) with characteristics equation of T-flip-flop.

$Q(t+1) = Q(t) \oplus T$

Hence, it is a T flip-flop.

Hence, the correct option is (A).

Question 17 **(Digital Electronics)**

Match the Exclusive-OR (XOR) operations (i) to (iv) with the results (p) to (s), where X is a Boolean input.

(i) $X \oplus X$ (p) 1

(ii) $X \oplus \overline{X}$ (q) 0

(iii) $X \oplus 0$ (r) $\overline{X}$

(iv) $X \oplus 1$ (s) X

(A) (i)-(q), (ii)-(r), (iii)-(s), (iv)-(p)

(B) (i)-(q), (ii)-(r), (iii)-(p), (iv)-(s)

(C) (i)-(p), (ii)-(s), (iii)-(q), (iv)-(r)

(D) (i)-(q), (ii)-(p), (iii)-(s), (iv)-(r)

Ans. **(D)**

Sol. For XOR gate, we know that,

$$A \oplus B = \overline{A}B + A\overline{B}$$

Solving all the given equations using this result of XOR gate,

$$X \oplus X = \overline{X}X + X\overline{X} = 0 + 0 = 0$$

$$X \oplus \overline{X} = \overline{X}\,\overline{X} + XX = X + \overline{X} = 1$$

$$X \oplus 0 = \overline{X}0 + X\overline{0} = X$$

$$X \oplus 1 = \overline{X}1 + X\overline{1} = \overline{X}$$

So, (i)-q, (ii)-p, (iii)-s, (iv)-r.

Hence, the correct option is (D).

Question 18

A light emitting diode (LED) emits light when it is _____biased. A photodiode provides maximum sensitivity to light when it is _____ biased.

(A) forward, forward

(B) forward, reverse

(C) reverse, reverse

(D) reverse, forward

Ans. **(B)**

Sol. LED emits light in the forward biased.

Photodiode provides maximum sensitivity to light in reverse biased.

Hence, the correct option is (B).

Question 19

$F(z) = \dfrac{1}{1-z}$, when expanded as a power series around $z = 2$, would result in $F(z) = \sum_{k=0}^{\infty} a_k (z-2)^k$, with the region of convergence (ROC) $|z-2| < 1$. The coefficients $a_k, k \geq 0$, are given by the expression________.

(A) $(-1)^k$

(B) $(-1)^{k+1}$

(C) $\left(\frac{1}{2}\right)^k$ (D) $\left(\frac{-1}{2}\right)^{k+1}$

Ans. (B)

Sol. **Given :** $F(z)=\frac{1}{1-z}$

Let z – 2 = t

z = 2 + t

$$F(t)=\frac{1}{1-2-t}=\frac{1}{-1-t}=\frac{-1}{1+t}$$

$$F(t)=(-1)(1-t+t^2-t^3+......)$$

$$F(t)=-1+t-t^2+t^3.....$$

$$F(z)=-1+(z-2)-(z-2)^2+(z-2)^3+......$$

$$F(z)=\sum_{k=0}^{\infty}(-1)^{k+1}(z-2)^k$$

$\therefore \quad a_k=(-1)^{k+1}$

Hence, the correct option is (B).

Question 20 **[Engineering Mathematics, Differential Equation]**

The solution $x(t)$, $t\geq 0$, to the differential equation $\ddot{x}=-k\dot{x}$, $k>0$ with initial condition $x(0)$ = 1 and $\dot{x}(0)=0$ is

(A) $x(t)=2e^{-kt}+2kt-1$ (B) $x(t)=2e^{-kt}-1$

(C) $x(t)=1$ (D) $x(t)=2e^{-kt}-kt-1$

Ans. (C)

Sol. **Method 1 :**

Given : Differential equation is, $\ddot{x}=-k\dot{x}$

Initial conditions, $x(0)=1,\ x'(0)=0$

$$\frac{d^2x(t)}{dt^2}=-k\frac{dx(t)}{dt}$$

Taking Laplace transform on both sides,

$$s^2X(s)-s\,x(0)-x'(0)=-k[sX(s)-x'(0)]$$

$$s^2X(s)-s\times 1-0=-k[sX(s)-1]$$

$$s^2X(s)-s=-ksX(s)+k$$

$$[s^2+ks]X(s)=s+k$$

$$X(s)=\frac{s+k}{s(s+k)}=\frac{1}{s}$$

Taking inverse Laplace transform,

$x(t)=1$

Hence, the correct option is (C).

Method 2 :

Given : Differential equation is, $\ddot{x}=-k\dot{x}$

$D^2=-kD$

$D(D+k)=0$

$D=0,\ D=-k$

$x(t)=C_1+C_2e^{-kt}$ ...(i)

Initial condition, $x(0)=1$

$1=C_1+C_2$ ...(ii)

$\dot{x}(t)=0+C_2(-k)e^{-kt}$

Also, $\dot{x}(0)=0 \Rightarrow 0=C_2e^0 \Rightarrow C_2=0$

From equation (ii), $C_1=1$

From equation (i), $x(t)=1$

Hence, the correct option is (C).

Question 21 **(Signals & Systems)**

A system has the transfer function $\dfrac{Y(s)}{X(s)}=\dfrac{s-\pi}{s+\pi}$. Let $u(t)$ be the unit step function. The input $x(t)$ that results in a steady-state output $y(t)=\sin\pi t$ is ________.

(B) $x(t)=\sin(\pi t)u(t)$

(B) $x(t)=\sin\left(\pi t+\dfrac{\pi}{2}\right)u(t)$

(C) $x(t)=\sin\left(\pi t-\dfrac{\pi}{2}\right)u(t)$

(D) $x(t)=\cos\left(\pi t+\dfrac{\pi}{4}\right)u(t)$

Ans. (C)

Sol. Given : Transfer function of system is, $\dfrac{Y(s)}{X(s)}=\dfrac{s-\pi}{s+\pi}$

Steady state output, $y(t)=\sin\pi t$ (Here, $\omega=\pi$ rad/sec)

Transfer function, $H(s)=\dfrac{s-\pi}{s+\pi}$

Put $s=j\omega$,

$$\Rightarrow \quad H(j\omega)=\frac{j\omega-\pi}{j\omega+\pi}$$

$$\Rightarrow \quad |H(j\omega)|=\frac{\sqrt{\omega^2+\pi^2}}{\sqrt{\omega^2+\pi^2}}=1$$

$$\angle H(j\omega)=180^0-2\tan^{-1}\frac{\omega}{\pi}$$

$\angle H(j\omega)|_{\omega=\pi} = 180 - 2\tan^{-1}1 = 90^0$

Since, given output, $y(t) = \sin \pi t$

Therefore, input $x(t)$ is,

$x(t) = \sin(\pi t - 90^0)$

$\therefore \quad x(t) = \sin\left(\pi t - \frac{\pi}{2}\right)u(t)$

Hence, the correct option is (C).

Question 22 **(Digital Electronics)**

Choose the fastest logic family among the following :

(A) Transistor-Transistor Logic
(B) Emitter-Coupled Logic
(C) CMOS Logic
(D) Resistor-Transistor Logic

Ans. (B)

Sol. Emitter coupled Logic is the fastest Logic family among the given options.

Hence, the correct option is (B).

Question 23 **[Engineering Mathematics, Limit & Series]**

What is $\lim_{x\to 0} f(x)$, where $f(x) = x\sin\frac{1}{x}$?

(A) 0
(B) 1
(C) ∞
(D) Limit does not exist

Ans. (A)

Sol. Given : $f(x) = x\sin\frac{1}{x}$

$\lim_{x\to 0} f(x) = \lim_{x\to 0} x\sin\frac{1}{x}$

Range of sin function will always be $[-1,1]$.

$\therefore \quad \lim_{x\to 0} x\sin\frac{1}{x} = 0\times[-1,1] = 0$

Hence, the correct option is (A).

Question 24 **[Control System, Routh's Array]**

The number of zeros of the polynomial $P(s) = s^3 + 2s^2 + 5s + 80$ in the right half plane is ________.

Ans. 2 (2 to 2)

Sol. Given : Polynomial, $P(s) = s^3 + 2s^2 + 5s + 80$

Routh tabulation of $P(s)$,

s^3	1	5	
s^2	2	80	
s^1	- 35		2 sign changes
s^0	80		

Since, there are 2 sign changes in the first column of Routh tabulation. The number of zeros in the right half of s-plane will be 2.

Hence, the correct answer is 2.

Question 25 **[Control System]**

The number of times the Nyquist plot of $G(s)H(s)=\frac{1}{2}\frac{(s-1)(s-2)}{(s+1)(s+2)}$ encircles the origin is ___________.

Ans. 2 (2 to 2)

Sol. Given : $G(s)H(s)=\frac{(s-1)(s-2)}{(s+1)(s+2)}$

Number of encirclement about origin

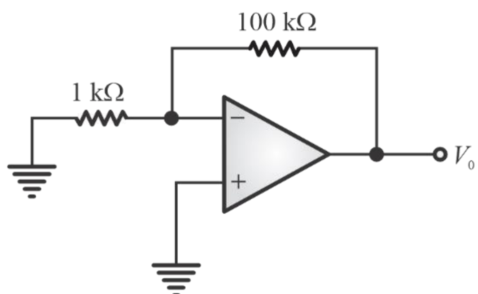
$N(0,0)=$open loop poles in the right half of s-plane open loop zero's in the right half of s-plane.

$=0-2\ =-2\ =2$ [in clockwise direction]

Hence, the correct answer is 2.

