GATE EC 2011

Q. No. 1 – 25 Carry One Mark Each

MCQ 1.1 Consider the following statements regarding the complex Poynting vector $\vec{P}$ for the power radiated by a point source in an infinite homogeneous and lossless medium. Re$(\vec{P})$ denotes the real part of $\vec{P}.S$ denotes a spherical surface whose centre is at the point source, and $\hat{n}$ denotes the unit surface normal on S. Which of the following statements is TRUE?

(A) Re$(\vec{P})$ remains constant at any radial distance from the source

(B) Re$(\vec{P})$ increases with increasing radial distance from the source

(C) $\oiint_S \text{Re}(\vec{P}).\hat{n}\, dS$ remains constant at any radial distance from the source

(D) $\oiint_S \text{Re}(\vec{P}).\hat{n}\, dS$ decreases with increasing radial distance form the source

SOL 1.1 Power radiated from any source is constant.
Hence (C) is correct option..

MCQ 1.2 A transmission line of characteristic impedance $50\,\Omega$ is terminated by a $50\,\Omega$ load. When excited by a sinusoidal voltage source at 10 GHz, the phase difference between two points spaced 2 mm apart on the line is found to be $\frac{\pi}{4}$ radians. The phase velocity of the wave along the line is

(A) 0.8×10^8 m/s | (B) 1.2×10^8 m/s

(C) 1.6×10^8 m/s | (D) 3×10^8 m/s

SOL 1.2 We have $d = 2$ mm and $f = 10$ GHz

$$\text{Phase difference} = \frac{2\pi}{\lambda} d = \frac{\pi}{4};$$

or

$$= \lambda = 8d = 8 \times 2\,\text{mm} = 16\text{ mm}$$

$$v = f\lambda = 10 \times 10^9 \times 16 \times 10^{-3}$$

$$= 1.6 \times 10^8\,\text{m/sec}$$

Hence (C) is correct option.

MCQ 1.3 An analog signal is band-limited to 4 kHz, sampled at the Nyquist rate and the samples are quantized into 4 levels. The quantized levels are assumed to be independent and equally probable. If we transmit two quantized samples per second, the information rate is _________ bits / second.

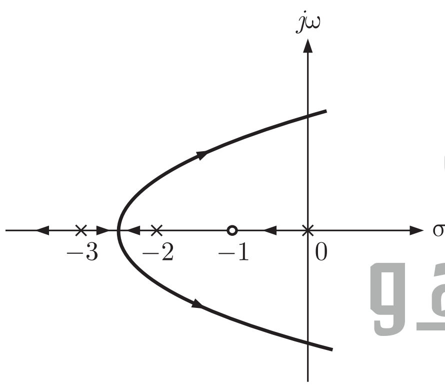
(A) 1 (B) 2

(C) 3 (D) 4

SOL 1.3 Quantized 4 level require 2 bit representation i.e. for one sample 2 bit are required. Since 2 sample per second are transmitted we require 4 bit to be transmitted per second.

Hence (D) is correct option.

MCQ 1.4 The root locus plot for a system is given below. The open loop transfer function corresponding to this plot is given by



(A) $G(s)\,H(s) = k\dfrac{s(s+1)}{(s+2)(s+3)}$

(B) $G(s)\,H(s) = k\dfrac{(s+1)}{s(s+2)(s+3)^2}$

(C) $G(s)\,H(s) = k\dfrac{1}{s(s-1)(s+2)(s+3)}$

(D) $G(s)\,H(s) = k\dfrac{(s+1)}{s(s+2)(s+3)}$

SOL 1.4 For given plot root locus exists from -3 to ∞, So there must be odd number of poles and zeros. There is a double pole at $s = -3$

$$\text{Now poles} = 0, -2, -3, -3$$

$$\text{zeros} = -1$$

Thus transfer function $G(s)\,H(s) = \dfrac{k(s+1)}{s(s+2)(s+3)^2}$

Hence (B) is correct option.

MCQ 1.5 A system is defined by its impulse response $h(n) = 2^n u(n-2)$. The system is

(A) stable and causal (B) causal but not stable

(C) stable but not causal (D) unstable and non-causal

SOL 1.5 Function $h(n) = a^n u(n)$ stable if $|a| < 1$ and Unstable if $|a| \geqslant 1$

We have $h(n) = 2^n u(n-2)$;

Here $|a| = 2$ therefore $h(n)$ is unstable and since $h(n) = 0$ for $n < 0$

Therefore $h(n)$ will be causal. So $h(n)$ is causal and not stable.

Hence (B) is correct option.

MCQ 1.6 If the unit step response of a network is $(1 - e^{-\alpha t})$, then its unit impulse response is

(A) $\alpha e^{-\alpha t}$ (B) $\alpha^{-1} e^{-\alpha t}$

(C) $(1 - \alpha^{-1}) e^{\alpha t}$ (D) $(1 - \alpha) e^{-\alpha t}$

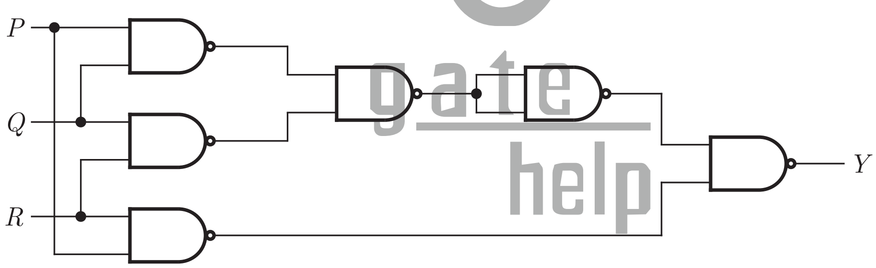
SOL 1.6 Hence (A) is correct option.

$$\text{Impulse response} = \frac{d}{dt}(\text{step response})$$

$$= \frac{d}{dt}(1 - e^{-\alpha t})$$

$$= 0 + \alpha e^{-\alpha t} = \alpha e^{-\alpha t}$$

MCQ 1.7 The output Y in the circuit below is always '1' when



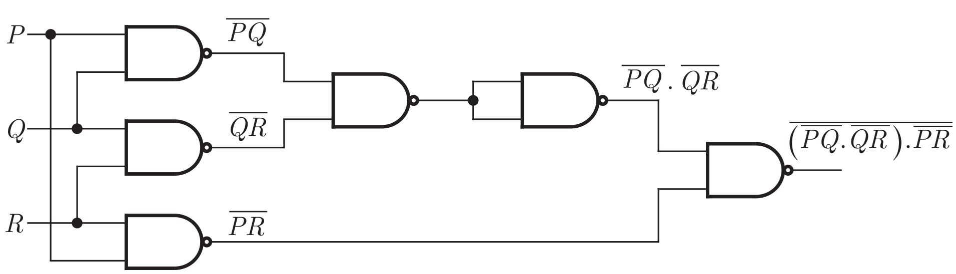
(A) two or more of the inputs P, Q, R are '0'

(B) two or more of the inputs P, Q, R are '1'

(C) any odd number of the inputs P, Q, R is '0'

(D) any odd number of the inputs P, Q, R is '1'

SOL 1.7 The given circuit is shown below:



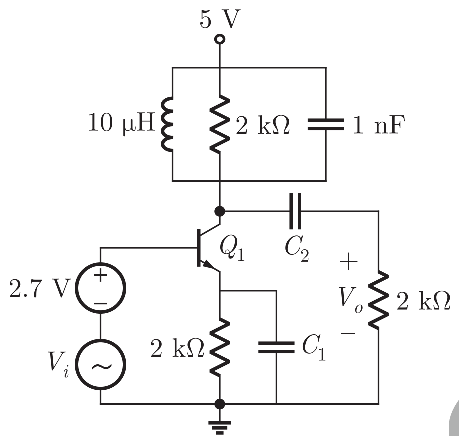
$$\overline{(\overline{PQ}\;\overline{QR})\;\overline{PR}} = \overline{(\overline{PQ + QR}\;\overline{PR})}$$

$$= \overline{\overline{PQ + QR}} + \overline{\overline{PR}}$$

$$= PQ + QR + PR$$

If any two or more inputs are '1' then output y will be 1.
Hence (B) is correct option.

MCQ 1.8 In the circuit shown below, capacitors C_1 and C_2 are very large and are shorts at the input frequency. v_i is a small signal input. The gain magnitude $\left|\frac{v_o}{v_i}\right|$ at 10 M rad/s is



(A) maximum (B) minimum

(C) unity (D) zero

SOL 1.8 For the parallel RLC circuit resonance frequency is,

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10 \times 10^{-6} \times 1 \times 10^{-9}}} = 10\,\text{M rad/s}$$

Thus given frequency is resonance frequency and parallel RLC circuit has maximum impedance at resonance frequency

Gain of the amplifier is $g_m \times (Z_C \parallel R_L)$ where Z_C is impedance of parallel RLC circuit.

At $\omega = \omega_r$, $Z_C = R = 2\,\text{k}\Omega = Z_{C\max}$.

Hence at this frequency (ω_r), gain is

$\text{Gain}\big|_{\omega=\omega_r} = g_m(Z_C \parallel R_L) = g_m(2\text{k} \parallel 2\text{k}) = g_m \times 10^3$ which is maximum. Therefore gain is maximum at $\omega_r = 10\,\text{M rad/sec}$.

Hence (A) is correct option.

