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ANALYSIS OF GATE 2016
Electronic & Communication Engineering

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* Indicates Questions from New Syllabus

**Faculty Feedback:** Few questions came from New Syllabus; General Ability was pretty easy; Not many calculations except from EDC & EMT, Analog qualifying is easy but scoring is tough, Time Management very critical. Practice previous year question papers will be beneficial.
GATE-2016

Question Paper &

Answer Keys
GATE 2016 Examination
Electronics and Communication Engineering

Test Date: 30/01/2016
Test Time: 9:00 AM to 12:00 PM
Subject Name: EC ELECTRONICS AND COMMUNICATION ENGINEERING

Section: General Aptitude

Q No. 1
Which of the following is CORRECT with respect to grammar and usage?

Mount Everest is ____________.
(A) the highest peak in the world
(B) highest peak in the world
(C) one of highest peak in the world
(D) one of the highest peak in the world

[Ans. A]
The sentence is stating the highest peak in the world. Since it is a specific thing, we need to use the definite article ‘the’ before it. Also the sentence is using the superlative degree and so we say ‘the highest peak in the world’ making option 1 the correct answer. There cannot be many highest peaks in the world and so options 3 and 4 are incorrect.

Q No. 2
The policeman asked the victim of a theft, “What did you _____?”

(A) loose  (B) lose  (C) loss  (D) louse

[Ans. B]
The context of the sentence is asking a person who has been deprived of something because of a theft. The word to be used to fill the blank is ‘lose’ which means to be deprived of something. ‘Loose’ means something that is not fitted. ‘Louse’ is the singular form of the word ‘lice’ that is a parasite that lives in the skin of mammals and birds. ‘Loss’ is a noun that means the process of losing someone or something. Eg: He suffered tremendous loss in his business.
Q No. 3

Despite the new medicine’s _______ in treating diabetes, it is not _______ widely.

(A) effectiveness --- prescribed    (B) availability --- used
(C) prescription --- available      (D) acceptance --- proscribed

[Ans. A]
The sentence is looking for a contrast as it is joined by the conjunction ‘despite’. The best pair of words that can fit the context of the sentence is ‘effectiveness...prescribed’. Though the medicine is ‘effective’ in treating diabetes, it is not being ‘prescribed’ widely. A new medicine cannot have a ‘prescription’ or ‘availability’ for treating a disease. ‘Prescribed’ means forbidden by law. In case we use ‘acceptance...proscribed’ the sentence will not make any sense because it will mean that though the medicine is accepted widely, it is not forbidden by law.

Q No. 4

In a huge pile of apples and oranges, both ripe and unripe mixed together, 15% are unripe fruits. Of the unripe fruits, 45% are apples. Of the ripe ones, 66% are oranges. If the pile contains a total of 5692000 fruits, how many of them are apples?

(A) 2029198    (B) 2467482    (C) 2789080    (D) 3577422

[Ans. A]
Let T = total no of fruits = 5692000
R = Ripe fruits
U = Unripe fruits
A = Apple
O = Oranges

Given U = 15% of T : \[ \frac{15}{100} \times 5692000 = 853800 \]
R = T - U = 4838200
A(U) = 45% of U: \[ \frac{45}{100} \times 853800 = 384210 \]
A(R) = (100 - 66)% of R: \[ \frac{34}{100} \times 4838200 = 1644988 \]

\[ \therefore A(U) + A(R) = 2029198 \]
Q No. 5

Michael lives 10 km away from where I live. Ahmed lives 5 km away and Susan lives 7 km away from where I live. Arun is farther away than Ahmed but closer than Susan from where I live. From the information provided here, what is one possible distance (in km) at which I live from Arun’s place?

(A) 3.00  (B) 4.99  (C) 6.02  (D) 7.01

[Ans. C]

Possible places where Arun live

In question it is given that Ahmed is 5 km away and Susan is 7 km away from where I live. Further it is given that Arun is farther away than Ahmed from where I live and not as far as Susan. That means Arun must be living at distance more than 5 km but less than 7 km from my house which is according to given options can be 6.02 km.

Note: Information about Michael is unnecessary and just given to confuse.

Q No. 6

A person moving through a tuberculosis prone zone has a 50% probability of becoming infected. However, only 30% of infected people develop the disease. What percentage of people moving through a tuberculosis prone zone remains infected but does not show symptoms of disease?

(A) 15  (B) 33  (C) 35  (D) 37

[Ans. C]

Percentage probability of being infected = \( P(A) = 50\% \)
Percentage probability of infected person developing disease is having system,
\[ \therefore P(B) = 30\% \]
\[ \therefore \text{Percentage probability of infected person not showing symptoms} = P(B) = 70\% \]
\[ \therefore \text{Percentage probability of person moving though a TB prone zone remaining infected but not showing symptoms} = P(A) \times \frac{70}{100} = 35\% \]
Q No. 7

In a world filled with uncertainty, he was glad to have many good friends. He had always assisted them in times of need and was confident that they would reciprocate. However, the events of the last week proved him wrong.

Which of the following inference(s) is/are logically valid and can be inferred from the above passage?

(i) His friends were always asking him to help them.
(ii) He felt that when in need of help, his friends would let him down.
(iii) He was sure that his friends would help him when in need.
(iv) His friends did not help him last week.

(A) (i) and (ii) (B) (iii) and (iv) (C) (iii) only (D) (iv) only

[Ans. B]

The paragraph states that the subject was very confident about his good friends helping him in his times of need because he had always helped them before in their time. Thus, inference iii follows.

Since the events of the last week proved him wrong, this means that his confidence was broken and his friends had not helped him. Thus inference iv also follows.

Q No. 8

Leela is older than her cousin Pavithra. Pavithra’s brother Shiva is older than Leela. When Pavithra and Shiva are visiting Leela, all three like to play chess. Pavithra wins more often than Leela does.

Which one of the following statements must be TRUE based on the above?

(A) When Shiva plays chess with Leela and Pavithra, he often loses.
(B) Leela is the oldest of the three.
(C) Shiva is a better chess player than Pavithra.
(D) Pavithra is the youngest of the three.
[Ans. D]
According to given information the points we got are
(A) Shiva is brother of Pavithra
(B) Shiva and Pavithra are cousins of Leela
(C) According to their ages Shiva > Leela > Pavithra
(D) They all live play chess
(E) Pavithra wins more often than Leela but information about winning cases of Shiva is not given.
So from the given options statement which is clearly true is that Pavithra is the youngest of all.