Question 26 **[Analog Electronics, Op-Amp]**

The op-amp in the circuit shown is ideal, except that it has an input bias current of 1 nA and an input offset voltage of $10\,\mu\text{V}$. The resulting worst-case output voltage will be $\pm$ _________ μV (rounded off to the nearest integer).

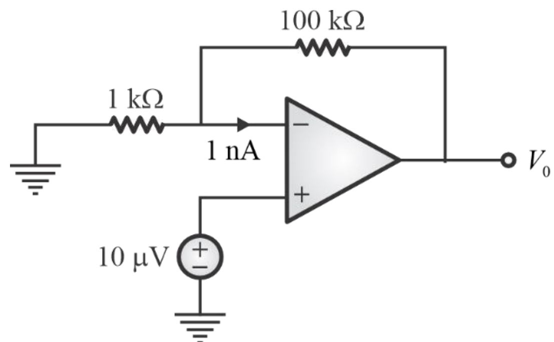


Ans. 1110 (1110 to 1110)

Sol. Given : Input bias current = 1 nA

Input offset voltage $=10\ \mu\text{V}$

Given circuit can be drawn as shown below,



Applying KCL at inverting terminal,

$$\frac{10\times10^{-6}-0}{1\ \text{k}\Omega}+\frac{10\times10^{-6}-V_0}{100\ \text{k}\Omega}+10^{-9}=0$$

$$\frac{1000\times10^{-6}+10\times10^{-6}-V_0}{100\ \text{k}\Omega}=-10^{-9}$$

$$V_0=1010\times10^{-6}+10^{2}\times10^{-9}\times10^{3}$$

$$V_0=1110\ \mu\text{V}$$

Hence, the correct answer is 1110.

Question 27

The force per unit length between two infinitely long parallel conductors, with a gap of 2 cm between them is 10 μN/m. When the gap is doubled, the force per unit length will be ____ μN/m (rounded off to one decimal place).

Ans. 5 (4.9 to 5.1)

Sol. Given : Gap = 2 cm and Force per unit length $F=10\ \mu\text{N/m}$

For two infinitely long,

Parallel conductors, $F\propto\frac{1}{gap}$

$$\frac{F_1}{F_2}=\frac{(gap)_2}{(gap)_1}$$

$$\Rightarrow \frac{10}{F_2}=\frac{4}{2} \quad (\because \text{ Gap is doubled})$$

$$\Rightarrow F_2=\frac{20}{4}=5\ \mu\text{N/m.}$$

Hence, the correct answer is 5.

Question 28 **(Signals & Systems)**

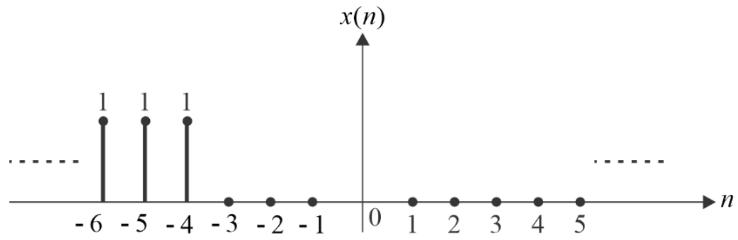
Consider the discrete time signal $x[n]=u[-n+5]-u[n+3]$, where $u[n]=\begin{cases}1; & n\geq 0\\ 0; & n<0\end{cases}$.

The smallest n for which $x[n]=0$ is _____.

Ans. **– 3 (– 3 to – 3)**

Sol. **Given :** $x(n) = u(-n+5) - u(n+3)$

The signal $x(n)$ can be plotted as shown below,



So, the smallest value of n is -3 for $x(n)$ to be zero.

Hence, the correct answer is – 3.

Question 29 **[Signal & System, Basic of Signal]**

Let $y(t) = x(4t)$, where $x(t)$ is a continuous-time periodic signal with fundamental period of 100 s. The fundamental period of $y(t)$ is _____s. (rounded off to the nearest integer)

Ans. **25 (25 to 25)**

Sol. **Given :** $y(t) = x(4t)$

Fundamental period of $x(t) = 100$ s

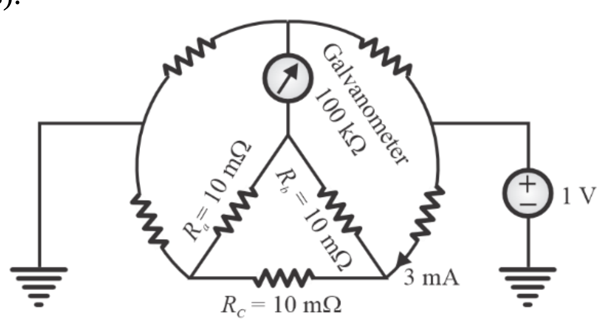
If $x(t)$ has time period T, then $x(at)$ will have the time period $\frac{T}{a}$.

$\therefore$ Time period of $y(t)$ will be, $T_y = \frac{100}{4} = 25\text{sec}$.

Hence, the correct answer is 25.

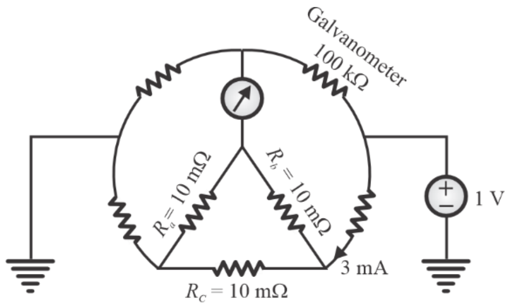
Question 30 **[Network Theory]**

When the bridge given below is balanced, the current through the resistor R_a is _______mA (rounded off to two decimal places).

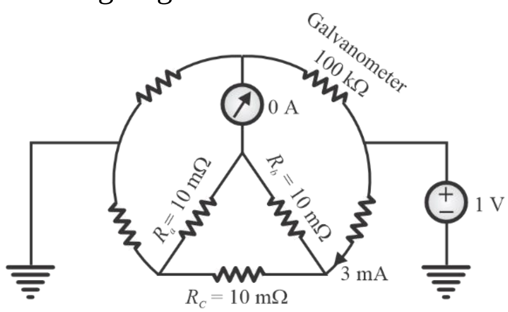


Ans. **1 (0.99 to 1.01)**

Sol. Given circuit is as shown below,



As the bridge is balanced, the reading of galvanometer will be zero.

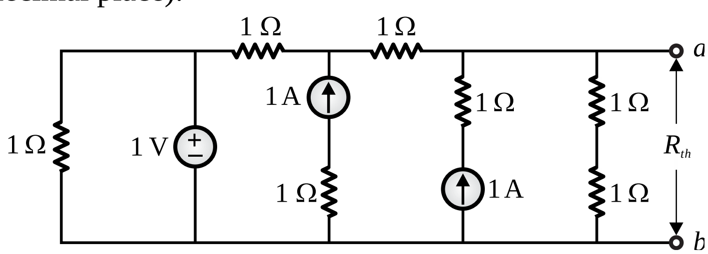


Using current division rule, current through R_a will be, $\frac{3\times10}{30}=1\text{mA}$.

Hence, the correct answer is 1.

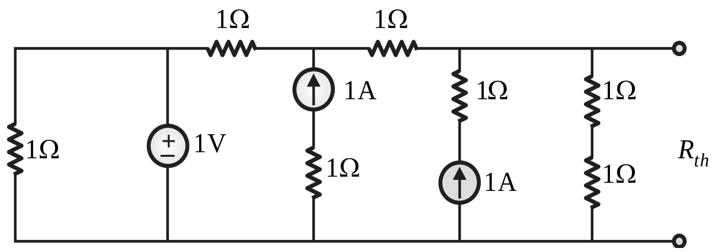
Question 31

In the circuit given, the Thevenin equivalent resistance R_{th} across the terminals 'a' and 'b' is ________ Ω (rounded off to one decimal place).

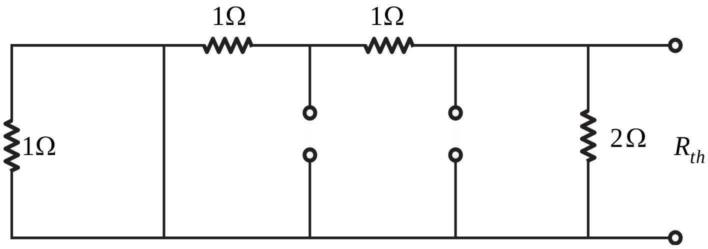


Ans. **1 (1.0 to 1.0)**

Sol. Given circuit is as shown below,



For calculating R_{th}, independent sources are replaced by their internal resistance i.e. voltage source is replaced by short circuit and current source by open circuit. Hence, the circuit becomes,



$R_{th} = 2 \| 2$

$R_{th} = 1\,\Omega$

Hence, the correct answer is 1.

Question 32 **[Engineering Mathematics, Probability & Statics]**

X is a discrete random variable which takes values 0, 1 and 2. The probabilities are $P(X=0)=0.25$ and $P(X=1)=0.5$. With $E[\bullet]$ denoting the expectation operator, the value of $E[X]-[X^2]$ is ________ (rounded off to one decimal places).

Ans. **– 0.5 (– 0.5 to – 0.5)**

Sol. **Given :** Data in the question can be tabulated as shown below,

X	0	1	2
P(X)	0.25	0.5	0.25

$\Rightarrow \quad E(X) = \Sigma X.P(X) = 0(0.25)+1(0.5)+2(0.25) = 0.5+0.5 = 1$

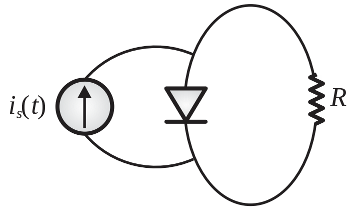
$E(X^2) = \Sigma X^2.P(X) = 0^2(0.25)+(1)^2(0.5)+2^2(0.25) = 1+0.5 = 1.5$

$E(X)-E(X^2) = 1-1.5 = -0.5$

Hence, the correct answer is – 0.5.