MCQ 1.9 Drift current in the semiconductors depends upon

(A) only the electric field

(B) only the carrier concentration gradient

(C) both the electric field and the carrier concentration

(D) both the electric field and the carrier concentration gradient

SOL 1.9 Hence (C) is correct option.

Drift current $I_d = qn\mu_n E$

It depends upon Electric field E and carrier concentration n

MCQ 1.10 A Zener diode, when used in voltage stabilization circuits, is biased in

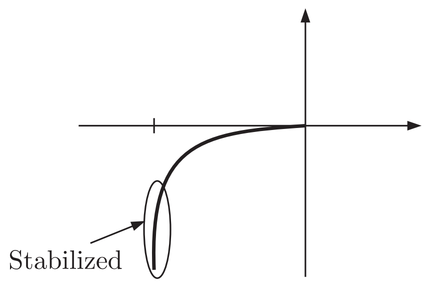
(A) reverse bias region below the breakdown voltage

(B) reverse breakdown region

(C) forward bias region

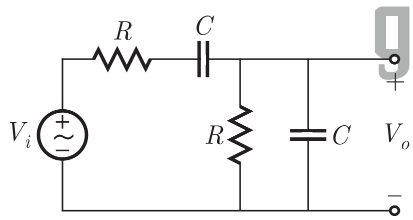
(D) forward bias constant current mode

SOL 1.10 Zener diode operates in reverse breakdown region.



Hence (B) is correct option.

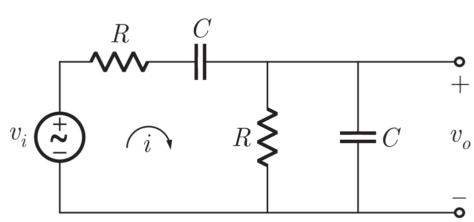
MCQ 1.11 The circuit shown below is driven by a sinusoidal input $v_i = v_p \cos(t/RC)$. The steady state output v_o



(A) $(v_p/3)\cos(t/RC)$ (B) $(v_p/3)\sin(t/RC)$

(C) $(v_p/2)\cos(t/RC)$ (D) $(v_p/2)\sin(t/RC)$

SOL 1.11 The given circuit is shown below



For parallel combination of R and C equivalent impedance is

$$Z_p = \frac{R \cdot \frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} = \frac{R}{1 + j\omega RC}$$

Transfer function can be written as

$$\frac{V_{out}}{V_{in}} = \frac{Z_p}{Z_s + Z_p} = \frac{\frac{R}{1 + j\omega RC}}{R + \frac{1}{j\omega C} + \frac{R}{1 + j\omega RC}}$$

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

$$= \frac{j}{j + (1 + j)^2} \qquad \text{Here } \omega = \frac{1}{RC}$$

$$\frac{V_{out}}{V_{in}} = \frac{j}{(1 + j)^2 + j} = \frac{1}{3}$$

Thus $v_{out} = \left(\frac{V_p}{3}\right)\cos(t/RC)$

Hence (A) is correct option.

MCQ 1.12 Consider a closed surface S surrounding volume V. If $\vec{r}$ is the position vector of a point inside S, with $\hat{n}$ the unit normal on S, the value of the integral $\oiint 5\hat{r}.\vec{n}\, dS$ is

(A) 3V (B) 5V

(C) 10V (D) 15V

SOL 1.12 From Divergence theorem, we have

$$\iiint \vec{\nabla} \cdot \vec{A}\, dv = \oint_s \vec{A} \cdot \hat{n}\, ds$$

The position vector

$$\vec{r} = (\hat{u}_x x + \hat{u}_y y + \hat{u}_z z)$$

Here, $\vec{A} = 5\vec{r}$, thus

$$\nabla \cdot \vec{A} = \left(\hat{u}_x \frac{\partial}{\partial x} + \hat{u}_y \frac{\partial}{\partial y} + \hat{u}_z \frac{\partial}{\partial z}\right) \cdot (\hat{u}_x x + \hat{u}_y y + \hat{u}_z z)$$

$$= \left(\frac{dx}{dx} + \frac{dy}{dy} + \frac{dz}{dz}\right)5 = 3 \times 5 = 15$$

So, $\iint_s 5\vec{r} \cdot \hat{n}\, ds = \iiint 15\, dv = 15V$

Hence (D) is correct option

MCQ 1.13 The modes in a rectangular waveguide are denoted by $\frac{TE_{mn}}{TM_{mn}}$ where m and n are the eigen numbers along the larger and smaller dimensions of the waveguide respectively. Which one of the following statements is TRUE?

(A) The TM_{10} mode of the wave does not exist

(B) The TE_{10} mode of the wave does not exist

(C) The TM_{10} and TE_{10} the modes both exist and have the same cut-off frequencies

(D) The TM_{10} and TM_{01} modes both exist and have the same cut-off frequencies

SOL 1.13 TM_{11} is the lowest order mode of all the TM_{mn} modes.

Hence (A) is correct option.

MCQ 1.14 The solution of the differential equation $\frac{dy}{dx} = ky$, $y(0) = c$ is

(A) $x = ce^{-ky}$ (B) $x = ke^{cy}$

(C) $y = ce^{kx}$ (D) $y = ce^{-kx}$

SOL 1.14 Hence (C) is correct answer

We have $\frac{dy}{dx} = ky$

Integrating $\int \frac{dy}{y} = \int k\,dx + A$

or $\ln y = kx + A$

Since $y(0) = c$ thus $\ln c = A$

So, we get, $\ln y = kx + \ln c$

or $\ln y = \ln e^{kx} + \ln c$

or $y = ce^{kx}$

MCQ 1.15 The Column-I lists the attributes and the Column-II lists the modulation systems. Match the attribute to the modulation system that best meets it

Column-I

P. Power efficient transmission of signals

Q. Most bandwidth efficient transmission of voice signals

R. Simplest receiver structure

S. Bandwidth efficient transmission of signals with Significant dc component

Column-II

1. Conventional AM
2. FM
3. VSB
4. SSB-SC

(A) P-4;Q-2;R-1;S-3 (B) P-2;Q-4;R-1;S-3

(C) P-3;Q-2;R-1;S-4 (D) P-2;Q-4;R-3;S-1

SOL 1.15 In FM the amplitude is constant and power is efficient transmitted. No variation in power.

There is most bandwidth efficient transmission in SSB- SC. because we transmit only one side band.

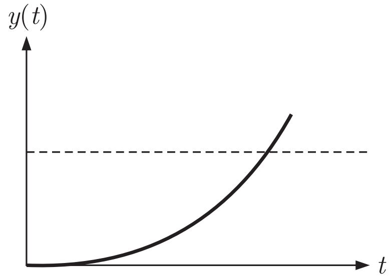
Simple Diode in Non linear region (Square law) is used in conventional AM that is simplest receiver structure.

In VSB dc. component exists.

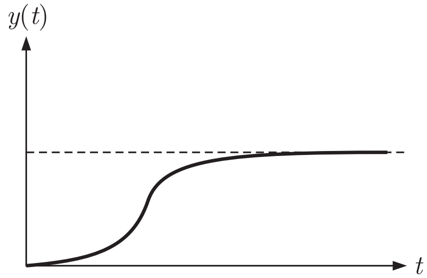
Hence (B) is correct option.

MCQ 1.16 The differential equation $100\frac{d^2y}{dt^2} - 20\frac{dy}{dt} + y = x(t)$ describes a system with an in put $x(t)$ and an output $y(t)$. The system, which is initially relaxed, is excited by a unit step input. The output y(t) can be represented by the waveform

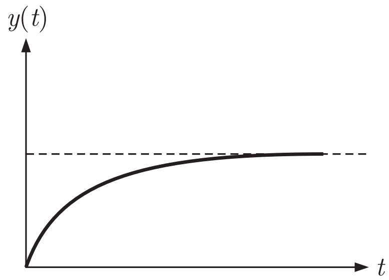
(A)



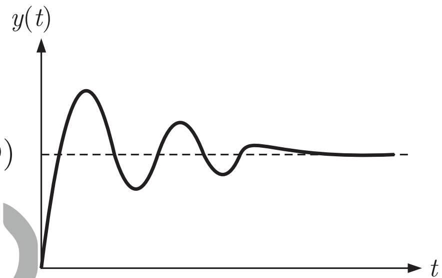
(B)



(C)



(D)



SOL 1.16 Hence (A) is correct option.

We have $$100\frac{d^2y}{dt^2} - 20\frac{dy}{dt} + y = x(t)$$

Applying Laplace transform we get

$$100s^2 Y(s) - 20sY(s) + Y(s) = X(s)$$

or $$H(s) = \frac{Y(s)}{X(s)} = \frac{1}{100s^2 - 20s + 1}$$

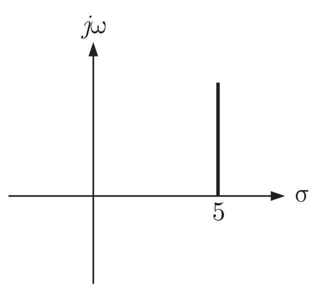
$$= \frac{1/100}{s^2 - (1/5)s + 1/100} = \frac{A}{s^2 + 2\xi\omega_n s + \omega^2}$$

Here $\omega_n = 1/10$ and $2\xi\omega_n = -1/5$ giving $\xi = -1$

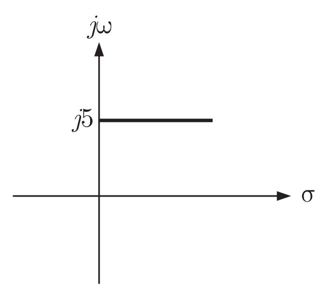
Roots are $s = 1/10, 1/10$ which lie on Right side of s plane thus unstable.