Q No. 9

If \( q^{-a} = \frac{1}{r} \) and \( r^{-b} = \frac{1}{s} \) and \( s^{-c} = \frac{1}{q} \), the value of abc is ___.

(A) \((rqs)^{-1}\)  (B) 0  (C) 1  (D) \(r+q+s\)

[Ans. C]

\( q^{-a} = \frac{1}{r} \); \( r^{-b} = \frac{1}{s} \) and \( s^{-c} = \frac{1}{q} \)

\[ \therefore q^a = r; \ r^b = s \text{ and } s^c = q \]

\[ \therefore a \log q = \log r \quad \ldots \ldots \text{ (1)} \]

And \( b \log r = \log s \quad \ldots \ldots \text{ (2)} \)

And \( c \log s = \log q \quad \ldots \ldots \text{ (3)} \)

Multiplying equations (1), (2) and (3)

\[ abc (\log q)(\log r)(\log s) = (\log r)(\log s)(\log q) \]

\[ \therefore abc = 1 \]

Q No. 10

P, Q, R and S are working on a project. Q can finish the task in 25 days, working alone for 12 hours a day. R can finish the task in 50 days, working alone for 12 hours per day. Q worked 12 hours a day but took sick leave in the beginning for two days. R worked 18 hours a day on all days. What is the ratio of work done by Q and R after 7 days from the start of the project?

(A) 10:11  (B) 11:10  (C) 20:21  (D) 21:20
After 7 days from start of project:
Q took sick leave on first 2 days
\[ \therefore \text{Man hours by } Q = 5 \times 12 \]
\[ \therefore \text{Work done by } Q = 5 \times 12 \times \frac{1}{25 \times 12} = \frac{1}{5} \]
\[ \text{Man hours by } R = 7 \times 18 \]
\[ \therefore \text{Work done by } R = \frac{1}{50 \times 12} \times 7 \times 18 = \frac{21}{100} \]
\[ \therefore \text{Ratio of work done by } Q \text{ to work done by } R = \frac{\frac{1}{5}}{\frac{21}{100}} = \frac{100}{5 \times 21} = \frac{20}{21} \]
Section: Technical

Q No. 1

Let $M^4 = I$, (where $I$ denotes the identity matrix) and $M \neq I$, $M^2 \neq I$ and $M^3 \neq I$. Then, for any natural number $k$, $M^{-1}$ equals:

(A) $M^{2k+1}$  
(B) $M^{12} + 2$  
(C) $M^{12} + 3$  
(D) $M^{12}$

[Ans. C]

$M^4 = I \quad M \neq I, M^2 \neq I, M^3 \neq I$

We can back calculate, lets say

$M^{-1} = M^{4k+3}$

$\Rightarrow M^{4k+3} M = I$ [Multiplying both sides by $M$]

$\Rightarrow M^{4k+4} = I$

$\Rightarrow M^{4(k+1)} = I$

$\Rightarrow I^{k+1} = I$ Which is true

Thus C is the answer

Q No. 2

The second moment of a Poisson-distributed random variable is 2. The mean of the random variable is ________

[Ans. *] Range: 0.9 to 1.1

We know that if $\lambda$ is a parameter of Poisson’s distribution

Then, first moment $= \lambda$; second moment $= \lambda^2 + \lambda$

Given, $\lambda^2 + \lambda = 2$

$\Rightarrow \lambda^2 + \lambda - 2 = 0$

$\Rightarrow (\lambda + 2)(\lambda - 1) = 0$

$\Rightarrow \lambda = 1 \quad [\because \lambda \neq -2, \text{can’t be negative}]$

$\therefore$ Mean of random variable $= \text{First moment} = 1$
Q No. 3

Given the following statements about a function \( f: \mathbb{R} \rightarrow \mathbb{R} \), select the right option:

P: If \( f(x) \) is continuous at \( x = x_0 \), then it is also differentiable at \( x = x_0 \).
Q: If \( f(x) \) is continuous at \( x = x_0 \), then it may not be differentiable at \( x = x_0 \).
R: If \( f(x) \) is differentiable at \( x = x_0 \), then it is also continuous at \( x = x_0 \).

(A) P is true, Q is false, R is false
(B) P is false, Q is true, R is true
(C) P is false, Q is true, R is false
(D) P is true, Q is false, R is true

[Ans. B]

If \( f(x) \) is continuous at \( x = x_0 \), then it may not be differentiable at \( x = x_0 \), but if \( f(x) \) is differentiable at \( x = x_0 \), then it is also continuous at \( x = x_0 \).

Q No. 4

Which one of the following is a property of the solutions to the Laplace equation: \( \nabla^2 f = 0 \)?

(A) The solutions have neither maxima nor minima anywhere except at the boundaries.
(B) The solutions are not separable in the coordinates.
(C) The solutions are not continuous.
(D) The solutions are not dependent on the boundary conditions.

[Ans. A]

The solution of Laplace function are called harmonic function and have the following properties. The properties are true irrespective of the number of dimensions (one, two or three) in which you solve the equation for \( \nabla^2 f = 0 \).

1. \( f(x, y, z) \) is the average of \( f \) values over a spherical surface of radius \( R \) centered at \( (x, y, z) \)
   \[
   f(x, y, z) = \frac{1}{4\pi R^2} \int_{\text{sphere}} f \, da
   \]
   This is for the case of three dimensional solution. In case of one dimension \( f(x) \) is the average of \( f(x + a) \) and \( f(x - a) \) for any \( a \), \( f(x) = \frac{1}{2} \left[ f(x + a) + f(x - a) \right] \). Similarly, for two dimension, the value \( f(x, y) \) will the average of values of \( f \) on any circle of radius \( R \) centered at the point \( (x, y) \).

2. Laplace’s equation tolerates no local minima or maxima; extreme values of \( f \) must occur at end points or boundary in general. Thus, seeing this we see only option a is true.
Q No. 5

Consider the plot of \( f(x) \) versus \( x \) as shown below.

Suppose \( F(x) = \int_{-5}^{x} f(y) \, dy \). Which one of the following is a graph of \( F(x) \)?

(A) \hspace{1cm} (B) \hspace{1cm} (C) \hspace{1cm} (D)

[Ans. C]

\[
F(x) = \int_{-5}^{x} f(y) \, dy
\]

Conceptually, we can solve this equation. Area of \( F(x) \) cannot be positive. Negative region of \( f(x) \) for \( x < 0 \) and positive region of \( f(x) \) for \( x > 0 \) compensate each other and \( F(x) \) final area will be zero. Thus C is the only option.
Q No. 6

Which one of the following is an eigen function of the class of all continuous-time, linear, time-invariant systems \((u(t)\) denotes the unit step function)?