Question 33

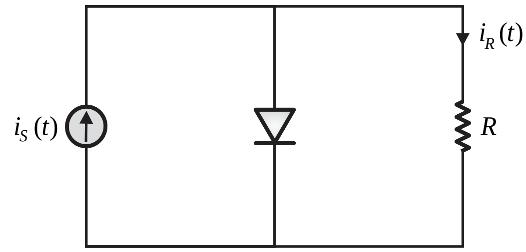
The diode in the circuit is ideal. The current source $i_s(t) = \pi \sin(3000\pi t)$ mA. The magnitude of average current flowing through the resistor R is _______ mA (rounded off to two decimal places).



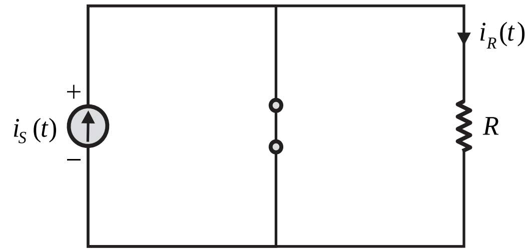
Ans. **1 (0.95 to 1.05)**

Sol. **Given :** $i_s(t) = \pi \sin(3000\pi t)$ mA

Given circuit can be drawn as shown below

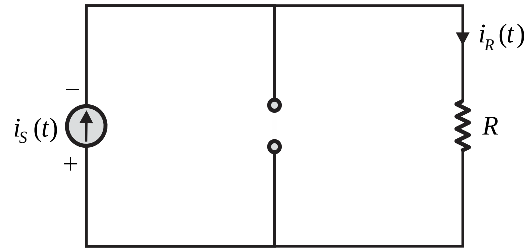


For positive half cycle, diode is forward biased (acts as short circuit).



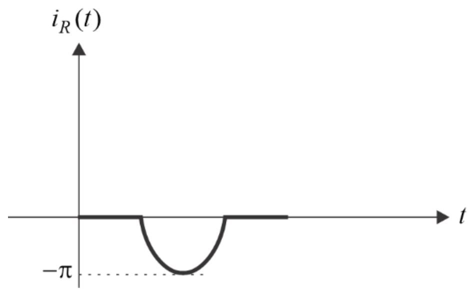
$\therefore \quad i_R(t) = 0\text{A}$

For negative half cycle, diode is reverse biased (acts as open circuit),



$\therefore \quad i_R(t) = -i_s(t)$

Waveform of $i_R(t)$ will be



$\therefore$ Average value of $i_R(t)$ will be,

$$(i_R(t))_{avg} = \frac{\text{Peak value}}{\pi} = \frac{-\pi}{\pi} = -1 \text{ mA}$$

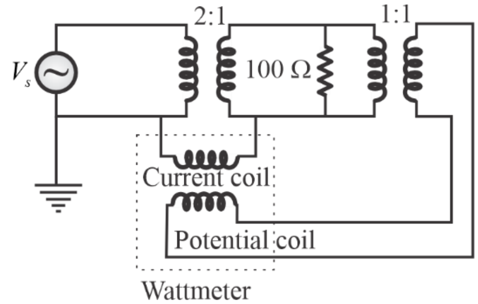
Magnitude of average current flowing through R,

$$\left| i_R(t)_{avg} \right| = 1 \text{ mA}$$

Hence, the correct answer is 1.

Question 34 **[Measurement]**

The full-scale range of the wattmeter shown in the circuit is 100 W. The turns ratio of the individual transformers are indicated in the figure. The RMS value of the ac source voltage V_s is 200 V. The wattmeter reading will be ______ W. (rounded off to the nearest integer)



Ans. 0 (0 to 0)

Question 35

The no-load steady-state output voltage of a DC stunt generator is 200 V when it is driven in the clockwise direction at its rated speed. If the same machine is driven at the rated speed but in the opposite direction, the steady-state output voltage will be____ V (round off to the nearest integer).

Ans. 0 (0 to 0)

Q.36 to Q.65 Carry Two Marks Each

Question 36 **(Signals & Systems)**

The impulse response of an LTI system is $h(t) = \delta(t) + 0.5\delta(t-4)$, where $\delta(t)$ is the continuous-time unit impulse signal. If the input signal $x(t) = \cos\left(\frac{7\pi}{4}t\right)$, the output is

(A) $0.5\cos\left(\frac{7\pi}{4}t\right)$

(B) $1.5\cos\left(\frac{7\pi}{4}t\right)$

(C) $0.5\sin\left(\frac{7\pi}{4}t\right)$

(D) $1.5\sin\left(\frac{7\pi}{4}t\right)$

Ans. (A)

Sol. **Given :** Input signal, $x(t) = \cos\left(\frac{7\pi}{4}t\right)$

Impulse response, $h(t) = \delta(t) + 0.5\delta(t-4)$

Taking Laplace transform on both sides, we get

$$H(s) = 1 + 0.5e^{-4s}$$

Put $s = j\omega$,

$$H(j\omega) = 1 + 0.5e^{-4j\omega}$$

$$H\left(j\frac{7\pi}{4}\right) = 1 + 0.5e^{-4j\times\frac{7\pi}{4}} = 0.5$$

$\therefore$ For input $x(t) = \cos\left(\frac{7\pi}{4}t\right)$, output will be

$$y(t) = H\left(j\frac{7\pi}{4}\right)x(t)$$

$$y(t) = 0.5\cos\left(\frac{7\pi}{4}t\right)$$

Hence, the correct option is (A).

Question 37 **(Signals & Systems)**

The Laplace transform of the continuous-time signal $x(t) = e^{-3t}u(t-5)$ is _______, where $u(t)$ denotes the continuous-time unit step signal.

(A) $\frac{e^{-5s}}{s+3}, \text{Real}\{s\} > -3$

(B) $\frac{e^{-5(s-3)}}{s-3}, \text{Real}\{s\} > 3$

(C) $\frac{e^{-5(s+3)}}{s+3}, \text{Real}\{s\} > -3$

(D) $\frac{e^{-5(s-3)}}{s+3}, \text{Real}\{s\} > -3$

Ans. (C)

Sol. **Given :** $x(t) = e^{-3t}u(t-5)$

$$x(t) = e^{-3(t-5+5)}u(t-5)$$

$$x(t) = e^{-15}e^{-3(t-5)}u(t-5)$$

Taking Laplace transform on both sides, we get

$$X(s) = e^{-15}\frac{e^{-5s}}{s+3} = \frac{e^{-5(s+3)}}{s+3}, \quad \text{Real}(s) > -3$$

Hence, the correct option is (C).

Question 38

In a p-i-n photodiode, a pulse of light containing 8×10^{12} incident photons at wavelength $\lambda_0 = 1.55\ \mu\text{m}$ gives rise to an average 4×10^{12} electrons collected at the terminals of the device. The quantum efficiency of the photodiode at this wavelength is ______ %.

(A) 50

(B) 54.2

(C) 62.5

(D) 80

Ans. (A)

Sol. **Given :** Number of electrons collected $= 4\times10^{12}$ and number of incident photons $= 8\times10^{12}$

Quantum efficiency,

$$\eta = \frac{\text{Number of electrons collected}}{\text{Number of incident photons}}\times100$$

$$\eta = \frac{4\times10^{12}}{8\times10^{12}}\times100 = 50\%$$

Hence, the correct option is (A).

Question 39 **[Engineering Mathematics, Complex Variable]**

Let $f(z) = j\left(\frac{1-z}{1+z}\right)$, where z denotes a complex number and j denotes $\sqrt{-1}$. The inverse function $f^{-1}(z)$ maps the real axis to the_________.

(A) Unit circle with centre at the origin

(B) Unit circle with centre not at the origin

(C) imaginary axis

(D) real axis

Ans. (A)

Sol. **Given :** $f(z) = j\frac{1-z}{1+z} = j\left(\frac{1-x-jy}{1+x+jy}\right)$

$$u + jv = \frac{j(1-x)+y}{(1+x)+jy}\cdot\frac{(1+x)-jy}{(1+x)-jy}$$

$$u + jv = \frac{y(1+x)+y(1-x)}{(1+x)^2+y^2} + j\frac{(1-x^2)-y^2}{(1+x)^2+y^2}$$

Image of real axis in w plane is

$$v = 0$$

$$\frac{(1-x^2)-y^2}{(1+x)^2+y^2} = 0$$

$$(1-x^2)-y^2 = 0$$

$$1 = x^2 + y^2$$

$\therefore$ Unit circle with center at the origin.

Hence, the correct option is (A).

Question 40 **(Digital Electronics)**

The simplified form of the Boolean function $F(W,X,Y,Z) = \Sigma(4,5,10,11,12,13,14,15)$ with the minimum number of terms and smallest number of literals in each term is __________.