MCQ 1.17 For the transfer function $G(j\omega) = 5 + j\omega$, the corresponding Nyquist plot for positive frequency has the form

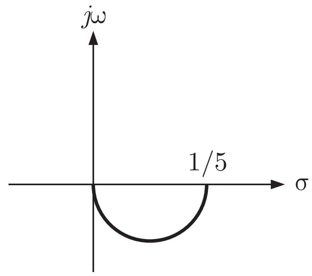
(A)



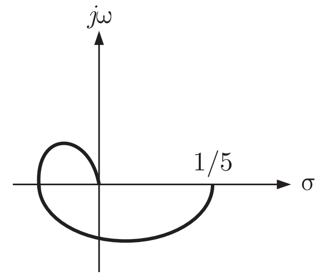
(B)



(C)



(D)



SOL 1.17 We have $G(j\omega) = 5 + j\omega$

Here $\sigma = 5$. Thus $G(j\omega)$ is a straight line parallel to $j\omega$ axis.

Hence (A) is correct option.

MCQ 1.18 The trigonometric Fourier series of an even function does not have the

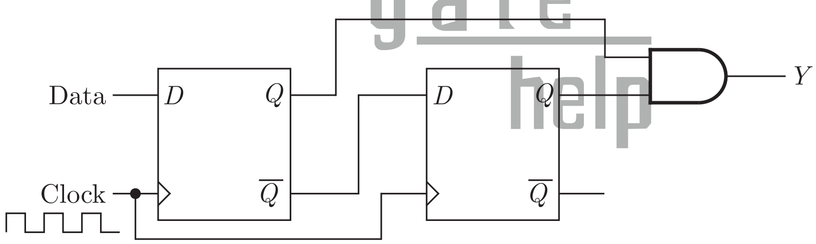
(A) dc term (B) cosine terms

(C) sine terms (D) odd harmonic terms

SOL 1.18 For an even function Fourier series contains dc term and cosine term (even and odd harmonics).

Hence (C) is correct option.

MCQ 1.19 When the output Y in the circuit below is '1', it implies that data has



(A) changed from 0 to 1 (B) changed from 1 to 0

(C) changed in either direction (D) not changed

SOL 1.19 For the output to be high, both inputs to AND gate should be high.

The D-Flip Flop output is the same, after a delay.

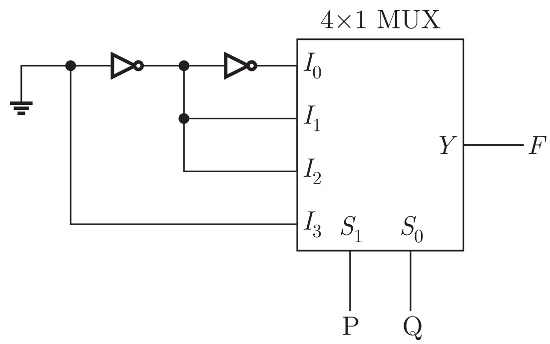
Let initial input be 0; (Consider Option A)

then $\overline{Q} = 1$ (For 1^{st} D-Flip Flop). This is given as input to 2^{nd} FF.

Let the second input be 1. Now, considering after 1 time interval; The output of 1^{st} Flip Flop is 1 and 2^{nd} FF is also 1. Thus Output = 1.

Hence (A) is correct option.

MCQ 1.20 The logic function implemented by the circuit below is (ground implies logic 0)



(A) $F = \text{AND}(P, Q)$ (B) $F = \text{OR}(P, Q)$
(C) $F = X\,\text{NOR}(P, Q)$ (D) $F = X\,\text{OR}(P, Q)$

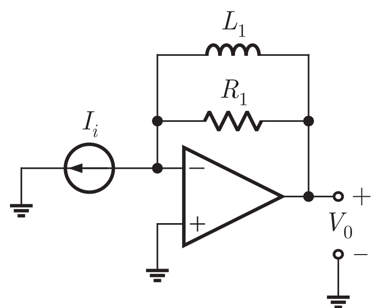
SOL 1.20 Hence (D) is correct option.

$$F = \overline{S}_1\overline{S}_0 I_0 + \overline{S}_1 S_0 I_1 + S_1\overline{S}_0 I_2 + S_1 S_0 I_3$$

$$I_0 = I_3 = 0$$

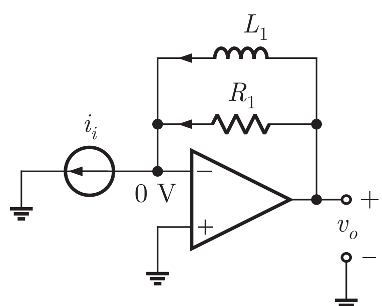
$$F = \overline{P}Q + P\overline{Q} = \text{XOR}(P,\ Q) \qquad (S_1 = P, S_0 = Q)$$

MCQ 1.21 The circuit below implements a filter between the input current ii and the output voltage v_o. Assume that the opamp is ideal. The filter implemented is a



(A) low pass filter (B) band pass filter
(C) band stop filter (D) high pass filter

SOL 1.21 The given circuit is shown below :



From diagram we can write

$$I_i = \frac{V_o}{R_1} + \frac{V_o}{sL_1}$$

Transfer function

$$H(s) = \frac{V_o}{I_1} = \frac{sR_1L_1}{R_1 + sL_1}$$

or $$H(j\omega) = \frac{j\omega R_1L_1}{R_1 + j\omega L_1}$$

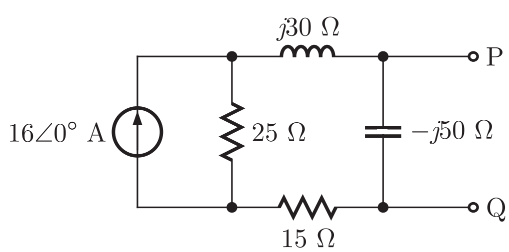
At $\omega = 0$
$H(j\omega) = 0$
At $\omega = \infty$
$H(j\omega) = R_1 =$ constant. Hence HPF.
Hence (D) is correct option.

MCQ 1.22 A silicon PN junction is forward biased with a constant current at room temperature. When the temperature is increased by 10°C, the forward bias voltage across the PN junction

(A) increases by 60 mV (B) decreases by 60 mV
(C) increases by 25 mV (D) decreases by 25 mV

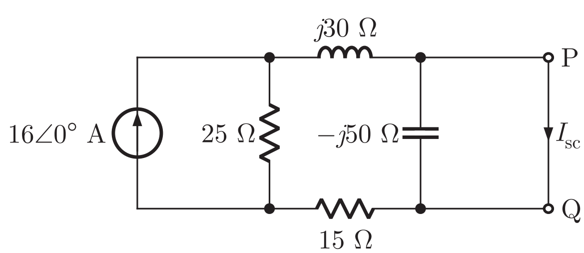
SOL 1.22 For every 1° C increase in temperature, forward bias voltage across diode decreases by 2.5 mV. Thus for 10° C increase, there us 25 mV decreases.
Hence (D) is correct option.

MCQ 1.23 In the circuit shown below, the Norton equivalent current in amperes with respect to the terminals P and Q is



(A) $6.4 - j\,4.8$ (B) $6.56 - j\,7.87$
(C) $10 + j0$ (D) $16 + j0$

SOL 1.23 Replacing $P - Q$ by short circuit as shown below we have

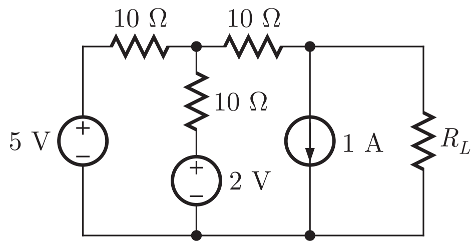


Using current divider rule the current I_{sc} is

$$I_{SC} = \frac{25}{25 + 15 + j30}(16\angle 0) = (6.4 - j4.8)\text{ A}$$

Hence (A) is correct option.

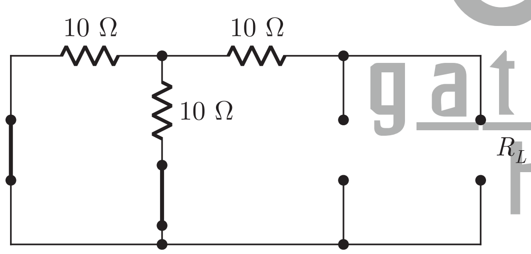
MCQ 1.24 In the circuit shown below, the value of R_L such that the power transferred to R_L is maximum is



(A) $5\,\Omega$ (B) $10\,\Omega$

(C) $15\,\Omega$ (D) $20\,\Omega$

SOL 1.24 Power transferred to R_L will be maximum when R_L is equal to the thevenin resistance. We determine thevenin resistance by killing all source as follows :



$$R_{TH} = \frac{10 \times 10}{10 + 10} + 10 = 15\,\Omega$$

Hence (C) is correct option.