(A) \(e^{j\omega_0 t}u(t)\)  
(B) \(\cos(\omega_0 t)\)  
(C) \(e^{j\omega_0 t}\)  
(D) \(\sin(\omega_0 t)\)

[Ans. C]

Complex exponentials are Eigen function of linear time invariant system. Eigen function of any system are a class of function which when applied to the system gives the same function as output together with a constant. We know this property for LTI systems is true for complex exponential. Thus \(e^{j\omega_0 t}\) is the required Eigen function. Suppose if we take input \(x(t) = e^{j\omega_0 t}\) then output \(y(t) = Ke^{j\omega_0 t}\), where \(K\) is a constant.

Q No. 7

A continuous-time function \(x(t)\) is periodic with period \(T\). The function is sampled uniformly with a sampling period \(T_s\). In which one of the following cases is the sampled signal periodic?

(A) \(T = \sqrt{2} T_s\)  
(B) \(T = 1.2 T_s\)  
(C) Always  
(D) Never

[Ans. B]

Q No. 8

Consider the sequence \(x[n] = a^n u[n] + b^n u[n]\), where \(u[n]\) denotes the unit step sequence and \(0 < |a| < |b| < 1\). The region of convergence (ROC) of the z-transform of \(x[n]\) is

(A) \(|z| > |a|\)  
(B) \(|z| > |b|\)  
(C) \(|z| < |a|\)  
(D) \(|a| < |z| < |b|\)

[Ans. B]

Q No. 9

Consider a two-port network with the transmission matrix: \(T = \begin{pmatrix} A & B \\ C & D \end{pmatrix}\). If the network is reciprocal, then

(A) \(T^{-1} = T\)  
(B) \(T^2 = T\)  
(C) Determinant \((T) = 0\)  
(D) Determinant \((T) = 1\)

[Ans. D]

If the network reciprocal then determinant \((T) = 1\)
Q No. 10

A continuous-time sinusoid of frequency 33 Hz is multiplied with a periodic Dirac impulse train of frequency 46 Hz. The resulting signal is passed through an ideal analog low-pass filter with a cutoff frequency of 23 Hz. The fundamental frequency (in Hz) of the output is ________

[Ans. *] Range: 12 to 14

The input sinusoid (let \( x(t) \)) spectrum is \( X(\omega) \)

\[
\begin{array}{c}
\text{33 Hz} \\
\uparrow \\
\text{33 Hz}
\end{array}
\]

When this sinusoid is sampled using a Delta impulse train frequency 46 Hz, the sinusoid spectrum shift to left and right by multiples of 46 Hz. So, the spectrum of sampled signal \( x_p(t) \) is \( X_p(\omega) \) as shown below

\[
\begin{array}{c}
\text{-59} \\
\uparrow \\
\text{-13} \\
\uparrow \\
\text{13} \\
\uparrow \\
\text{59} \\
\hline \\
\end{array}
\]

After passing \( X_p(\omega) \) through a filter with cutoff 23 Hz we have \( X_p(\omega) \) LPF is given by

\[
\begin{array}{c}
\text{-13} \\
\uparrow \\
\text{13} \\
\text{Hz}
\end{array}
\]

Thus, fundamental frequency of \( X_p(\omega) \) LPF is 13 Hz
Q No. 11

A small percentage of impurity is added to an intrinsic semiconductor at 300 K. Which one of the following statements is true for the energy band diagram shown in the following figure?

(A) Intrinsic semiconductor doped with pentavalent atoms to form n-type semiconductor
(B) Intrinsic semiconductor doped with trivalent atoms to form n-type semiconductor
(C) Intrinsic semiconductor doped with pentavalent atoms to form p-type semiconductor
(D) Intrinsic semiconductor doped with trivalent atoms to form p-type semiconductor

[Ans. A]
The diagram is energy band diagram of n-type semiconductor using pentavalent atom impurity energy level will go very near the conduction band in Ge/Si.

Q No. 12

Consider the following statements for a metal oxide semiconductor field effect transistor (MOSFET):

P: As channel length reduces, OFF-state current increases.
Q: As channel length reduces, output resistance increases.
R: As channel length reduces, threshold voltage remains constant.
S: As channel length reduces, ON current increases.

Which of the above statements are INCORRECT?
(A) P and Q  (B) P and S  (C) Q and R  (D) R and S

[Ans. C]
For MOSFET
When channel length reduces, $V_{Th}$ also reduced and output resistance decreased.
Q No. 13

Consider the constant current source shown in the figure below. Let $\beta$ represent the current gain of the transistor.

The load current $I_0$ through $R_L$ is

(A) $I_0 = \left(\frac{\beta+1}{\beta}\right) \frac{V_{\text{ref}}}{R}$  
(B) $I_0 = \left(\frac{\beta}{\beta+1}\right) \frac{V_{\text{ref}}}{R}$  
(C) $I_0 = \left(\frac{\beta+1}{\beta}\right) \frac{V_{\text{ref}}}{2R}$  
(D) $I_0 = \left(\frac{\beta}{\beta+1}\right) \frac{V_{\text{ref}}}{2R}$
Voltage at non-inverting terminal = inverting terminal = \( V_{CC} - V_{ref} \)

\[ I_E = \frac{V_{CC} - (V_{CC} - V_{ref})}{R} = \frac{V_{ref}}{R} \]

\[ \therefore \text{Collector current } I_E = \frac{(1 + \beta)I_C}{\beta} \]

\[ \therefore I_C = I_o \left( \frac{\beta}{1 + \beta} \right) \frac{V_{ref}}{R} \]
Q No. 14

The following signal \( V_i \) of peak voltage 8 V is applied to the non-inverting terminal of an ideal opamp. The transistor has \( V_{BE} = 0.7 \text{ V}, \beta = 100; V_{LED} = 1.5 \text{ V}, V_{CC} = 10 \text{ V} \) and \( -V_{CC} = -10 \text{ V} \).