(A) $WX + \overline{W}X\overline{Y} + W\overline{X}Y$

(B) $WX + WY + X\overline{Y}$

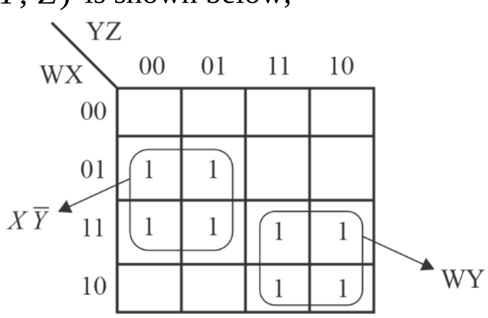
(C) $X\overline{Y} + WY$

(D) $\overline{X}Y + \overline{W}\,\overline{Y}$

Ans. (C)

Sol. **Given :** $F(W,X,Y,Z) = \Sigma(4,5,10,11,12,13,14,15)$

K-map of function $F(W, X, Y, Z)$ is shown below,

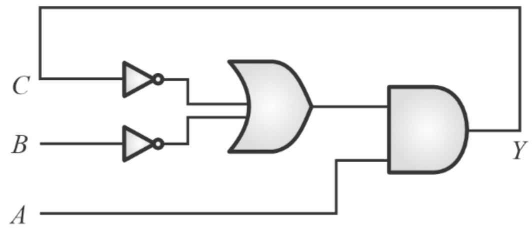


$\therefore \quad F(W, X, Y, Z) = X\bar{Y} + WY$

Hence, the correct option is (C).

Question 41 **[Digital Electronics]**

For the given digital circuit, $A = B = 1$. Assume that AND, OR and NOT gates have propagation delays of 10ns, 10ns, and 5ns respectively. All lines have zero propagation delay. Given that C=1 when the circuit is turned on, the frequency of steady state oscillations of the output Y is ________.

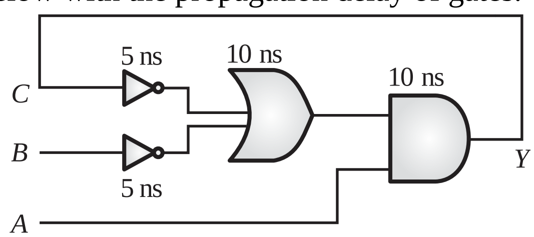


(A) 20 MHz (B) 15 MHz

(C) 40 MHz (D) 50 MHz

Ans. **(A)**

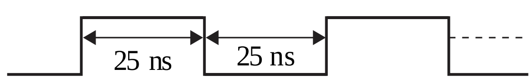
Sol. Given circuit is as shown below with the propagation delay of gates.



Overall propagation delay of the circuit $= 5\text{ns} + 10\text{ns} + 10\text{ns} = 25\text{ns}$

$\therefore$ Output Y will toggle for every 25 ns.

The waveform at Y will be,



Time period, $T = 50$ ns

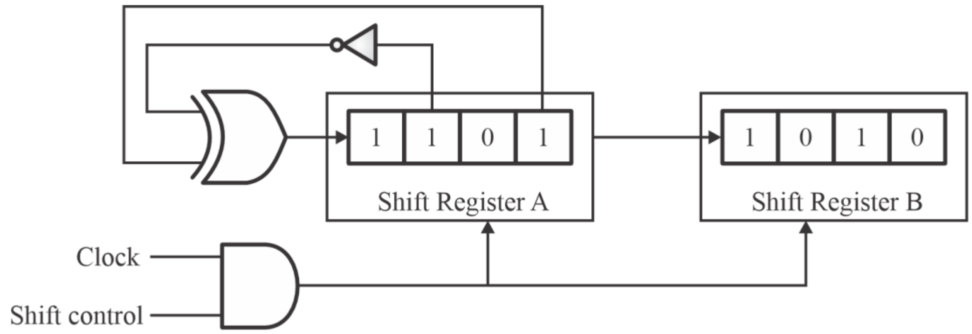
Frequency, $f = \dfrac{1}{T} = \dfrac{1}{50 \text{ ns}} = 20$ MHz

Hence, the correct option is (A).

Question 42 **(Digital Electronics)**

In the circuit shown, the initial binary content of shift register A is 1101 and that of shift register B is 1010. The shift registers are positive edge triggered, and the gates have no delay.

When the shift control is high, what will be the binary content of the shift registers A and B after four clock pulses?

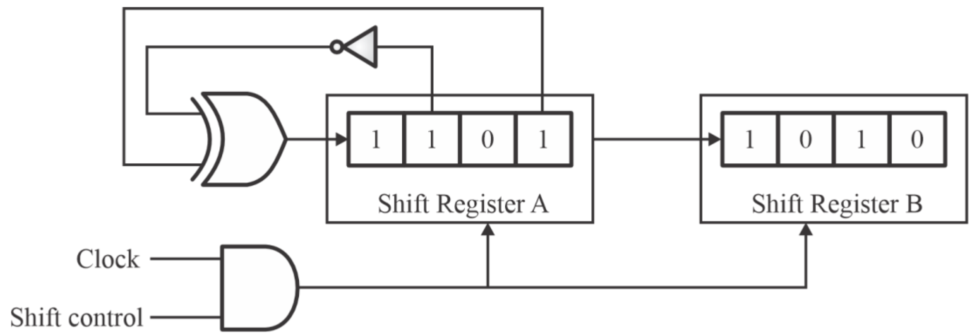


(A) $A = 1101, B = 1101$ (B) $A = 1110, B = 1001$

(C) $A = 0101, B = 1101$ (D) $A = 1010, B = 1111$

Ans. **(C)**

Sol. Given circuit is shown below,



From the given circuit,

Input to shift register, $A = \bar{A}_2 \oplus A_0$

Truth table for the given circuit is shown below,

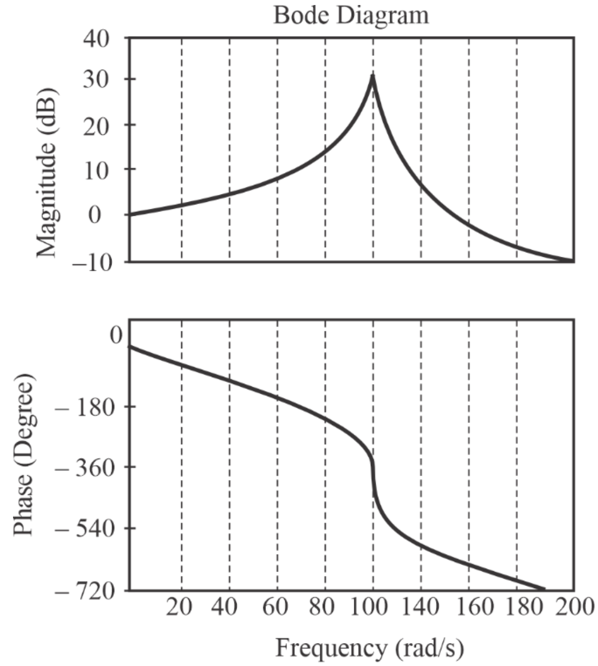
ClK	$\bar{A}_2 \oplus A_0$	$A_3A_2A_1A_0$	$B_3B_2B_1B_0$
–	1	1 1 0 1	1 0 1 0
1	0	1 1 1 0	1 1 0 1
2	1	0 1 1 1	0 1 1 0
3	0	1 0 1 1	1 0 1 1
4		0 1 0 1	1 1 0 1

So, after four clock pulses, $A = 0101$ and $B = 1101$

Hence, the correct option is (C).

Question 43

The magnitude and phase plots shown in the figure match with the transfer function_______.



(B) $\dfrac{10000}{s^2+2s+10000}$ (B) $\dfrac{10000}{s^2+2s+10000}e^{-0.05s}$

(C) $\dfrac{10000}{s^2+2s+10000}e^{-0.5\times10^{-12}s}$ (D) $\dfrac{100}{s^2+2s+100}$

Ans. (B)

Sol. From the bode plot, the natural frequency $\omega_n = 100$ rad/sec.

Phase at $\omega_n = 100$ rad/sec is $\phi = -360^0$.

So, option (B) will be the approximate answer.

Hence, the correct option is (B).

Question 44 **[Signals & Systems, Fourier Transform]**

A Continuous real valued signal $x(t)$ has finite positive energy and $x(t)=0, \forall t<0$. From the list given below, select **ALL** the signals whose continuous-time Fourier transform is purely imaginary.

(A) $x(t)+x(-t)$ (B) $x(t)-x(-t)$

(C) $j\left(x(t)+x(-t)\right)$ (D) $j\left(x(t)-x(-t)\right)$

Ans. (B), (C)

Sol. **Given :** $x(t)$ is a real signal having finite positive energy and $x(t)=0,\ \forall t<0$.

Consider option (A) :

Let $y(t)=x(t)+x(-t)$ ....(i)

$y(-t)=x(-t)+x(t)$ ....(ii)

From equations (i) and (ii),

$y(-t)=y(t)$

Also, $y(t)$ is a real function

$\therefore$ $y(t)$ is real and even function. So, fourier transform of $y(t)$ will be Real and even function.

So, option (A) is incorrect.

Consider option (B) :

Let $y(t) = x(t) - x(-t)$ ...(i)

$y(-t) = x(-t) - x(t)$

$y(-t) = -[x(t) - x(-t)]$ ...(ii)

From equation (i) and (ii),

$y(-t) = -y(t)$

Also, $y(t)$ is a real function

$\therefore$ $y(t)$ is real and odd function

So, Fourier transform of $y(t)$ will be imaginary and odd function.

So, option (B) is correct.

Consider option (C) :

Let $y(t) = j[x(t) + x(-t)]$ ...(i)

$y(-t) = j[x(-t) + x(t)]$ ...(ii)

From equation (i) and (ii),

$y(-t) = y(t)$

Also, $y(t)$ is an imaginary function

$\therefore$ $y(t)$ is imaginary and even function

So, Fourier transform of $y(t)$ will be imaginary and even function

So, option (C) is correct.