MCQ 1.25 The value of the integral $\oint_c \frac{-3z + 4}{(z^2 + 4z + 5)}\text{dz}$ where c is the circle $|z| = 1$ is given by

(A) 0 (B) 1/10

(C) 4/5 (D) 1

SOL 1.25 C R Integrals is $\oint_C \frac{-3z + 4}{z^2 + 4z + 5} dz$ where C is circle $|z| = 1$

$$\oint_C f(z)\,dz = 0 \text{ if poles are outside C.}$$

Now $z^2 + 4z + 5 = 0$

$$(z + 2)^2 + 1 = 0$$

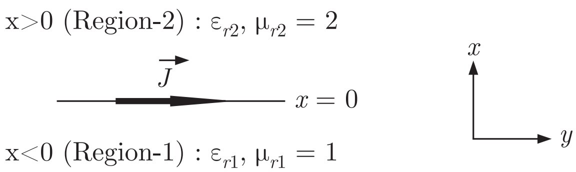
Thus $z_{1,2} = -2 \pm j \Rightarrow |z_{1,2}| > 1$

So poles are outside the unit circle.

Hence (A) is correct option.

Q. No. 26 – 51 Carry Two Marks Each

MCQ 1.26 A current sheet $\overline{J} = 10\hat{u}_y$ A/m lies on the dielectric interface $x = 0$ between two dielectric media with $\varepsilon_{r1} = 5$, $\mu_{r1} = 1$ in Region -1 $(x < 0)$ and $\varepsilon_{r2} = 5$, $\mu_{r2} = 2$ in Region $-2\,(x > 0)$. If the magnetic field in Region-1 at $x = 0^-$ is $\vec{H}_1 = 3\hat{u}_x + 30\hat{u}_y$ A/m the magnetic field in Region-2 at $x = 0^+$ is



(A) $H_2 = 1.5\hat{u}_x + 30\hat{u}_y - 10\hat{u}_z$ A/m

(B) $\vec{H}_2 = 1.5\hat{u}_x + 30\hat{u}_y - 10\hat{u}_z$ A/m

(C) $\vec{H}_2 = 1.5\hat{u}_x + 40\hat{u}_y$ A/m

(D) $\vec{H}_2 = 3\hat{u}_x + 30\hat{u}_y + 10\hat{u}_z$ A/m

SOL 1.26 From boundary condition

$$Bn_1 = Bn_2$$

$$\mu_1 Hx_1 = \mu_2 Hx_2$$

or $$Hx_2 = \frac{Hx_1}{2} = 1.5$$

or $$Hx_2 = 1.5\hat{u}_x$$

Further if $$\overline{H}_z = 1.5\hat{u}_x + A\hat{u}_y + Bu_z$$

Then from Boundary condition

$$(3\hat{u}_x + 30\hat{u}_y)\,\hat{u}_x = (1.5\hat{u}_x + A\hat{u}_y + B\hat{u}_z)\,\hat{x} + \frac{10\hat{u}_y}{\vec{J}}$$

$$= -30\hat{u}_z = -A\hat{u}_z + B\hat{u}_y + 10\hat{u}_y$$

Comparing we get $A = 30$ and $B = -10$

So $$\overline{H}_z = 1.5\hat{u}_x + 30\hat{u}_y - 10\hat{u}_z \text{ A/m}$$

Hence (A) is correct option.

MCQ 1.27 A transmission line of characteristic impedance 50 W is terminated in a load impedance Z_L. The VSWR of the line is measured as 5 and the first of the voltage maxima in the line is observed at a distance of $\frac{\lambda}{4}$ from the load. The value of Z_L is

(A) $10\,\Omega$ (B) $250\,\Omega$

(C) $(19.23 + j46.15)\,\Omega$ (D) $(19.23 - j46.15)\,\Omega$

SOL 1.27 Since voltage maxima is observed at a distance of $\lambda/4$ from the load and we know that the separation between one maxima and minima equals to $\lambda/4$ so voltage minima will be observed at the load, Therefore load can not be complex it must be pure resistive.

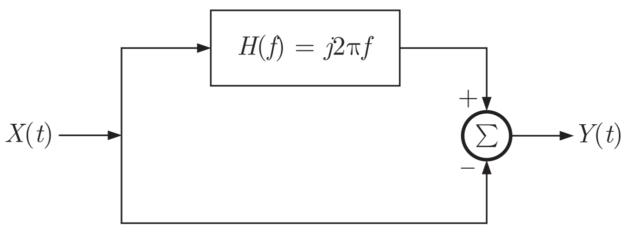
Now $$|\Gamma| = \frac{s-1}{s+1}$$

also $R_L = \frac{R_0}{s}$ (since voltage maxima is formed at the load)

$$R_L = \frac{50}{5} = 10\,\Omega$$

Hence (A) is correct option.

MCQ 1.28 $x(t)$ is a stationary random process with auto-correlation function. $R_x(\tau) = \exp(\pi r^2)$. This process is passed through the system shown below. The power spectral density of the output process $y(t)$ is

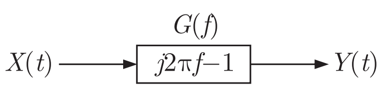


(A) $(4\pi^2 f^2 + 1)\exp(-\pi f^2)$
(B) $(4\pi^2 f^2 - 1)\exp(-\pi f^2)$
(C) $(4\pi^2 f^2 + 1)\exp(-\pi f)$
(D) $(4\pi^2 f^2 - 1)\exp(-\pi f)$

SOL 1.28 Hence (A) is correct option.

We have
$$S_x(f) = F\{R_x(\tau)\} = F\{\exp(-\pi\tau^2)\}$$
$$= e^{-\pi f^2}$$

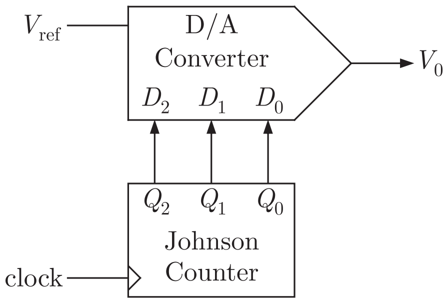
The given circuit can be simplified as

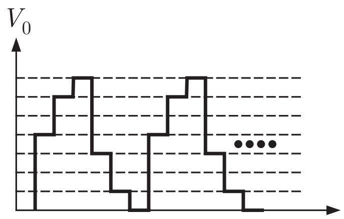


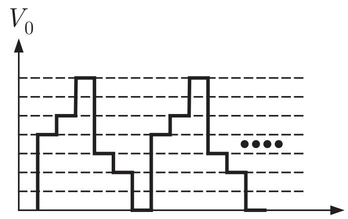
Power spectral density of output is
$$S_y(f) = |G(f)|^2 S_x(f)$$
$$= |j2\pi f - 1|^2 e^{-\pi f^2}$$
$$= (\sqrt{(2\pi f)^2 + 1})^2 e^{-\pi f^2}$$

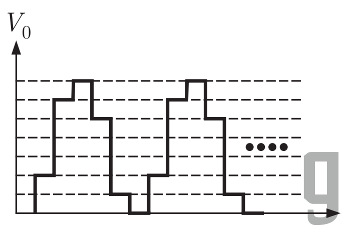
or
$$S_y(f) = (4\pi^2 f^2 + 1)\, e^{-\pi f^2}$$

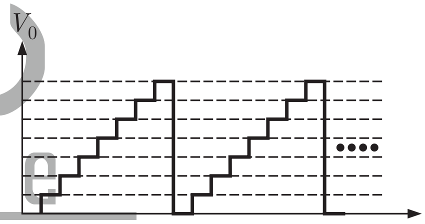
MCQ 1.29 The output of a 3-stage Johnson (twisted ring) counter is fed to a digital-to analog (D/A) converter as shown in the figure below. Assume all the states of the counter to be unset initially. The waveform which represents the D/A converter output v_o is



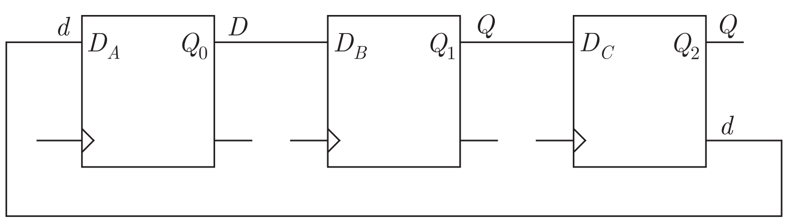
(A)


(B)


(C)


(D)


SOL 1.29 All the states of the counter are initially unset.



State Initially are shown below in table :

Q_2	Q_1	Q_0	
0	0	0	0
1	0	0	4
1	1	0	6
1	1	1	7
0	1	1	3
0	0	1	1
0	0	0	0

Hence (A) is correct option.

MCQ 1.30 Two D flip-flops are connected as a synchronous counter that goes through the following $Q_B Q_A$ sequence $00 \rightarrow 11 \rightarrow 01 \rightarrow 10 \rightarrow 00 \rightarrow ....$

The combination to the inputs DA and DB are

(A) $D_A = Q_B$; $D_B = Q_A$

(B) $D_A = \overline{Q_A}$; $D_B = \overline{Q_B}$

(C) $D_A = (Q_A \overline{Q_B} + \overline{Q_A} Q_B)$; $D_B = \overline{Q_A}$

(D) $D_A = (Q_A Q_B + \overline{Q_A Q_B})$; $D_B = \overline{Q_B}$

SOL 1.30 The sequence is $Q_B Q_A$

$00 \rightarrow 11 \rightarrow 01 \rightarrow 10 \rightarrow 00 \rightarrow ...$

Q_B	Q_A	$Q_B(t+1)$	$Q_A(t+1)$
0	0	1	1
1	1	0	1
0	1	1	0
1	0	0	0

$Q_B(t+1)$

Q_A \ Q_B	0	1
0	1	1
1	0	0

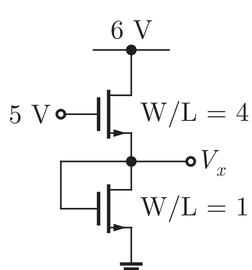
$Q_B(t+1) = \overline{Q}_A$

Q_A \ Q_B		
	1	0
	0	1

$$D_A = \overline{Q}_A \overline{Q}_B + Q_A Q_B$$

Hence (D) is correct option.