The number of times the LED glows is ________

[Ans.*] Range: 2.9 to 3.1
Q No. 15

Consider the oscillator circuit shown in the figure. The function of the network (shown in dotted lines) consisting of the 100 kΩ resistor in series with the two diodes connected back-to-back is to:

(A) introduce amplitude stabilization by preventing the op amp from saturating and thus producing sinusoidal oscillations of fixed amplitude

(B) introduce amplitude stabilization by forcing the opamp to swing between positive and negative saturation and thus producing square wave oscillations of fixed amplitude

(C) introduce frequency stabilization by forcing the circuit to oscillate at a single frequency

(D) enable the loop gain to take on a value that produces square wave oscillations
Q No. 16

The block diagram of a frequency synthesizer consisting of a Phase Locked Loop (PLL) and a divide-by-N counter (comprising +2, +4, +8, +16 outputs) is sketched below. The synthesizer is excited with a 5 kHz signal (Input 1). The free-running frequency of the PLL is set to 20 kHz. Assume that the commutator switch makes contacts repeatedly in the order 1-2-3-4.

The corresponding frequencies synthesized are:
(A) 10 kHz, 20 kHz, 40 kHz, 80 kHz
(B) 20 kHz, 40 kHz, 80 kHz, 160 kHz
(C) 80 kHz, 40 kHz, 20 kHz, 10 kHz
(D) 160 kHz, 80 kHz, 40 kHz, 20 kHz

[Ans. A]
Q No. 17

The output of the combinational circuit given below is

(A) A+B+C  (B) A(B+C)  (C) B(C+A)  (D) C(A+B)

[Ans. C]

For sake of calculation putting the value of C = 0
And thus we get x = 0; z = AB; y = AB
So Only possible answer is B(C + A)
Q No. 18

What is the voltage $V_{out}$ in the following circuit?

(A) $0 \text{ V}$
(B) $\frac{(V_T \text{ of PMOS} + V_T \text{ of NMOS})}{2}$
(C) Switching threshold of inverter
(D) $V_{DD}$

[Ans. C]

Q No. 19

Match the inferences X, Y, and Z, about a system, to the corresponding properties of the elements of first column in Routh’s Table of the system characteristic equation.

X: The system is stable ... P: ... when all elements are positive
Y: The system is unstable ... Q: ... when any one element is zero
Z: The test breaks down ... R: ... when there is a change in sign of coefficients

(A) $X\rightarrow P$, $Y\rightarrow Q$, $Z\rightarrow R$
(B) $X\rightarrow Q$, $Y\rightarrow P$, $Z\rightarrow R$
(C) $X\rightarrow R$, $Y\rightarrow Q$, $Z\rightarrow P$
(D) $X\rightarrow P$, $Y\rightarrow R$, $Z\rightarrow Q$
Q No. 20

A closed-loop control system is stable if the Nyquist plot of the corresponding open-loop transfer function

(A) encircles the s-plane point \((-1 + j0)\) in the counterclockwise direction as many times as the number of right-half s-plane poles.

(B) encircles the s-plane point \((0 - j1)\) in the clockwise direction as many times as the number of right-half s-plane poles.

(C) encircles the s-plane point \((-1 + j0)\) in the counterclockwise direction as many times as the number of left-half s-plane poles.

(D) encircles the s-plane point \((-1 + j0)\) in the counterclockwise direction as many times as the number of right-half s-plane zeros.

[Ans. A]

From the principal of argument theorem the number of encirclements about \((-1, 0)\) is \(N = P - Z\)

\(P = \) Number of open loop poles on Right - Half of s - plane

\(Z = \) Number of Closed Loop Poles on Right Half of s - plane

Given that closed loop system is stable means \(z = 0 \Rightarrow N = P\)

\(\therefore\) So the Nyquist encircles the s - plane point \((-1 + j0)\) in the counter clockwise direction as many times as the number of right half s - plane poles

Q No. 21

Consider binary data transmission at a rate of 56 kbps using baseband binary pulse amplitude modulation (PAM) that is designed to have a raised-cosine spectrum. The transmission bandwidth (in kHz) required for a roll-off factor of 0.25 is ________

[Ans. *] Range: 34.5 to 35.5
Q No. 22

A superheterodyne receiver operates in the frequency range of 58 MHz - 68 MHz. The intermediate frequency $f_{IF}$ and local oscillator frequency $f_{LO}$ are chosen such that $f_{IF} \leq f_{LO}$. It is required that the image frequencies fall outside the 58 MHz - 68 MHz band. The minimum required $f_{IF}$ (in MHz) is ________

[Ans. *] Range: 4.9 to 5.1

Q No. 23

The amplitude of a sinusoidal carrier is modulated by a single sinusoid to obtain the amplitude modulated signal $s(t) = 5 \cos 1600\pi t + 20 \cos 1800\pi t + 5 \cos 2000\pi t$. The value of the modulation index is ________

[Ans. *] Range: 0.49 to 0.51

Q No. 24

Concentric spherical shells of radii 2 m, 4 m, and 8 m carry uniform surface charge densities of 20 nC/m², −4 nC/m² and $\rho_s$, respectively. The value of $\rho_s$ (nC/m²) required to ensure that the electric flux density $\vec{D} = \vec{0}$ at radius 10 m is ________

[Ans. *] Range: −0.28 to 0.22

Q No. 25

The propagation constant of a lossy transmission line is $(2 + j5)$ m⁻¹ and its characteristic impedance is $(50 + j0)$ $\Omega$ at $\omega = 10^6$ rad s⁻¹. The values of the line constants $L, C, R, G$ are, respectively,

(A) $L = 200$ $\mu$H/m, $C = 0.1$ $\mu$F/m, $R = 50$ $\Omega$/m, $G = 0.02$ S/m
(B) $L = 250$ $\mu$H/m, $C = 0.1$ $\mu$F/m, $R = 100$ $\Omega$/m, $G = 0.04$ S/m
(C) $L = 200$ $\mu$H/m, $C = 0.2$ $\mu$F/m, $R = 100$ $\Omega$/m, $G = 0.02$ S/m
(D) $L = 250$ $\mu$H/m, $C = 0.2$ $\mu$F/m, $R = 50$ $\Omega$/m, $G = 0.04$ S/m
Q No. 26

The integral \( \frac{1}{2\pi} \int_D (x + y + 10) \, dx \, dy \), where \( D \) denotes the disc: \( x^2 + y^2 \leq 4 \), evaluates to_____.