Consider option (D) :

Let $y(t) = j[x(t) - x(-t)]$ ...(i)

$y(-t) = j[x(-t) - x(t)]$

$y(-t) = -j[x(t) - x(-t)]$ ...(ii)

From equation (i) and (ii),

$y(-t) = -y(t)$

Also, $y(t)$ is an imaginary function,

$\therefore$ $y(t)$ is imaginary and odd function.

So, Fourier transform of $y(t)$ will be real and odd function.

So, option (D) is incorrect.

Hence, the correct options are (B) and (C).

Question 45

A silica-glass fiber has a core refractive index of 1.47 and a cladding refractive index of 1.44. If the cladding is completely stripped out and the core is dipped in water having a refractive index of 1.33, the numerical aperture of the modified fiber is_______ (rounded off to three decimal places).

Ans. 0.626 (0.620 to 0.640)

Sol. **Given :** Refractive index of core $(n_1) = 1.47$ and refractive index of cladding $(n_2) = 1.44$

Now, the cladding is completely stripped out and the core is dipped in water of refractive index 1.33

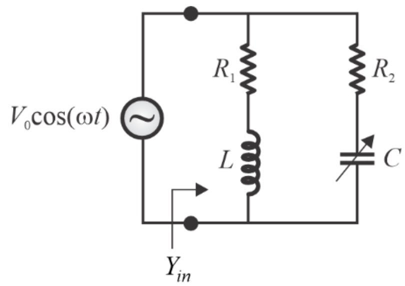
$\therefore$ Modified value of n_2 will be $n_2^1 = 1.33$

Modified numerical aperture $= \sqrt{n_1^2 - (n_2^1)^2} = \sqrt{(1.47)^2 - (1.33)^2} = 0.626$

Hence, the correct answer is 0.626.

Question 46 **[Network Theory, Resonance]**

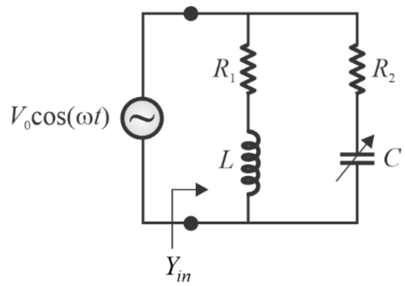
In the circuit shown, $\omega = 100\pi$ rad/s, $R_1 = R_2 = 2.2\,\Omega$ and $L = 7\,\text{mH}$. The capacitance C for which Y_{in} is purely real is _______ mF (rounded off to two decimal places).



Ans. **1.44 (1.40 to 1.50)**

Sol. **Given :** $\omega = 100\pi$ rad/s, $R_1 = R_2 = 2.2\,\Omega$ and $L = 7\,\text{mH}$.

Given circuit is shown below,



Input admittance of given circuit is,

$$Y_{in} = \frac{1}{R_1 + j\omega L} + \frac{1}{R_2 + \frac{1}{j\omega C}} = \frac{1}{R_1 + j\omega L} + \frac{j\omega C}{j\omega R_2 C + 1}$$

$$Y_{in} = \frac{R_1 - j\omega L}{R_1^2 + (\omega L)^2} + \frac{j\omega C(1 - j\omega R_2 C)}{1 + \omega^2 R_2^2 C^2}$$

For Y_{in} to be real, its imaginary part must be zero

$$\Rightarrow \frac{\omega L}{R_1^2 + (\omega L)^2} = \frac{\omega C}{1 + \omega^2 R_2^2 C^2}$$

$$\Rightarrow \frac{L}{C} = \frac{R_1^2 + (\omega L)^2}{1 + \omega^2 R_2^2 C^2}$$

$$\Rightarrow L + \omega^2 R_2^2 L C^2 = R_1^2 C + C\omega^2 L^2$$

$$\Rightarrow L - R_1^2 C = C\omega^2 L^2 - \omega^2 R_2^2 L C^2$$

$$\Rightarrow \omega^2 = \frac{L - R_1^2 C}{L^2 C - R_2^2 L C^2}$$

$$\Rightarrow \omega^2 = \frac{L - R_1^2 C}{LC(L - R_2^2 C)}$$

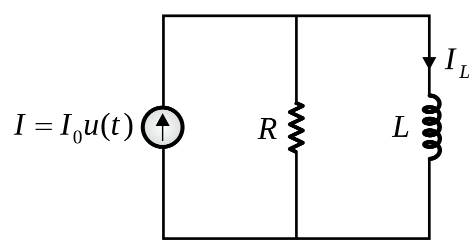
$$\Rightarrow \omega^2 = \frac{1}{LC} \qquad [\text{Sicne, } R_1 = R_2]$$

$$\Rightarrow C = \frac{1}{\omega^2 L} = \frac{1}{(100\pi)^2 \times 7 \times 10^{-3}} = 1.44 \text{ mF}$$

Hence, the correct answer is 1.44.

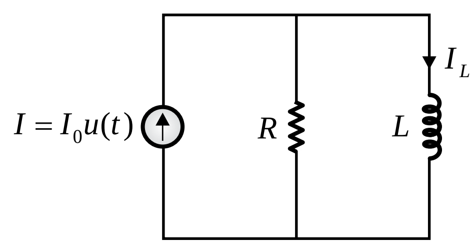
Question 47 **[Network Theory, Transient]**

The RL circuit with $R = 10 \text{ k}\Omega$ and $L = 1 \text{ mH}$ is excited by a step current $I_0 u(t)$. At $t = 0^-$, there is a current $I_L = I_0/5$ flowing through the inductor. The minimum time taken for the current through the inductor to reach 99% of its final value is ________ μs (rounded off to two decimal places).



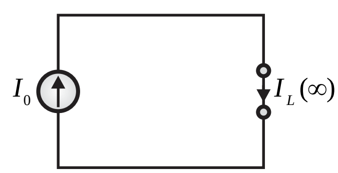
Ans. **0.438 (0.43 to 0.45)**

Sol. Given circuit is shown below,



Given : $I_L(0^-) = \frac{I_0}{5}$, $R = 10 \text{ k}\Omega$ and $L = 1 \text{ mH}$

At $t \to \infty$, inductor act as short circuit,



$$I_L(\infty) = I_0$$

Time constant $\tau = \frac{L}{R} = \frac{10^{-3}}{10^4} = 10^{-7}$ sec

Current in the inductor is given by,

$$\therefore \quad I_L(t) = I_L(\infty) + [I_L(0^-) - I_L(\infty)]e^{\frac{-t}{\tau}}$$

$$= I_0 + \left[\frac{I_0}{5} - I_0\right]e^{-10^7 t} = I_0 - \frac{4I_0}{5}e^{-10^7 t}$$

For minimum time taken by current to reach 99% of its final value,

$$I_L(t) = 0.99 I_0 \text{ then } 0.99 I_0 = I_0 - \frac{4I_0}{5}e^{-10^7 t}$$

$$\Rightarrow \frac{4}{5}e^{-10^7 t} = 0.01$$

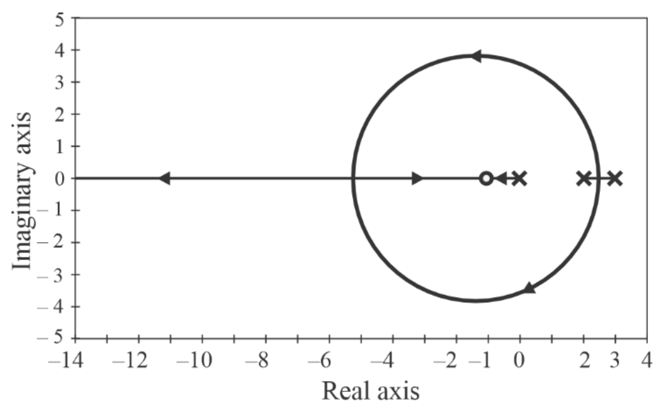
$$\Rightarrow e^{-10^7 t} = 0.0125$$

$$\Rightarrow t = \frac{\ln(0.0125)}{-10^7} = 0.438\ \mu\text{sec}$$

Hence, the correct answer 0.438.

Question 48 **[Control System]**

Consider a standard negative feedback configuration with $G(s) = \frac{1}{(s-2)(s-3)}$ and the controller $C(s) = K_p + \frac{K_I}{s} + K_D s$. The root locus of $G(s)C(s)$ is presented in the figure below. The gain $C(j\omega) = 2$ at $\omega = 1\text{rad/s}$. The value of K_D is _________(rounded off to one decimal place).



Ans. **1 (0.9 to 1.1)**

Sol. Given : $G(s) = \frac{1}{(s-2)(s-3)}$ and $C(s) = K_p + \frac{K_I}{s} + K_D s$

$$G(s)C(s) = \frac{k_p + \frac{k_I}{s} + k_D s}{(s-2)(s-3)}$$

$$G(s)C(s) = \frac{s^2 k_D + s k_P + k_I}{s(s-2)(s-3)}$$

From the root locus plot, there will be 2 zero's at $s = -1$.

$\therefore \quad s^2k_D + sk_P + k_I = (s+1)^2$

$\Rightarrow \quad s^2k_D + sk_P + k_I = s^2 + 2s + 1$

$\therefore$ On comparison we get $k_D = 1$

Hence, the correct answer is 1.

Question 49 **[Engineering Mathematics, Probability & Statics]**

How many five digit numbers can be formed using the integers 3, 4, 5 and 6 with exactly one digit appearing twice?