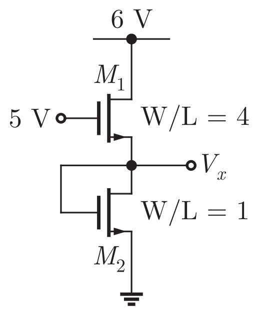
MCQ 1.31 In the circuit shown below, for the MOS transistors, $\mu_n C_{ox} = 100\,\mu/\text{A/V}^2$ and the threshold voltage $V_T = 1\,\text{V}$. The voltage Vx at the source of the upper transistor is



(A) 1 V (B) 2 V

(C) 3 V (D) 3.67 V

SOL 1.31 Given circuit is shown below.



For transistor M_2,

$$V_{GS} = V_G - V_S = V_x - 0 = V_x$$

$$V_{DS} = V_D - V_S = V_x - 0 = V_x$$

Since $V_{GS} - V_T = V_x - 1 < V_{DS}$, thus M_2 is in saturation.

By assuming M_1 to be in saturation we have

$$I_{DS(M_1)} = I_{DS(M_2)}$$

$$\frac{\mu_n C_{0x}}{2}(4)(5 - V_x - 1)^2 = \frac{\mu_n C_{0x}}{2} 1 (V_x - 1)^2$$

$$4(4 - V_x)^2 = (V_x - 1)^2$$

or $$2(4 - V_x) = \pm (V_x - 1)$$

Taking positive root,

$$8 - 2V_x = V_x - 1$$

$$V_x = 3\text{ V}$$

At $V_x = 3\text{ V}$ for $M_1, V_{GS} = 5 - 3 = 2\text{ V} < V_{DS}$. Thus our assumption is true and $V_x = 3\text{ V}$.

Hence (C) is correct option.

MCQ 1.32 An input $x(t) = \exp(-2t)u(t) + \delta(t-6)$ is applied to an LTI system with impulse response $h(t) = u(t)$. The output is

(A) $[1 - \exp(-2t)]u(t) + u(t+6)$ (B) $[1 - \exp(-2t)]u(t) + u(t-6)$

(C) $0.5[1 - \exp(-2t)]u(t) + u(t+6)$ (D) $0.5[1 - \exp(-2t)]u(t) + u(t-6)$

SOL 1.32 Hence (D) is correct option.

We have $x(t) = \exp(-2t)\mu(t) + s(t-6)$ and $h(t) = u(t)$

Taking Laplace Transform we get

$$X(s) = \left(\frac{1}{s+2} + e^{-6s}\right) \text{ and } H(s) = \frac{1}{s}$$

Now $$Y(s) = H(s)X(s)$$

$$= \frac{1}{s}\left[\frac{1}{s+2} + e^{-6s}\right] = \frac{1}{s(s+2)} + \frac{e^{-6s}}{s}$$

or $$Y(s) = \frac{1}{2s} - \frac{1}{2(s+2)} + \frac{e^{-6s}}{s}$$

Thus $$y(t) = 0.5[1 - \exp(-2t)]u(t) + u(t-6)$$

MCQ 1.33 For a BJT the common base current gain $\alpha = 0.98$ and the collector base junction reverse bias saturation current $I_{co} = 0.6\,\mu\text{A}$. This BJT is connected in the common emitter mode and operated in the active region with a base drive current $I_B = 204$ A. The collector current I_c for this mode of operation is

(A) 0.98 mA (B) 0.99 mA

(C) 1.0 mA (D) 1.01 mA

SOL 1.33 Hence (D) is correct option.

We have $\alpha = 0.98$

Now $\beta = \frac{\alpha}{1-\alpha} = 4.9$

In active region, for common emitter amplifier,

$$I_C = \beta I_B + (1+\beta) I_{CO} \quad ...(1)$$

Substituting $I_{CO} = 0.6\,\mu\text{A}$ and $I_B = 20\,\mu\text{A}$ in above eq we have,

$$I_C = 1.01\text{ mA}$$

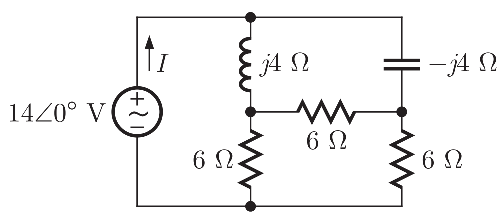
MCQ 1.34 If $F(s) = L[f(t)] = \frac{2(s+1)}{s^2+4s+7}$ then the initial and final values of $f(t)$ are respectively

(A) 0, 2 (B) 2, 0

(C) 0, 2/7 (D) 2/7, 0

SOL 1.34 Correct Option is ( )

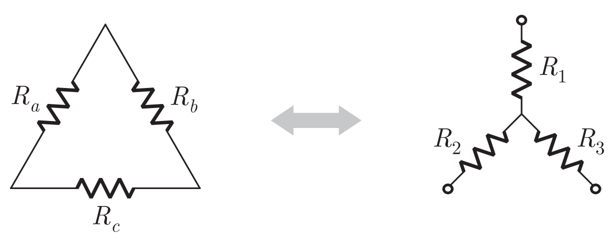
MCQ 1.35 In the circuit shown below, the current I is equal to



(A) $14\angle 0°$ A (B) $2.0\angle 0°$ A

(C) $2.8\angle 0°$ A (D) $3.2\angle 0°$ A

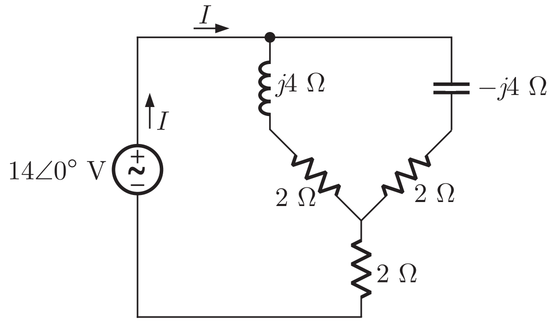
SOL 1.35 From star delta conversion we have



Thus $R_1 = \dfrac{R_a R_b}{R_a + R_b + R_c} = \dfrac{6.6}{6+6+6} = 2\,\Omega$

Here $R_1 = R_2 = R_3 = 2\,\Omega$

Replacing in circuit we have the circuit shown below :



Now the total impedance of circuit is

$$Z = \frac{(2+j4)(2-j4)}{(2+j4)(2-j4)} + 2 = 7\,\Omega$$

Current $I = \dfrac{14\angle 0^\circ}{7} = 2\angle 0^\circ$

Hence (B) is correct option.

MCQ 1.36 A numerical solution of the equation $f(x)+\sqrt{x-3}=0$ can be obtained using Newton- Raphson method. If the starting value is $x=2$ for the iteration, the value of x that is to be used in the next step is

(A) 0.306 (B) 0.739

(C) 1.694 (D) 2.306

SOL 1.36 Hence (C) is correct option.

We have $f(x) = x + \sqrt{x} - 3 = 0$

$$f'(x) = 1 + \frac{1}{2\sqrt{x}}$$

Substituting $x_0 = 2$ we get

$$f'(x_0) = 1.35355 \text{ and } f(x_0) = 2 + \sqrt{2} - 3 = 0.414$$

Newton Raphson Method

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$

Substituting all values we have

$$x_1 = 2 - \frac{0.414}{1.3535} = 1.694$$

MCQ 1.37 The electric and magnetic fields for a TEM wave of frequency 14 GHz in a homogeneous medium of relative permittivity ε_r and relative permeability $\mu_r = 1$ are given by

$\vec{E} = E_p e^{j(\omega t - 280\pi y)} \hat{u}_z$ V/m $\qquad \vec{H} = 3e^{j(\omega t - 280\pi y)} \hat{u}_x$ A/m

Assuming the speed of light in free space to be 3×10^8 m/s, the intrinsic impedance of free space to be 120π , the relative permittivity ε_r of the medium and the electric field amplitude E_p are

(A) $\varepsilon_r = 3,\ E_p = 120\pi$ (B) $\varepsilon_r = 3,\ E_b = 360\pi$

(C) $\varepsilon_r = 9,\ E_p = 360\pi$ (D) $\varepsilon_r = 9,\ E_p = 120\pi$

SOL 1.37 From the expressions of $\vec{E}$ & $\vec{H}$, we can write,

$$\beta = 280\,\pi$$

or $$\frac{2\pi}{\lambda} = 280\,\pi \;\Rightarrow\; \lambda = \frac{1}{140}$$

Wave impedance, $Z_w = \frac{|\vec{E}|}{|\vec{H}|} = \frac{E_p}{3} = \frac{120\,\pi}{\sqrt{\varepsilon_r}}$

again, $$f = 14\,\text{GHz}$$

Now $$\lambda = \frac{C}{\sqrt{\varepsilon_r f}} = \frac{3 \times 10^8}{\sqrt{\varepsilon_r}\,14 \times 10^9} = \frac{3}{140\sqrt{\varepsilon_r}}$$

or $$\frac{3}{140\sqrt{\varepsilon_r}} = \frac{1}{140}$$

or $$\varepsilon_r = 9$$

Now $$\frac{E_p}{3} = \frac{120\pi}{\sqrt{9}} \Rightarrow E_p = 120\pi$$

Hence (D) is correct option.