[Ans. *] Range: 18 to 22

Given that \( I = \frac{1}{2\pi} \int_D (x + y + 10) \, dx \, dy \) and \( x^2 + y^2 \leq 4 \)

Put \( x = r \cos \theta, y = r \sin \theta, \, dx \, dy = r \, dr \, d\theta \)

\[
I = \frac{1}{2\pi} \int_{r=0}^{2\pi} \int_{r=0}^{\sqrt{4}} (r \cos \theta + r \sin \theta + 10) r \, dr \, d\theta
\]

\[
= \frac{1}{2\pi} \int_{\theta=0}^{2\pi} \left( \frac{r^3}{3} \cos \theta + \frac{r^3}{3} \sin \theta + 5r^2 \right) \, d\theta
\]

\[
= \frac{1}{2\pi} \left[ \int_{\theta=0}^{2\pi} \left( \frac{8}{3} \cos \theta + \frac{8}{3} \sin \theta + 20 \right) \, d\theta \right]
\]

\[
= \frac{1}{2\pi} \left[ \frac{8}{3} \left( \sin \theta + \cos \theta \right) + 20 \theta \right]_{0}^{\pi}
\]

\[
= \frac{20}{3} \pi + \frac{160}{3}
\]

Q No. 27

A sequence \( x[n] \) is specified as

\[
\begin{bmatrix}
  x[n] \\
  x[n-1]
\end{bmatrix} = \begin{bmatrix}
  1 & 1 \\
  1 & 0
\end{bmatrix} \begin{bmatrix}
  1 \\
  0
\end{bmatrix}, \text{for } n \geq 2.
\]

The initial conditions are \( x[0] = 1, \, x[1] = 1, \) and \( x[n] = 0 \) for \( n < 0 \). The value of \( x[12] \) is_____.

[Ans. *] Range: 230 to 240
Q No. 28

In the following integral, the contour $C$ encloses the points $2\pi j$ and $-2\pi j$

$$\frac{1}{2\pi j} \int_C \frac{\sin z}{(z - 2\pi j)^3} \, dz$$

The value of the integral is ________

[Ans. *] Range: $-137$ to $-130$

Q No. 29

The region specified by $\{(\rho, \varphi, z): 3 \leq \rho \leq 5, \frac{\pi}{8} \leq \varphi \leq \frac{\pi}{4}, 3 \leq z \leq 4.5\}$ in cylindrical coordinates has volume of ________

[Ans. *] Range: $4.66$ to $4.76$
Q No. 30

The Laplace transform of the causal periodic square wave of period $T$ shown in the figure below is

$$f(t)$$

1

0 $T/2$ $T$ $3T/2$ $2T$

t

(A) $F(s) = \frac{1}{1 + e^{-sT/2}}$
(B) $F(s) = \frac{1}{s \left(1 + e^{sT/2}\right)}$
(C) $F(s) = \frac{1}{s(1 - e^{-sT})}$
(D) $F(s) = \frac{1}{1 - e^{-sT}}$

[Ans. B]

Laplace transform for periodic signal is given as

$$F(s) = \frac{1}{1 - e^{-sT}} \int_0^T f(t)e^{-st} \, dt$$

$$= \frac{1}{1 - e^{-sT}} \left[ \int_0^{T/2} (1) \cdot e^{-st} \, dt + 0 \right] = \frac{1}{1 - e^{-sT}} \left[ \frac{e^{-st}T/2}{-s} \right]_0$$

$$= \frac{1}{(1 - e^{-sT})} \cdot \frac{1}{s} \left[ 1 - e^{-st/2} \right] = \frac{1 - e^{-sT/2}}{s \left(1 + e^{-sT/2} \right) \left(1 - e^{-sT/2} \right)}$$

$$F(s) = \frac{1}{s \left(1 + e^{-sT/2}\right)}$$
Q No. 31

A network consisting of a finite number of linear resistor (R), inductor (L), and capacitor (C) elements, connected all in series or all in parallel, is excited with a source of the form

\[ \sum_{k=1}^{3} a_k \cos(k\omega_0 t), \text{where } a_k \neq 0, \omega_0 \neq 0. \]

The source has nonzero impedance. Which one of the following is a possible form of the output measured across a resistor in the network?

(A) \[ \sum_{k=1}^{2} b_k \cos(k\omega_0 t + \phi_k), \text{where } b_k \neq a_k, \forall k \]

(B) \[ \sum_{k=1}^{4} b_k \cos(k\omega_0 t + \phi_k), \text{where } b_k \neq 0, \forall k \]

(C) \[ \sum_{k=1}^{3} a_k \cos(k\omega_0 t + \phi_k) \]

(D) \[ \sum_{k=1}^{2} a_k \cos(k\omega_0 t + \phi_k) \]

[Ans. A]

Given input \( x(t) = \sum_{k=1}^{3} a_k \cos(k\omega_0 t) \)

Suppose \( R = 1, L = 1, C = 1 \) and they are connected in series then transfer function of system

\[ H(s) = R + sL + \frac{1}{sC} \]

\[ \Rightarrow H(s) = R + sL + \frac{1}{s} = 1 + s + \frac{1}{s} = \frac{s^2 + s + 1}{s} \]

At \( \omega = k\omega_0 \Rightarrow H(j\omega) = M2\phi \)

\[ \therefore y(t) = \sum_{k=1}^{3} a_k M\cos(k\omega_0 t + \phi) = \sum_{k=1}^{3} b_k \cos(k\omega_0 t + \phi) \]

Where \( b_k \neq a_k \)
Q No. 32

A first-order low-pass filter of time constant \( T \) is excited with different input signals (with zero initial conditions up to \( t = 0 \)). Match the excitation signals \( X, Y, Z \) with the corresponding time responses for \( t \geq 0 \):

\[
\begin{align*}
X: & \quad \text{Impulse} & P: & \quad 1 - e^{-t/T} \\
Y: & \quad \text{Unit step} & Q: & \quad t - T(1 - e^{-t/T}) \\
Z: & \quad \text{Ramp} & R: & \quad e^{-t/T}
\end{align*}
\]

(A) \( X \rightarrow R, \ Y \rightarrow Q, \ Z \rightarrow P \)  
(B) \( X \rightarrow Q, \ Y \rightarrow P, \ Z \rightarrow R \)  
(C) \( X \rightarrow R, \ Y \rightarrow P, \ Z \rightarrow Q \)  
(D) \( X \rightarrow P, \ Y \rightarrow R, \ Z \rightarrow Q \)

[Ans. C]

Let open loop transfer function \( G(s) = \frac{1}{sT} \)

Closed loop transfer function \( H(s) = \frac{1}{1 + sT} \) (assume unity negative feedback)

\( Y(s) = X(s). H(s) \)

Case i:
If input = impulse \( \rightarrow X(s) = 1 \)

\[
Y(s) = \frac{1}{1 + sT} \left( \frac{1}{T + s} \right)
\]

\( y(t) = \frac{1}{T} e^{-\frac{t}{T}} \)

Case ii:
If input = unit step \( \rightarrow X(s) = \frac{1}{s} \)

\[
Y(s) = \frac{1}{1 + sT} \frac{1}{s} = \frac{1}{s} - \frac{T}{s + T} = \frac{1}{T + s} - \frac{1}{s}
\]

\( y(t) = 1 - e^{-\frac{t}{T}} \)

Case iii:
If input = Ramp \( \rightarrow x(s) = \frac{1}{s^2} \)

\[
Y(s) = \frac{1}{1 + sT} \frac{1}{s^2} = \frac{1}{s^2} + \frac{T^2}{1 + sT} + \frac{s}{s}
\]

\( y(t) = t + Te^{-\frac{t}{T}} - T = t - T \left( 1 - e^{-\frac{t}{T}} \right) \)
Q No. 33
An AC voltage source $V = 10 \sin(t)$ volts is applied to the following network. Assume that $R_1 = 3$ kΩ, $R_2 = 6$ kΩ and $R_3 = 9$ kΩ, and that the diode is ideal.