Ans. **240 (240 to 240)**

Sol. **Given :** Integers are 3, 4, 5 and 6, we have to form a five digit number using the given digits.

Let digit 3 is repeated twice.

3 3 4 5 6

$\therefore$ Number of five digit number that will be formed when digit 3 is repeated $= \frac{5!}{2!} = 60$

Let digit 4 is repeated twice.

3 4 4 5 6

$\therefore$ Number of five digit number that will be formed when digit 4 is repeated $= \frac{5!}{2!} = 60$

Let digit 5 is repeated twice.

3 4 5 5 6

$\therefore$ Number of five digit number that will be formed when digit 5 is repeated $= \frac{5!}{2!} = 60$

Let digit 6 is repeated twice.

$\therefore$ Number of 5 digit number that will be formed when digit 6 is repeated $= \frac{5!}{2!} = 60$

Total number of 5 digit number that will be formed when a digit is repeated twice will be $60 \times 4 = 240$.

Hence, the correct answer is 240.

Question 50 **[Control System, Frequency Response]**

The phase margin of the transfer function $G(s) = \frac{2(1-s)}{(1+s)^2}$ is _________degrees (rounded off to the nearest integer).

Ans. **0**

Sol. **Given :** $G(s) = \frac{2(1-s)}{(1+s)^2}$

$$G(j\omega) = \frac{2(1-j\omega)}{(1+j\omega)^2}$$

Phase Margin is given by,

$$PM = 180^0 + \angle G(j\omega)_{\omega=\omega_{gc}}$$

Gain cross over frequency is given by,

$$|G(j\omega)|_{\omega=\omega_{gc}}=1$$

$$|G(j\omega)|=\frac{2\sqrt{1+\omega^2}}{(1+\omega^2)}$$

At $\omega=\omega_{gc}$,

$$\frac{2\sqrt{1+\omega_{gc}^2}}{(1+\omega_{gc}^2)}=1$$

$$2\sqrt{1+\omega_{gc}^2}=(1+\omega_{gc}^2)$$

$$2=\sqrt{1+\omega_{gc}^2}$$

$$4=1+\omega_{gc}^2$$

$$\omega_{gc}^2=3$$

$$\omega_{gc}=\sqrt{3}\text{ rad/sec}$$

$$\angle G(j\omega)=-\tan^{-1}\omega-2\tan^{-1}\omega=-3\tan^{-1}\omega$$

At $\omega=\omega_{gc}$,

$$\angle G(j\omega_{gc})=-3\tan^{-1}\sqrt{3}=180^0$$

Phase Margin $=180^0+\angle G(j\omega_{gc})=180^0-180^0=0^0$

Hence, the correct answer is 0.

Question 51

A wire-wound 'resistive potentiometer type' angle sensor with 72 turns is used in an application. The first turn of the potentiometer is connected to ground while its last turn is connected to 3.6 V. The width of the wiper covers two turns ensuring make-before-break. The output (wiper) voltage when the wiper is on top of both the turns 35 and 36 is _______V (rounded off to two decimal places).

Ans. 1.77 (1.77 to 1.78)

Question 52 **[Measurement]**

The two secondaries of a linear variable differential transformer (LVDT) showed a magnitude of 2 V (RMS) for zero displacement position of the core. It is noted that the phase of one of the secondaries has a deviation of one degree from the expected phase. Other than this deviation, the LVDT is ideal.

If the differential output sensitivity of the LVDT is 1 mV (RMS)/1 μm, the output for zero displacement is __________ μm (rounded off to one decimal place).

Ans. 34.9 (34.5 to 35.5)

Sol. Zero disp

$$V_1=2\angle 0$$

$$V_2=2\angle 1^0$$

$$V_0=V_1-V_2$$

$$V_0 = [2^2 + 2^2 - 2\times2\times2\cos 1^0]^{\frac{1}{2}} = 2\sqrt{2}(1-\cos 1^0)^{\frac{1}{2}}$$

$$V_0 = 2\sqrt{2}\times\sqrt{2}\sin 0.5 = 34.9\,\text{mV}$$

$$S = 1\,\text{mv}/\mu\text{v}$$

$$\text{disp} = 34.9\,\mu\text{m}$$

Hence, the correct answer is 34.9.

Question 53 **[Measurement, Error]**

Five measurements are made using a weighing machine, and the readings are 80 kg, 79 kg, 81 kg, 79 kg and 81 kg. The sample standard deviation of the measurement is _______kg (rounded off to two decimal places).

Ans. 1 (0.98 to 1.02)

Sol. Given : Measurements are 80 kg, 79 kg, 81 kg, 79 kg and 81 kg.

The sample standard deviation is given as,

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}[x_i - \overline{x}]^2} \qquad \text{where, } N = 5$$

$$\overline{x} = \frac{80+79+81+79+81}{5} = 80$$

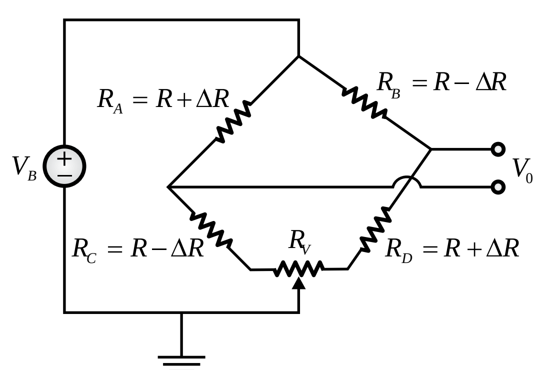
$$\sigma = \sqrt{\frac{1}{4}\left[(80-80)^2 + (79-80)^2 + (81-80)^2 + (79-80)^2 + (81-80)^2\right]}$$

$$= \sqrt{\frac{1}{4}[0+1+1+1+1]} = 1$$

Hence, the correct answer is 1.

Question 54 **[Measurement, Bridge]**

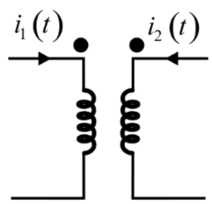
Four strain gauges R_A, R_B, R_C and R_D, each with nominal resistance R, are connected in a bridge configuration. When a force is applied, R_A and R_D increase by ΔR and R_B and R_C decrease by ΔR as shown. A potentiometer with total resistance R_V is connected as shown. If $R = 100\ \Omega$ and $\Delta R = 1\ \Omega$, the minimum value of resistance R_V required to balance the bridge is ______ Ω. (rounded off to two decimal places)



Ans. 4.04 (4.00 to 4.10)

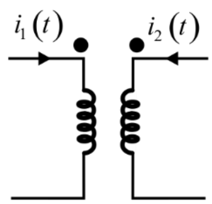
Question 55 **[Network Theory, Magnetic Coupled Circuit]**

A sinusoidal current of $i_1(t) = 1\sin(200\pi t)\,\text{mA}$ is flowing through a 4 H inductor which is mutually coupled to another 5 H inductor carrying $i_2(t) = 2\sin(200\pi t)\,\text{mA}$ as shown in figure. The coupling coefficient between the inductors is 0.6. The peak energy stored in the circuit is _______ μJ (rounded off to two decimal places).



Ans. 17.37 (17.00 to 18.00)

Sol. Given : Coupled circuit is shown below,



$i_1(t) = \sin(200\pi t)$ mA

$i_2(t) = 2\sin(200\pi t)$ mA

$L_1 = 4$ H

$L_2 = 5$ H

Coupling coefficient $K = 0.6$.

Mutual inductance $M = K\sqrt{L_1 L_2}$

$\Rightarrow M = 0.6 \times \sqrt{5 \times 4}$

$\Rightarrow M = 0.6 \times \sqrt{20} = 2.683$

$\therefore$ Peak value of energy will be,

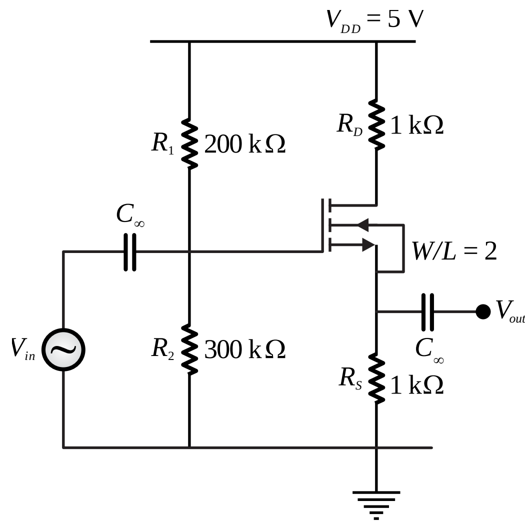
$$E_P = \frac{1}{2} \times 4 \times 1^2 + \frac{1}{2} \times 5 \times 2^2 + 2.683 \times 1 \times 2$$

$E_P = 2 + 10 + 5.366 = 17.366\ \mu\text{J}$

Hence, the correct answer is 17.366

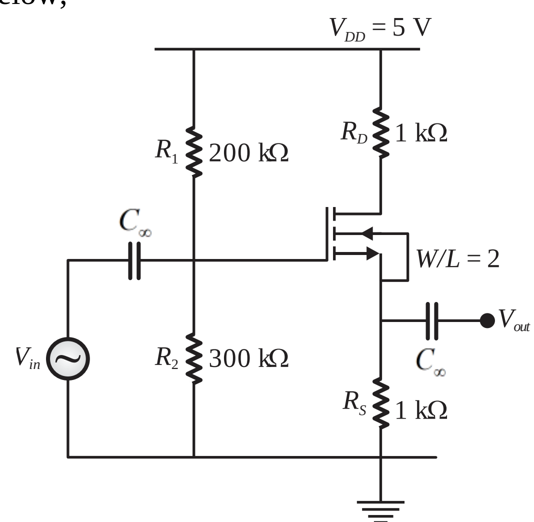
Question 56

The figure below shows a feedback amplifier constructed using an nMOS transistor. Assume that $\mu_n C_{ox} = 1\ \text{mA/V}^2$, threshold voltage $V_T = 1$ V and W/L = 2. The bias voltage at the drain terminal is 4 V. The capacitors C_∞ offer zero impedance at the signal frequency. The ratio V_{out}/V_{in} is _______. (rounded off to two decimal places)