MCQ 1.38 A message signal $m(t) = \cos 200\pi t + 4\cos \pi t$ modulates the carrier $c(t) = \cos 2\pi f_c t$ where $f_c = 1\,\text{MHz}$ to produce an AM signal. For demodulating the generated AM signal using an envelope detector, the time constant RC of the detector circuit should satisfy

(A) 0.5 ms $<$ RC $<$ 1 ms (B) 1 μs $<<$ RC $<$ 0.5 ms

(C) RC $<<$ μs (D) RC $>>$ 0.5 ms

SOL 1.38 Highest frequency component in $m(t)$ is $f_m = 4000\pi/2\pi = 2000$ Hz

Carrier frequency $f_C = 1$ MHz

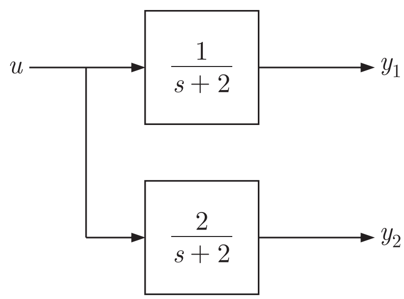
For Envelope detector condition

$$1/f_C << RC << 1/f_m$$

$$1\ \mu\text{s} << RC << 0.5\,\text{ms}$$

Hence (B) is correct option.

MCQ 1.39 The block diagram of a system with one input it and two outputs y_1 and y_2 is given below.



A state space model of the above system in terms of the state vector $\underline{x}$ and the output vector $\underline{y} = [y_1 \ \ y_2]^T$ is

(A) $\dot{\underline{x}} = [2]\,\underline{x} + [1]\,u\,; \quad \underline{y} = [1 \ \ 2]\,\underline{x}$

(B) $\dot{\underline{x}} = [-2]\,\underline{x} + [1]\,u; \quad \underline{y} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}\underline{x}$

(C) $\dot{\underline{x}} = \begin{bmatrix} -2 & 0 \\ 0 & -2 \end{bmatrix}\underline{x} + \begin{bmatrix} 1 \\ 1 \end{bmatrix}u\,; \quad \underline{y} = [1 \ \ 2]\,\underline{x}$

(D) $\dot{\underline{x}} = \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}\underline{x} + \begin{bmatrix} 1 \\ 1 \end{bmatrix}u\,; \quad \underline{y} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}\underline{x}$

SOL 1.39 Hence (B) is correct option.

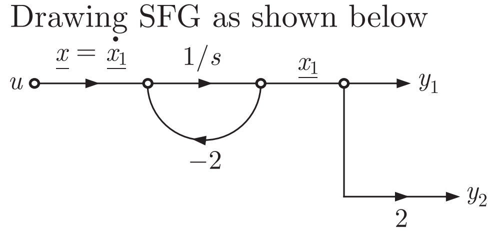
Here $\quad x = y_1$ and $\dot{x} = \frac{dy_1}{dx}$

$$\underline{y} = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} x \\ 2x \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}\underline{x}$$

Now $\quad y_1 = \frac{1}{s+2}u$

$$y_1(s+2) = u$$
$$\dot{y}_1 + 2y_1 = u$$
$$\dot{x} + 2x = u$$
$$\dot{x} = -2x + u$$
$$\dot{\underline{x}} = [-2]\,\underline{x} + [1]\,u$$

Drawing SFG as shown below



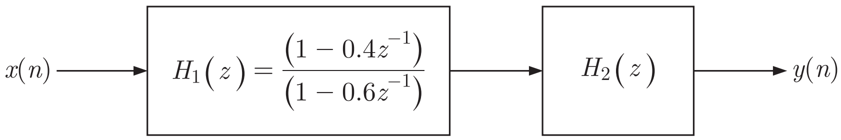
Thus $\quad \dot{x}_1 = [-2]\,\underline{x}_1 + [1]\,u$

$$y_1 = \underline{x}_1; \ y_2 = 2\underline{x}_1$$

$$\underline{y} = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}\underline{x}_1$$

Here $\underline{x_1} = \underline{x}$

MCQ 1.40 Two systems $H_1(Z)$ and $H_2(Z)$ are connected in cascade as shown below. The overall output $y(n)$ is the same the input $x(n)$ with a one unit delay. The transfer function of the second system $H_2(Z)$ is



(A) $\dfrac{1-0.6z^{-1}}{z^{-1}(1-0.4z^{-1})}$ (B) $\dfrac{z^{-1}(1-0.6z^{-1})}{(1-0.4z^{-1})}$

(C) $\dfrac{z^{-1}(1-0.4z^{-1})}{(1-0.6z^{-1})}$ (D) $\dfrac{1-0.4\,z^{-1}}{z^{-1}(1-0.6z^{-1})}$

SOL 1.40 Hence (B) is correct option.

$$y(n) = x(n-1)$$

or $$Y(z) = z^{-1}X(z)$$

or $$\frac{Y(z)}{X(z)} = H(z) = z^{-1}$$

Now $$H_1(z)\,H_2(z) = z^{-1}$$

$$\left(\frac{1-0.4z^{-1}}{1-0.6z^{-1}}\right)H_2(z) = z^{-1}$$

$$H_2(z) = \frac{z^{-1}(1-0.6z^{-1})}{(1-0.4z^{-1})}$$

MCQ 1.41 An 8085 assembly language program is given below. Assume that the carry flag is initially unset. The content of the accumulator after the execution of the program is

```
MVI   A, 07H
RLC
MOV   B, A
RLC
RLC
ADD   B
RRC
```

(A) 8 CH (B) 64 H

(C) 23 H (D) 15 H

SOL 1.41 Initially Carry Flag, $C = 0$

MVI A, 07 H ; $A = 0000\,0111$

RLC ; Rotate left without carry. $A = 0000\,1110$

MVO B, A ; $B = A = 0000\,1110$

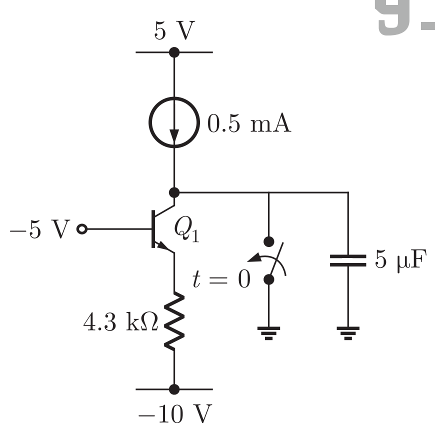
RLC ; $A = 00011100$
RLC ; $A = 00111000$
ADD B ; $A = \;\; 00111000$
; $\;\;\; +00001110$
; $\;\;\; 01000110$
RRC ; Rotate Right with out carry, $A = 0010\ 0011$
Thus $A = 23\,\text{H}$
Hence (C) is correct option.

MCQ 1.42 The first six points of the 8-point DFT of a real valued sequence are $5, 1-j3, 0, 3-j4, 0$ and $3+j4$..... The last two points of the DFT are respectively

(A) $0, 1-j3$ (B) $0, 1+j3$
(C) $1+j3, 5$ (D) $1-j3, 5$

SOL 1.42 For 8 point DFT, $x^*[1] = x[7]; x^*[2] = x[6]; x^*[3] = x[5]$ and it is conjugate symmetric about $x[4]$, $x[6] = 0$; $x[7] = 1+j3$
Hence (B) is correct option.

MCQ 1.43 For the BJT Q_L in the circuit shown below, $\beta = \infty, V_{BE\,\text{on} = 0.7\,\text{V}, V_{CE\text{sat}}} = 0.7\ \text{V}$. The switch is initially closed. At time $t = 0$, the switch is opened. The time t at which Q_1 leaves the active region is



(A) 10 ms (B) 25 ms
(C) 50 ms (D) 100 ms

SOL 1.43 Hence (C) is correct option

In active region $V_{BEon} = 0.7\ \text{V}$

Emitter voltage $V_E = V_B - V_{BEon} = -5.7\ \text{V}$

Emitter Current $I_E = \dfrac{V_E - (-10)}{4.3\text{k}} = \dfrac{-5.7 - (-10)}{4.3\text{k}} = 1\,\text{mA}$

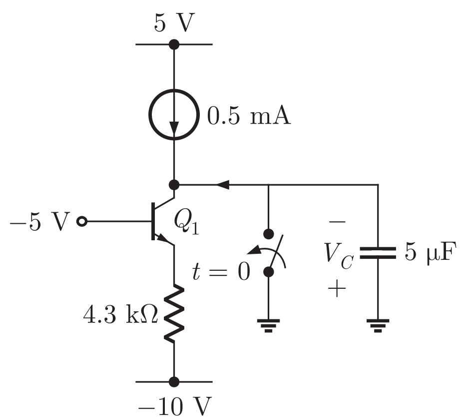
Now $I_C \approx I_E = 1\,\text{mA}$

Applying KCL at collector

$$i_1 = 0.5\,\text{mA}$$

Since $$i_1 = C\frac{dV_C}{dt}$$

or $$V_C = \frac{1}{C}\int i_1\,dt = \frac{i_1}{C}t \qquad ...(1)$$



with time, the capacitor charges and voltage across collector changes from 0 towards negative.