RMS current $I_{\text{rms}}$ (in mA) through the diode is ________

[Ans.*] Range: 0.68 to 0.72

Q No. 34
In the circuit shown in the figure, the maximum power (in watt) delivered to the resistor $R$ is ________

[Ans.*] Range: 0.78 to 0.82
Q No. 35

Consider the signal

\[ x[n] = 6 \delta[n + 2] + 3 \delta[n + 1] + 8 \delta[n] + 7 \delta[n - 1] + 4 \delta[n - 2]. \]

If \( X(e^{j\omega}) \) is the discrete-time Fourier transform of \( x[n] \),

then \( \frac{1}{\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) \sin^2(2\omega) \, d\omega \)

is equal to

\[ \text{Range: 7.9 to 8.1} \]

\[ \frac{1}{\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) \sin^2(2\omega) \, d\omega \]

We have

\[ \sin^2(2\omega) = \frac{1 - \cos 4\omega}{2} \]

Thus,

\[ \frac{1}{\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) \frac{1 - \cos 4\omega}{2} \, d\omega \]

\[ = \frac{1}{2\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) \, d\omega - \frac{1}{2\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) \cos 4\omega \, d\omega \]

We have

\[ \frac{1}{2\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) \, d\omega = x[0] = 8 \]

And from the \( \cos 4\omega \) term

\[ = \frac{1}{2\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) \times \left( \frac{e^{j4\omega} + e^{-j4\omega}}{2} \right) \, d\omega \]

\[ = \frac{1}{2} \left[ \frac{1}{2\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) e^{j4\omega} \, d\omega + \frac{1}{2\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) e^{-j4\omega} \, d\omega \right] \]

\[ = \frac{1}{2} \left[ x[4] + x[-4] \right] = \frac{1}{2} \left[ 0 + 0 \right] = 0 \]

Thus,

\[ \frac{1}{\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) \sin^2(2\omega) \, d\omega = 8 - 0 = 8 \]
Q No. 36

Consider a silicon p-n junction with a uniform acceptor doping concentration of $10^{17}$ cm$^{-3}$ on the p-side and a uniform donor doping concentration of $10^{16}$ cm$^{-3}$ on the n-side. No external voltage is applied to the diode. Given: $kT/q = 26$ mV, $n_i = 1.5 \times 10^{10}$ cm$^{-3}$, $\varepsilon_{Si} = 12\varepsilon_0$, $\varepsilon_0 = 8.85 \times 10^{-14}$ F/m, and $q = 1.6 \times 10^{-19}$ C.

The charge per unit junction area (nC cm$^{-2}$) in the depletion region on the p-side is __________

[Ans. *] Range: $-49$ to $-47$

Q No. 37

Consider an n-channel metal oxide semiconductor field effect transistor (MOSFET) with a gate-to-source voltage of 1.8 V. Assume that $\frac{W}{L} = 4$, $\mu_N C_{ox} = 70 \times 10^{-6}$ AV$^{-2}$, the threshold voltage is 0.3 V, and the channel length modulation parameter is 0.09 V$^{-1}$. In the saturation region, the drain conductance (in microseimens) is __________

[Ans. *] Range: 28 to 29

The equation of current in saturation is given by

$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T)^2 (1 + \lambda V_{DS})$$

Drain Conductance $= \frac{\partial I_D}{\partial V_{DS}} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T)^2 \lambda$

$$= \frac{1}{2} \times 70 \times 10^{-6} \times 4 \times (1.8 - 0.3)^2 \times 0.09$$

$$= 28.35 \times 10^{-6} \mu\text{seimens} = 28.35 \mu\text{seimens}$$

Q No. 38

The figure below shows the doping distribution in a p-type semiconductor in log scale.

The magnitude of the electric field (in kV/cm) in the semiconductor due to non uniform doping is __________

[Ans. *] Range: 1.10 to 1.25
Q No. 39

Consider a silicon sample at $T = 300$ K, with a uniform donor density $N_d = 5 \times 10^{16}$ cm$^{-3}$, illuminated uniformly such that the optical generation rate is $G_{opt} = 1.5 \times 10^{20}$ cm$^{-2}$s$^{-1}$ throughout the sample. The incident radiation is turned off at $t = 0$. Assume low-level injection to be valid and ignore surface effects. The carrier lifetimes are $\tau_{po} = 0.1$ $\mu$s and $\tau_{n0} = 0.5$ $\mu$s.

The hole concentration at $t = 0$ and the hole concentration at $t = 0.3$ $\mu$s, respectively, are

(A) $1.5 \times 10^{13}$ cm$^{-3}$ and $7.47 \times 10^{11}$ cm$^{-3}$
(B) $1.5 \times 10^{13}$ cm$^{-3}$ and $8.23 \times 10^{11}$ cm$^{-3}$
(C) $7.5 \times 10^{13}$ cm$^{-3}$ and $3.73 \times 10^{11}$ cm$^{-3}$
(D) $7.5 \times 10^{13}$ cm$^{-3}$ and $4.12 \times 10^{11}$ cm$^{-3}$

[Ans. A]

Q No. 40

An ideal opamp has voltage sources $V_1, V_2, V_3, \ldots, V_{N-1}$ connected to the non-inverting input and $V_2, V_4, V_6, \ldots, V_N$ connected to the inverting input as shown in the figure below ($+V_{CC} = 15$ volt, $-V_{CC} = -15$ volt). The voltages $V_1, V_2, V_3, V_4, V_5, V_6, \ldots$ are $1, -1/2, 1/3, -1/4, 1/5, -1/6, \ldots$ volt, respectively. As $N$ approaches infinity, the output voltage (in volt) is ________

[Ans. *} Range: 14.9 to 15.5
A $p$-$i$-$n$ photodiode of responsivity 0.8A/W is connected to the inverting input of an ideal opamp as shown in the figure. $+V_{cc} = 15$ V, $-V_{cc} = -15$ V, Load resistor $R_L = 10$ kΩ. If 10 μW of power is incident on the photodiode, then the value of the photocurrent (in μA) through the load is ________

![Diagram of the circuit with opamp and photodiode]

[Ans. *] Range: 790 to 810
By Virtual Ground concept voltage at inverting = Non-inverting = 0V
Responsibility $= \frac{I_p}{P_0}$
$\Rightarrow$ Photodiode current $I_p = 0.8 \times 10 \times 10^{-6} = 8\mu$ A

$-I_p = \frac{0 - V_0}{1 \text{ MΩ}} = \frac{8}{10^4} = 800\mu$A
Q No. 42

Identify the circuit below.