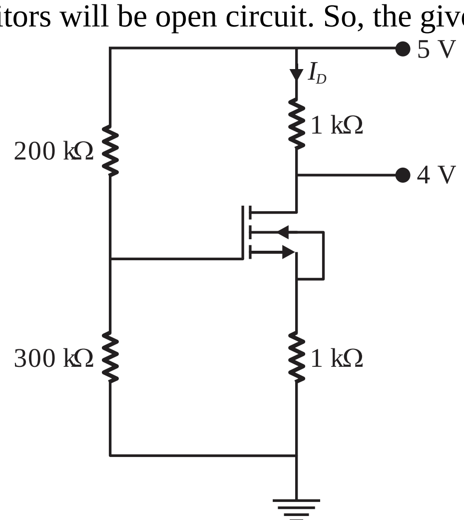
Ans. 0.666 (0.64 to 0.70)

Sol. Given circuit is as shown below,



Also given that the bias voltage at the drain terminal is 4 V.

For DC analysis, all the capacitors will be open circuit. So, the given circuit becomes as shown below,



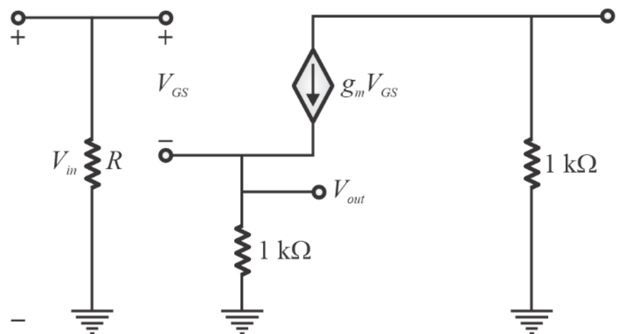
Drain current, $I_D = \frac{5-4}{1} = 1 \text{ mA}$

Given, $\mu_n C_{ox} = 1 \text{ mA/V}^2$, $\frac{W}{L} = 2$ and threshold voltage $V_T = 1 \text{ V}$.

$\therefore$ Transconductance, $g_m = \sqrt{2\mu_n C_{ox} \frac{W}{L} I_D}$

$g_m = \sqrt{2\times1\times10^{-3}\times2\times10^{-3}} = 2 \text{ m℧}$

For AC analysis, all the capacitors become short circuit and the small signal equivalent model can be drawn as shown below,



Here, $R = 200 \text{ k}\Omega \,||\, 300 \text{ k}\Omega$

KVL $\Rightarrow V_{in} - V_{GS} - V_{out} = 0$

But $V_{out} = g_m V_{GS} \times 1 \text{ k}\Omega$ ...(i)

$V_{in} - V_{GS} - g_m V_{GS} \times 1 \text{ k}\Omega = 0$

$V_{in} = V_{GS}[1 + g_m \times 1 \text{ k}\Omega]$

$V_{GS} = \frac{V_{in}}{1 + g_m \times 1 \text{ k}\Omega}$ ...(ii)

Substituting equation (ii) in equation (i), we get

$V_{out} = \frac{g_m V_{in} \times 1 \text{ k}\Omega}{1 + g_m \times 1 \text{ k}\Omega}$

$\frac{V_{out}}{V_{in}} = \frac{g_m \times 1 \text{ k}\Omega}{1 + g_m \times 1 \text{ k}\Omega}$

But $g_m = 2 \text{ m℧}$,

$\frac{V_{out}}{V_{in}} = \frac{2\times10^{-3}\times10^3}{1+2\times10^{-3}\times10^3} = \frac{2}{3} = 0.66$

Hence, the correct answer is 0.66.

Question 57 **[Engineering Mathematics, Maxima & Minima]**

Consider the real-valued function $g(x) = \max\{(x-2)^2, -2x+7\}$ where $x \in (-\infty, \infty)$. The minimum value attained by $g(x)$ is ________. (rounded off to one decimal place)

Ans. **1 (0.9 to 1.1)**

Sol. Given : $g(x) = \max\{(x-2)^2, -2x+7\}$, where $x \in (-\infty, \infty)$.

The point of intersection of $(x-2)^2$ and $(-2x+7)$ can be obtained as shown below,

$$(x-2)^2 = -2x+7$$

$$x^2 - 4x + 4 = -2x + 7$$

$$x^2 - 2x - 3 = 0$$

$$x^2 - 3x + x - 3 = 0$$

$$x(x-3) + 1(x-3) = 0$$

$$(x-3)(x+1) = 0$$

$$x = 3 \text{ and } x = -1$$

$\therefore$ When $x = 3$, $g(x) = \max\{1, 1\} = 1$

When $x = -1$, $g(x) = \max\{9, 9\} = 9$

Co-ordinates of points of intersection are (3, 1) and (– 1, 9).

$\therefore$ Minimum value of $g(x)$ is 1.

Hence, the correct answer is 1.

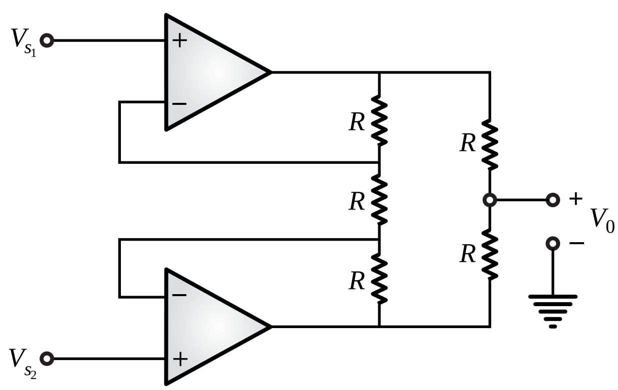
Question 58 **[Machine, Transforms]**

A short-circuit test is conducted on a single-phase transformer by shorting its secondary. The frequency of input voltage is 1 kHz. The corresponding wattmeter reading, primary current and primary voltage are 8 W, 2 A & 6 V respectively. Assume that the no-load losses & the no-load currents are negligible, and the core has linear magnetic characteristics. Keeping the secondary shorted, the primary is connected to a 2 V (rms), 1 kHz sinusoidal source in series with $\frac{1}{2\pi\sqrt{5}}$ mF capacitor. The primary current (rms) will be _____ A. (rounded off to two decimal places)

Ans. **1 (0.95 to 1.05)**

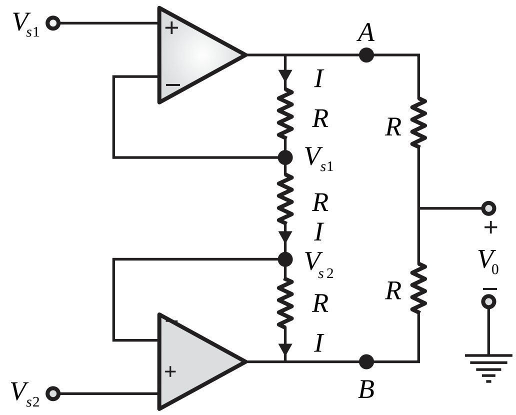
Question 59

The Op-Amps in the circuit are ideal. The input signals are $V_{s_1} = 3 + 0.1\sin(300t)\text{V}$ and $V_{s_2} = -2 + 0.11\sin(300t)\text{V}$. The average value of voltage V_0 is _______V. (rounded off to two decimal places).



Ans. 0.5 (0.49 to 0.51)

Sol. Given circuit is as shown below,



Using voltage division rule and superposition theorem, we get

$$\Rightarrow V_0 = \frac{V_A \times R}{2R} + \frac{V_B \times R}{2R}$$

$$\Rightarrow V_0 = \frac{V_A}{2} + \frac{V_B}{2} = \frac{V_A + V_B}{2}$$

$$\Rightarrow V_0 = \frac{IR + V_{s1} + V_{s2} - IR}{2} \qquad (\because\ V_A = IR + V_{s1},\ V_B = V_{s2} - IR)$$

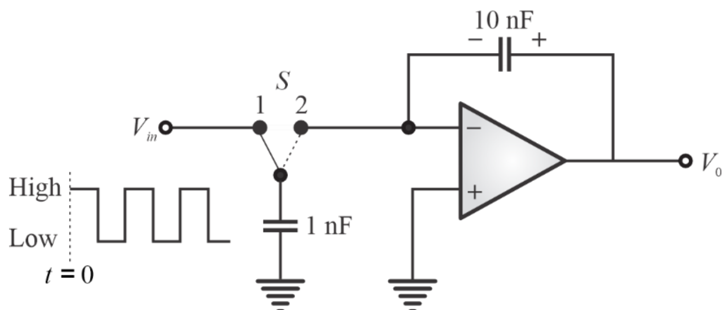
$$\Rightarrow V_0 = \frac{V_{s1} + V_{s2}}{2}$$

$$\Rightarrow (V_0)_{avg} = \frac{(V_{s1})_{avg} + (V_{s2})_{avg}}{2} = \frac{3-2}{2} = 0.5 \quad [\because\ (V_{s1})_{avg} = 3 \text{ and } (V_{s2})_{avg} = -2]$$

Hence, the correct answer is 0.5.