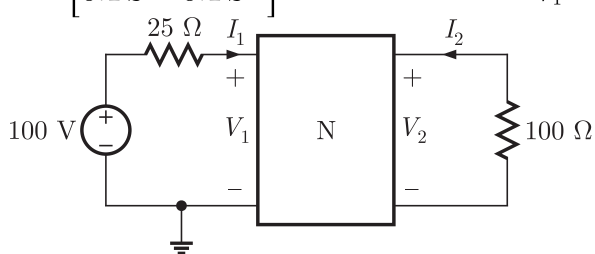
When saturation starts, $V_{CE} = 0.7 \Rightarrow V_C = +5$ V (across capacitor)

Thus from (1) we get, $$+5 = \frac{0.5\,\text{mA}}{5\,\mu\text{A}}T$$

or $$T = \frac{5\times 5\times 10^{-6}}{0.5\times 10^{-3}} = 50\,\text{m sec}$$

.

MCQ 1.44 In the circuit shown below, the network N is described by the following Y matrix: $Y = \begin{bmatrix} 0.1\,\text{S} & -0.01\,\text{S} \\ 0.1\,\text{S} & 0.1\,\text{S}\end{bmatrix}$. the voltage gain $\frac{V_2}{V_1}$ is



(A) 1/90 (B) –1/90

(C) –1/99 (D) –1/11

SOL 1.44 From given admittance matrix we get

$$I_1 = 0.1\,V_1 - 0.01\,V_2 \text{ and} \qquad ...(1)$$

$$I_2 = 0.01\,V_1 + 0.1\,V_2 \qquad ...(2)$$

Now, applying KVL in outer loop;

$$V_2 = -100 I_2$$

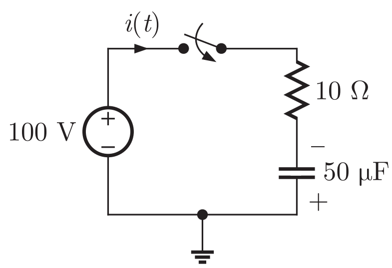
or $$I_2 = -0.01\,V_2 \qquad ...(3)$$

From eq (2) and eq (3) we have

$$-0.01\,V_2 = 0.01\,V_1 + 0.1\,V_2$$
$$-0.11\,V_2 = 0.01\,V_1$$
$$\frac{V_2}{V_1} = \frac{-1}{11}$$

Hence (D) is correct option.

MCQ 1.45 In the circuit shown below, the initial charge on the capacitor is 2.5 mC, with the voltage polarity as indicated. The switch is closed at time $t = 0$. The current $i(t)$ at a time t after the switch is closed is



(A) $i(t) = 15\exp(-2 \times 10^3 t)$ A
(B) $i(t) = 5\exp(-2 \times 10^3 t)$ A
(C) $i(t) = 10\exp(-2 \times 10^3 t)$ A
(D) $i(t) = -5\exp(-2 \times 10^3 t)$ A

SOL 1.45 Here we take the current flow direction as positive.

At $t = 0^-$ voltage across capacitor is

$$V_C(0^-) = -\frac{Q}{C} = -\frac{2.5 \times 10^{-3}}{50 \times 10^{-6}} = -50 \text{ V}$$

Thus $$V_C(0^+) = -50 \text{ V}$$

In steady state capacitor behave as open circuit thus

$$V(\infty) = 100 \text{ V}$$

Now, $$V_C(t) = V_C(\infty) + (V_C(0^+) - V_C(\infty))\,e^{-t/RC}$$
$$= 100 + (-50 - 100)\,e^{\frac{-t}{10 \times 50 \times 10^{-6}}}$$
$$= 100 - 150e^{-(2 \times 10^3 t)}$$

Now $$i_c(t) = C\frac{dV}{dt}$$
$$= 50 \times 10^{-6} \times 150 \times 2 \times 10^3\,e^{-2 \times 10^3 t} \text{ A}$$
$$= 15e^{-2 \times 10^3 t}$$
$$i_c(t) = 15\exp(-2 \times 10^3 t) \text{ A}$$

Hence (A) is correct option.

MCQ 1.46 The system of equations

$x + y + z = 6$

$x + 4y + 6y = 20$

$x + 4y + \lambda z = \mu$
has NO solution for values of λ and μ given by

(A) $\lambda = 6, \mu = 20$ (B) $\lambda = 6, \mu \neq 20$

(C) $\lambda \neq 6, \mu = 20$ (D) $\lambda \neq 6, \mu = 20$

SOL 1.46 Writing $A:B$ we have

$$\begin{bmatrix} 1 & 1 & 1 & : & 6 \\ 1 & 4 & 6 & : & 20 \\ 1 & 4 & \lambda & : & \mu \end{bmatrix}$$

Apply $R_3 \to R_3 - R_2$

$$\begin{bmatrix} 1 & 1 & 1 & : & 6 \\ 1 & 4 & 6 & : & 20 \\ 0 & 0 & \lambda - 6 & : & \mu - 20 \end{bmatrix}$$

For equation to have solution, rank of A and $A:B$ must be same. Thus for no solution; $\lambda = 6$, $\mu \neq 20$

Hence (B) is correct option

MCQ 1.47 A fair dice is tossed two times. The probability that the second toss results in a value that is higher than the first toss is

(A) 2/36 (B) 2/6

(C) 5/12 (D) ½

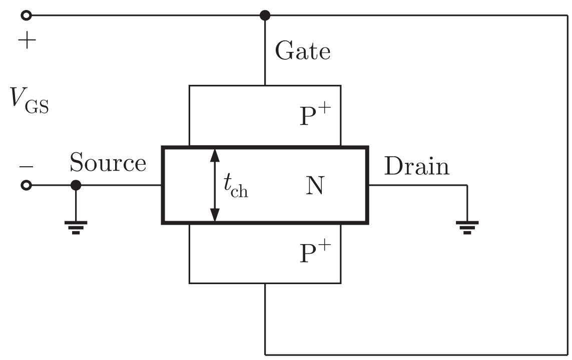
SOL 1.47 Total outcome are 36 out of which favorable outcomes are :
(1, 2), (1, 3), (1, 4), (1, 5), (1, 6), (2, 3), (2, 4), (2, 5), (2, 6);
(3, 4), (3, 5), (3, 6), (4, 5), (4, 6), (5, 6) which are 15.

Thus $$P(E) = \frac{\text{No. of favourable outcomes}}{\text{No. of total outcomes}} = \frac{15}{36} = \frac{5}{12}$$

Hence (C) is correct option.

Common Data Questions: 48 & 49

The channel resistance of an N-channel JFET shown in the figure below is $600\,\Omega$ when the full channel thickness (t_{ch}) of 10μm is available for conduction. The built-in voltage of the gate P^+N junction (V_{bi}) is -1 V. When the gate to source voltage (V_{GS}) is 0 V, the channel is depleted by 1 μm on each side due to the built in voltage and hence the thickness available for conduction is only 8 μm



MCQ 1.48 The channel resistance when $V_{GS} = -3$ V is

(A) 360 Ω (B) 917 Ω

(C) 1000 Ω (D) 3000 Ω

SOL 1.48 Full channel resistance is

$$r \frac{\rho \times L}{W \times a} = 600\,\Omega \quad ...(1)$$

If V_{GS} is applied, Channel resistance is

$$r' = \frac{\rho \times L}{W \times b} \qquad \text{where } b = a\left(1 - \sqrt{\frac{V_{GS}}{V_p}}\right)$$

Pinch off voltage,

$$|V_p| = \frac{qN_D}{2\varepsilon}a^2 \quad ...(2)$$

If depletion on each side is $d = 1$ μm at $V_{GS} = 0$.

$$V_j = \frac{qN_D}{2\varepsilon}d^2$$

or $$1 = \frac{qN_D}{2\varepsilon}(1 \times 10^{-6})^2 \Rightarrow \frac{qN_D}{2\varepsilon} = 10^{12}$$

Now from equation (2), we have

$$|V_p| = 10^{12} \times (5 \times 10^{-6})^2$$

or $$V_p = -25\text{ V}$$

At $V_{GS} = -3$ V;

$$b = 5\left(1 - \sqrt{\frac{-3}{-25}}\right)\mu\text{m} = 3.26\,\mu\text{m}$$

$$r' = \frac{\rho L}{W \times b} = \frac{\rho L}{Wa} \times \frac{a}{b} = 600 \times \frac{5}{3.26} = 917\,\Omega$$

Hence (B) is correct option.

MCQ 1.49 The channel resistance when $V_{GS} = 0$ V is

(A) 480 Ω (B) 600 Ω

(C) 750 Ω (D) 1000 Ω

SOL 1.49

At $V_{GS} = 0\,\text{V},\ b = 4\,\mu\text{m}$

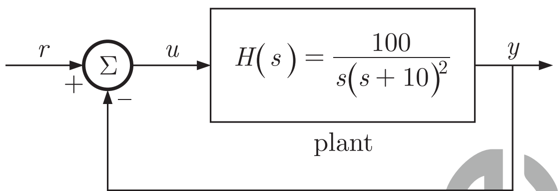
since $2b = 8\,\mu\text{m}$

Thus $r' = \frac{\rho L}{Wa} \times \frac{a}{b} = 600 \times \frac{5}{4} = 750\,\Omega$

Hence (C) is correct option.