(A) Binary to Gray code converter
(B) Binary to XS3 converter
(C) Gray to Binary converter
(D) XS3 to Binary converter

[Ans. C]
Assume $X_2 X_1 X_0 = (1 1 1)_2 = 7_{10}$
Then output of first decoder = $O_{P7}$ which is connected to $I_{P5}$ of encoder
$((5)_{10} = (101)_2$)
∴ Output of encoder $Y_2 Y_1 Y_0 = 1 0 1$
∴ Input to the circuit = 1 1 1 and output = 1 0 1
Consider Gray to Binary converter if input = 111 then output is 101.
∴ So the given circuit acts like Gray to Binary converter
Q No. 43

The functionality implemented by the circuit below is

\[ \text{(A) 2-to-1 multiplexer} \quad \text{(B) 4-to-1 multiplexer} \quad \text{(C) 7-to-1 multiplexer} \quad \text{(D) 6-to-1 multiplexer} \]

[Ans. B]

From the given figure

<table>
<thead>
<tr>
<th>( C_1 )</th>
<th>( C_0 )</th>
<th>( Y )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>( P )</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>( Q )</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>( R )</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>( S )</td>
</tr>
</tbody>
</table>

Truth table describes the function ability of a 4 to 1 multiplexer
Q No. 44

In an 8085 system, a PUSH operation requires more clock cycles than a POP operation. Which one of the following options is the correct reason for this?

(A) For POP, the data transceivers remain in the same direction as for instruction fetch (memory to processor), whereas for PUSH their direction has to be reversed.

(B) Memory write operations are slower than memory read operations in an 8085 based system.

(C) The stack pointer needs to be pre-decremented before writing registers in a PUSH, whereas a POP operation uses the address already in the stack pointer.

(D) Order of registers has to be interchanged for a PUSH operation, whereas POP uses their natural order.

[Ans. C]

Q No. 45

The open-loop transfer function of a unity-feedback control system is

\[ G(s) = \frac{K}{s^2 + 5s + 5} \]

The value of \( K \) at the breakaway point of the feedback control system's root-locus plot is __________

[Ans. *] Range: 1.2 to 1.3

Given open loop transfer function \( G(s) = \frac{K}{(s^2 + 5s + 5)} \)

\[ 1 + G(s)H(s) \rightarrow 1 + \frac{K}{(s^2 + 5s + 5)} = 0 \]

\[ K = -(s^2 + 5s + 5) \]

For Break-point calculation we need \( \frac{dK}{ds} = 0 \)

\[ \rightarrow 2s + 5 = 0 \rightarrow s = -2.5 \]

At \( s = -2.5 \) \( G(s) = \frac{K}{6.25 + 5(-2.5) + 5} \)

Form magnitude Criterion \( |G(s)| = 1 \) at \( s = 2.5 \)

\[ \left| \frac{K}{11.25 - 12.5} \right| = 1 \]

\[ \left| \frac{K}{-1.25} \right| = 1 \rightarrow K = 1.25 \]
Q No. 46

The open-loop transfer function of a unity-feedback control system is given by

\[ G(s) = \frac{K}{s(s + 2)} \]

For the peak overshoot of the closed-loop system to a unit step input to be 10%, the value of K is ____________

[Ans. *] Range: 2.7 to 3.0

Q No. 47

The transfer function of a linear time invariant system is given by

\[ H(s) = 2s^4 - 5s^3 + 5s - 2 \]

The number of zeros in the right half of the s-plane is ____________

[Ans. *] Range: 3 to 3

Given \( H(s) = 2s^4 - 5s^3 + 5s - 2 \)

Obtain RH criteria we get

| \( s^4 \) | 2 | 0 | 2 |
| \( s^3 \) | -5 | 5 |
| \( s^2 \) | 2 | -2 |
| \( s^1 \) | 4(0) |
| \( s^0 \) | -2 |

Auxiliary Equation AE: \( 2s^2 - 2 = 0 \) and \( \frac{d\text{AE}}{ds} = 4 \)

\( \therefore \) No. of sign changes in first columns = 3

\( \therefore \) No. of roots in Right Half of s-plane = 3

Q No. 48

Consider a discrete memoryless source with alphabet \( S = \{ s_0, s_1, s_2, s_3, s_4, \ldots \} \) and respective probabilities of occurrence \( P = \left\{ \frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}, \ldots \right\} \). The entropy of the source (in bits) is ________
Q No. 49

A digital communication system uses a repetition code for channel encoding/decoding. During transmission, each bit is repeated three times (0 is transmitted as 000, and 1 is transmitted as 111). It is assumed that the source puts out symbols independently and with equal probability. The decoder operates as follows: In a block of three received bits, if the number of zeros exceeds the number of ones, the decoder decides in favor of a 0, and if the number of ones exceeds the number of zeros, the decoder decides in favor of a 1. Assuming a binary symmetric channel with crossover probability p = 0.1, the average probability of error is _______

[Ans. *] Range: 0.025 to 0.030

Probability of decoding correctly [P: Cross over probability]

\[ P = \binom{3}{0}p^0(1-p)^3 + \binom{3}{1}p^1(1-p)^3 = (0.9)^3 + 3(0.1)(0.9)^2 = 0.972 \]

\[ \therefore \text{Average probability of error} = 1 - 0.972 = 0.028 \]

Q No. 50
An analog pulse $s(t)$ is transmitted over an additive white Gaussian noise (AWGN) channel. The received signal is $r(t) = s(t) + n(t)$, where $n(t)$ is additive white Gaussian noise with power spectral density $\frac{N_0}{2}$. The received signal is passed through a filter with impulse response $h(t)$. Let $E_s$ and $E_h$ denote the energies of the pulse $s(t)$ and the filter $h(t)$, respectively. When the signal-to-noise ratio (SNR) is maximized at the output of the filter (SNR$_{\text{max}}$), which of the following holds?