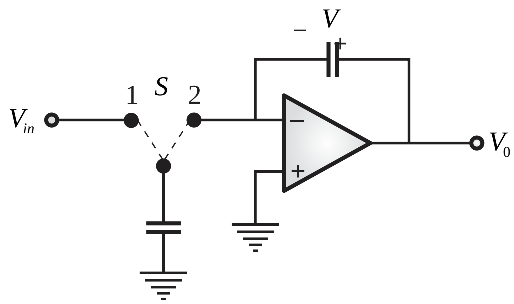
Question 60 **[Analog Electronics, Op-Amp]**

In the circuit shown, the input voltage $V_{in} = 100\,\text{mV}$. The switch and the op-amp are ideal. At time $t = 0$, the initial charge stored in the 10 nF capacitor is 1 nC, with the polarity as indicated in the figure. The switch S is controlled using a 1 kHz square wave voltage signal V_s as shown. Whenever V_s is 'High', S is in position '1' and when V_s is 'Low', S is in position '2'. At $t = 20\,\text{ms}$, the magnitude of the voltage V_0 will be ________ mV (rounded off the nearest integer).



Ans. 100 (99 to 101)

Sol. Given circuit can be drawn as shown below,



$$V = \frac{\ln C}{10\text{ nF}} = 0.1\text{V} = 100\text{ mV}$$

Given frequency of square wave $f = 1\text{ kHz} \Rightarrow T = 1\text{ms}$

At $t = 1\text{ms}$, V_{in} will complete 1 cycle and switch will be in position 2.

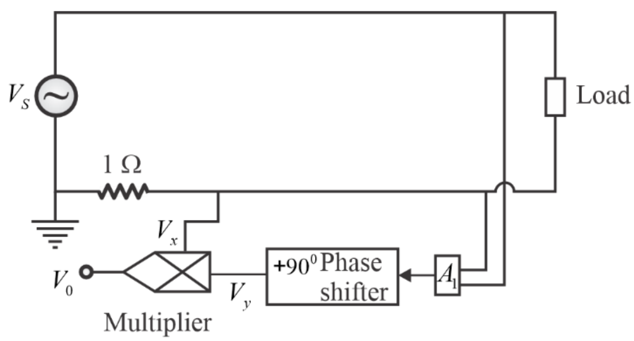
So, $V_0 = V = 100\text{ mV}$ at $t = 1\text{ ms}$

Similarly at $t = 20\text{ msec}$, $V_0 = V = 100\text{ mV}$.

Hence, the correct answer is 100.

Question 61

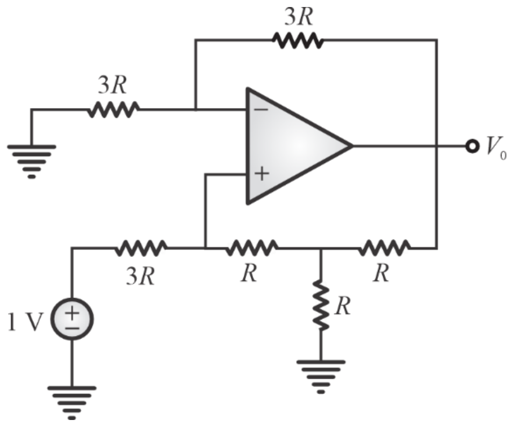
In the diagram shown, the frequency of the sinusoidal source voltage V_s is 50 Hz. The load voltage is 230 V (rms), and the load impedance is $\frac{230}{\sqrt{2}} + j\frac{230}{\sqrt{2}}\,\Omega$. The value of attenuator $A_1 = \frac{1}{50\sqrt{2}}$. The multiplier output voltage $V_0 = \frac{V_x V_y}{1V}$, where V_x and V_y are the inputs. The magnitude of the average value of the multiplier output V_0 is _____V. (round off to one decimal place)



Ans. 2.1 to 2.5

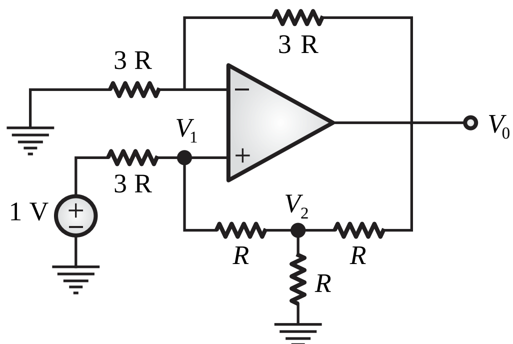
Question 62 **[Analog Electronics, Op-Amp]**

In the circuit shown, assuming an ideal opamp, the value of the output voltage V_0 = _______V (rounded off to one decimal place).



Ans. **2 (1.9 to 2.1)**

Sol. Circuit is as shown below,



KCL at V_1,

$$\frac{V_1 - 1}{3R} + \frac{V_1 - V_2}{R} = 0$$

$$V_1 - 1 + 3V_1 - 3V_2 = 0$$

$$4V_1 - 3V_2 = 1$$

$$V_1 = \frac{1 + 3V_2}{4} \quad \text{...(i)}$$

KCL at V_2,

$$\frac{V_2}{R} + \frac{V_2 - V_0}{R} + \frac{V_2 - V_1}{R} = 0$$

$$3V_2 = V_1 + V_0 \quad \text{...(ii)}$$

On substituting equation (ii) in equation (i), we get

$$\Rightarrow V_1 = \frac{1}{4}[1 + V_1 + V_0]$$

$$\Rightarrow 3V_1 = V_0 + 1$$

$$\Rightarrow V_1 = \frac{V_0 + 1}{3}$$

$\therefore \quad V_0 = \left(1 + \frac{3R_1}{3R}\right) V_1$

$\therefore \quad V_0 = \left(1 + \frac{3R}{3R}\right) \times \frac{(V_0 + 1)}{3} = \frac{2}{3} V_0 + \frac{2}{3}$

$\Rightarrow \frac{V_0}{3} = \frac{2}{3}$

$\Rightarrow V_0 = 2 \text{ V}$

Hence, the correct option is 2.

Question 63 **[Engineering Mathematics, Linear Algebra]**

The rank of the matrix A given below is one. The ratio $\frac{\alpha}{\beta}$ is ________. (rounded off to the nearest integer)

$$A = \begin{bmatrix} 1 & 4 \\ -3 & \alpha \\ \beta & 6 \end{bmatrix}$$

Ans. – 8 (– 8 to – 8)

Sol. Given : Rank of A, $\rho(A) = 1$

So, all 2×2 minors are zero,

$$\begin{vmatrix} 1 & 4 \\ -3 & \alpha \end{vmatrix} = 0$$

$\alpha + 12 = 0$

$\alpha = -12$

$$\begin{vmatrix} 1 & 4 \\ \beta & 6 \end{vmatrix} = 0$$

$6 - 4\beta = 0$

$4\beta = 6$

$\beta = \frac{3}{2}$

$\frac{\alpha}{\beta} = \frac{-12}{\frac{3}{2}} = -\frac{24}{3} = -8$

Hence, the correct answer is – 8.

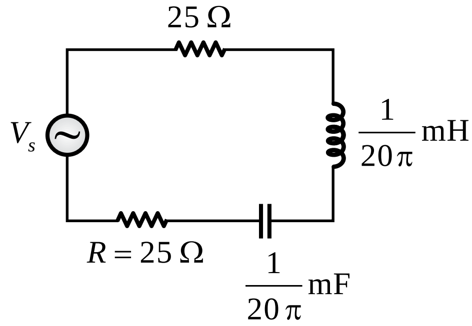
Question 64

A 1.999 V true RMS 3-1/2 digit multi-meter has an accuracy of $\pm 0.1\%$ of reading ± 2 digits. It is used to measure 100 A (RMS) current flowing through a line using a 100:5 ratio, Class-1 current transformer with a burden of $0.1\,\Omega \pm 0.5\%$. The worst-case absolute error in the multimeter output is ______V (rounded off to three decimal places).

Ans. 0.010 (0.009 to 0.011)

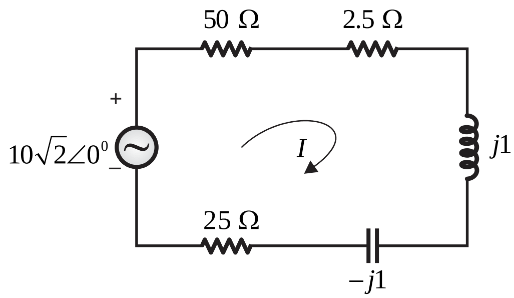
Question 65 **[Network Theory, AC Analysis]**

The voltage source $V_s = 10\sqrt{2}\sin(20000\,\pi t)\,\text{V}$ has an internal resistance of $50\,\Omega$. The RMS value of current through R is ________ mA (rounded off to one decimal places).



Ans. 100 (99.0 to 101.0)

Sol. Given circuit can be drawn in phasor form as shown below



$$I = \frac{10\sqrt{2}\angle 0^0}{50 + 25 + j1 - j1 + 25}$$

$$I = \frac{10\sqrt{2}}{100} = 100\sqrt{2}\ \text{mA}$$

$\therefore$ RMS value of current will be, $I_{RMS} = \dfrac{100\sqrt{2}}{\sqrt{2}} = 100\ \text{mA}$

Hence, the correct answer is 100.

❑❑❑