(A) $E_s = E_h$; $\text{SNR}_{\text{max}} = \frac{2E_s}{N_0}$
(B) $E_s = E_h$; $\text{SNR}_{\text{max}} = \frac{E_s}{2N_0}$
(C) $E_s > E_h$; $\text{SNR}_{\text{max}} > \frac{2E_s}{N_0}$
(D) $E_s < E_h$; $\text{SNR}_{\text{max}} = \frac{2E_h}{N_0}$

[Ans. A]

The SNR is maximum when the filter is matched to the input signal. And when the filter is matched to the input the energies of both the input and matched filter responses is same. Thus $E_s = E_h$. And in that case the SNR $= \frac{2E_s}{N_0} = \frac{2E_h}{N_0}$.

Q No. 51

The current density in a medium is given by

$$ \vec{J} = \frac{400 \sin \theta}{2\pi (r^2 + 4)} \hat{a}_r \text{ Am}^{-2} $$

The total current and the average current density flowing through the portion of a spherical surface $r = 0.8 \text{ m}$, $\frac{\pi}{12} \leq \theta \leq \frac{\pi}{4}$, $0 \leq \phi \leq 2\pi$ are given, respectively, by

(A) 15.09 A, 12.86 Am$^2$
(B) 18.73 A, 13.65 Am$^2$
(C) 12.86 A, 9.23 Am$^2$
(D) 10.28 A, 7.56 Am$^2$

[Ans. A]

Q No. 52

An antenna pointing in a certain direction has a noise temperature of 50 K. The ambient temperature is 290 K. The antenna is connected to a pre-amplifier that has a noise figure of 2 dB and an available gain of 40 dB over an effective bandwidth of 12 MHz. The effective input noise temperature $T_e$ for the amplifier and the noise power $P_{\text{in}}$ at the output of the preamplifier, respectively, are

(A) $T_e = 169.36$ K and $P_{\text{in}} = 3.73 \times 10^{-10}$ W
(B) $T_e = 170.8$ K and $P_{\text{in}} = 4.56 \times 10^{-10}$ W
(C) $T_e = 182.5$ K and $P_{\text{in}} = 3.85 \times 10^{-10}$ W
(D) $T_e = 160.62$ K and $P_{\text{in}} = 4.6 \times 10^{-10}$ W
Q No. 53

Two lossless X-band horn antennas are separated by a distance of 200λ. The amplitude reflection coefficients at the terminals of the transmitting and receiving antennas are 0.15 and 0.18, respectively. The maximum directivities of the transmitting and receiving antennas (over the isotropic antenna) are 18 dB and 22 dB, respectively. Assuming that the input power in the lossless transmission line connected to the antenna is 2 W, and that the antennas are perfectly aligned and polarization matched, the power (in mW) delivered to the load at the receiver is _______.

[Ans. *] Range: 2.7 to 3.3
Q No. 54

The electric field of a uniform plane wave travelling along the negative $z$ direction is given by the following equation:

$$\vec{E}_w = (\hat{a}_x + j\hat{a}_y)E_0 e^{jkz}$$

This wave is incident upon a receiving antenna placed at the origin and whose radiated electric field towards the incident wave is given by the following equation:

$$\vec{E}_a = (\hat{a}_x + 2\hat{a}_y)E_1 \frac{1}{r} e^{-jkr}$$

The polarization of the incident wave, the polarization of the antenna and losses due to the polarization mismatch are, respectively,

(A) Linear, Circular (clockwise), $-5\text{dB}$  
(B) Circular (clockwise), Linear, $-5\text{dB}$

(C) Circular (clockwise), Linear, $-3\text{dB}$  
(D) Circular (anti-clockwise), Linear, $-3\text{dB}$

[Ans. C, D]

The incident electric field is circular polarised as the two components are equal and phase shifted by $90^\circ$. When we multiply the time exponential $e^{j\omega t}$. We see that the wave is anticlockwise circular. The antenna electric filed is linearly polarised as the two components are in phase. Thus, without calculating polarisation loss we see the correct option is D.

Q No. 55

The far-zone power density radiated by a helical antenna is approximated as:

$$\overline{W}_{rad} = \overline{W}_{average} \approx \hat{a}_r C_0 \frac{1}{\gamma^2} \cos^4 \theta$$

The radiated power density is symmetrical with respect to $\phi$ and exists only in the upper hemisphere, $0 \leq \theta \leq \frac{\pi}{2}$; $0 \leq \phi \leq 2\pi$. $C_0$ is a constant. The power radiated by the antenna (in watts) and the maximum directivity of the antenna, respectively, are

(A) $1.5C_0$, 10dB  
(B) $1.256C_0$, 10dB  
(C) $1.256C_0$, 12dB  
(D) $1.5C_0$, 12dB

[Ans. C, D]
[Ans. B]

Given that \( W_{rad} = W_{avg} = \frac{1}{r^2} \cos 4\theta \cdot C_0 \cdot \vec{a}_r \)

Power radiated = \( \int W_{rad} \cdot d\vec{S} \)

But \( d\vec{S} = r^2 \sin \theta \ d\theta d\phi \cdot \vec{a}_r \)

Power radiated = \( \int \int \frac{1}{r^2} \cos 4\theta \cdot C_0 \cdot r^2 \sin \theta \ d\theta d\phi \)

Where \( 0 \leq \theta \leq \pi/2 \) and \( 0 \leq \phi \leq 2\pi \)

\( \Rightarrow \) Power Radiated, \( P_{rad} = \int \int \cos 4\theta \cdot C_0 \cdot \sin \theta \ d\theta d\phi \)

\( = C_0 (2\pi) \int \cos^4 \theta \cdot \sin \theta \ d\theta \) where \( 0 \leq \theta \leq \pi/2 \)

\( = C_0 \cdot 2\pi \left( \frac{3}{5} \cdot \frac{1}{3} \cdot \frac{1}{3} \right) = 1.256C_0 \)

Radiation intensity = \( U = r^2 \cdot W_{rad} = \cos^4 \theta \cdot C_0 \)

Directivity \( D_0 = 4\pi \cdot \frac{U_{max}}{P_{rad}} = 4\pi \cdot \frac{C_0}{1.256 C_0} = 10.005 \)

Directivity in (dB) = \( 10 \log_{10} 10.005 = 10 \)