Common Data Questions: 50 & 51

The input-output transfer function of a plant $H(S) = \frac{100}{s(s+10)^2}$. The plant is placed in a unity negative feedback configuration as shown in the figure below.



MCQ 1.50 The gain margin of the system under closed loop unity negative feedback is

(A) 0 dB (B) 20 dB

(C) 26 dB (D) 46 dB

SOL 1.50 Hence (C) is correct option.

We have $G(s)\,H(s) = \frac{100}{s(s+10)^2}$

Now $G(j\omega)\,H(j\omega) = \frac{100}{j\omega(j\omega+10)^2}$

If ω_p is phase cross over frequency $\angle G(j\omega)\,H(j\omega) = 180^\circ$

Thus $-180^\circ = 100\tan^{-1}0 - \tan^{-1}\infty - 2\tan^{-1}\left(\frac{\omega_p}{10}\right)$

or $-180^\circ = -90 - 2\tan^{-1}(0.1\omega_p)$

or $45^\circ = \tan^{-1}(0.1\omega_p)$

or $\tan 45^\circ = 0.1\omega_p = 1$

or $\omega_p = 10\,\text{rad/se}$

Now $|G(j\omega)\,H(j\omega)| = \frac{100}{\omega(\omega^2+100)}$

At $\omega = \omega_p$

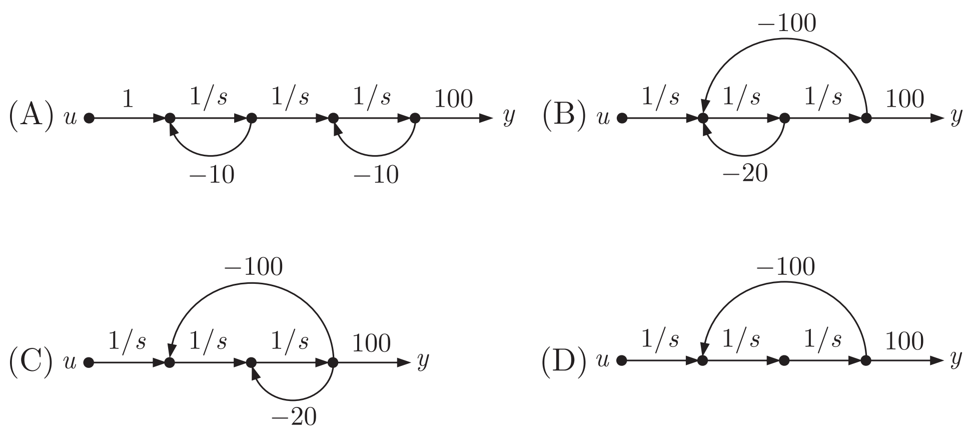
$|G(j\omega)\,H(j\omega)| = \frac{100}{10(100+100)} = \frac{1}{20}$

Gain Margin $= -20\log_{10}|G(j\omega)\,H(j\omega)|$

$= -20\log_{10}\left(\frac{1}{20}\right)$

$= 26\,\text{dB}$

MCQ 1.51 The signal flow graph that DOES NOT model the plant transfer function $H(S)$ is



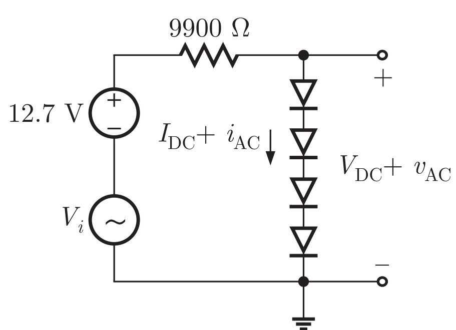
SOL 1.51 Hence (D) is correct option

From option (D) $TF = H(s)$

$$= \frac{100}{s(s^2+100)} \neq \frac{100}{s(s+10)^2}$$

Linked Answer Questions: Q.52 to Q.55 Carry Two Marks Each

Statement for Linked Answer Questions: 52 & 53



MCQ 1.52 The bias current I_{DC} through the diodes is

(A) 1 mA (B) 1.28 mA

(C) 1.5 mA (D) 2 mA

SOL 1.52 Hence (A) is correct option.

The current flows in the circuit if all the diodes are forward biased. In forward biased there will be 0.7 V drop across each diode.

Thus $$I_{DC} = \frac{12.7 - 4(0.7)}{9900} = 1\,\text{mA}$$

MCQ 1.53 The ac output voltage V_{ac} is

(A) $0.25\cos(\omega t)$ mV (B) $1\cos(\omega t)$ mV

(C) $2\cos(\omega t)$ mV (D) $22\cos(\omega t)$ mV

SOL 1.53 Hence (B) is correct option.

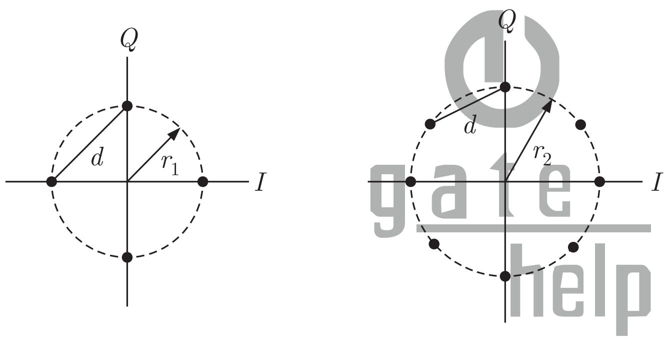
The forward resistance of each diode is

$$r = \frac{V_T}{I_C} = \frac{25\text{ mV}}{1\text{ mA}} = 25\,\Omega$$

Thus
$$V_{ac} = V_i \times \left(\frac{4(r)}{4(r) + 9900}\right)$$
$$= 100\text{ mV}\cos(\omega t)\,0.01 = 1\cos(\omega t)\text{ mV}$$

Statement for Linked Answer Questions: 54 & 55

A four-phase and an eight-phase signal constellation are shown in the figure below.

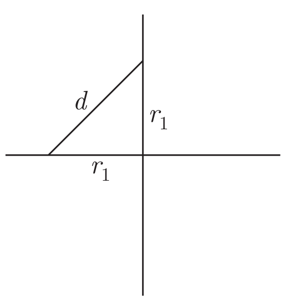


MCQ 1.54 For the constraint that the minimum distance between pairs of signal points be d for both constellations, the radii r_1, and r_2 of the circles are

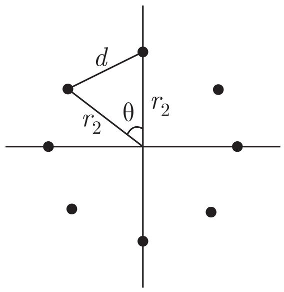
(A) $r_1 = 0.707d$, $r_2 = 2.782d$ (B) $r_1 = 0.707d$, $r_2 = 1.932d$

(C) $r_1 = 0.707d$, $r_2 = 1.545d$ (D) $r_1 = 0.707d$, $r_2 = 1.307d$

SOL 1.54 Four phase signal constellation is shown below



Now
$$d^2 = r_1^2 + r_1^2$$
$$d^2 = 2r_1^2$$
$$r_1 = d/\sqrt{2} = 0.707\text{d}$$



$$\theta = \frac{2\pi}{M} = \frac{2\pi}{8} = \frac{\pi}{4}$$

Applying Cooine law we have

$$d^2 = r_2^2 + r_2^2 - 2r_2^2 \cos\frac{\pi}{4}$$

$$= 2r_2^2 - 2r_2^2 \ 1/\sqrt{2} = (2-\sqrt{2})\,r_2^2$$

or $$r_2 = \frac{d}{\sqrt{2-\sqrt{2}}} = 1.3065\text{d}$$

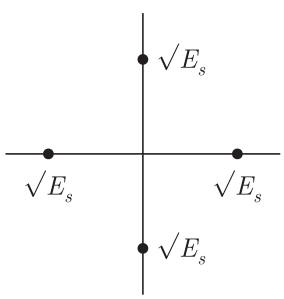
Hence (D) is correct option.

MCQ 1.55 Assuming high SNR and that all signals are equally probable, the additional average transmitted signal energy required by the 8-PSK signal to achieve the same error probability as the 4-PSK signal is

(A) 11.90 dB (B) 8.73 dB

(C) 6.79 dB (D) 5.33 dB

SOL 1.55 Here P_e for 4 PSK and 8 PSK is same because P_e depends on d. Since P_e is same, d is same for 4 PSK and 8 PSK.



Additional Power SNR

$$= (SNR)_2 - (SNR)_1$$

$$= 10\log\left(\frac{E_{S2}}{No}\right) - 10\log\left(\frac{E_{S1}}{No}\right)$$

$$= 10\log\left(\frac{E_{S2}}{E_{S1}}\right)$$

$$= 10\log\left(\frac{r_2}{r_1}\right)^2 \Rightarrow 20\log\left(\frac{r_2}{r_1}\right) = 20\log\frac{1.3065\text{d}}{0.707\text{d}}$$

Additional SNR $= 5.33\,\text{dB}$

Hence (D) is correct option.

Q. No. 56 – 60 Carry One Mark Each

MCQ 1.56 There are two candidates P and Q in an election. During the campaign, 40% of the voters promised to vote for P, and rest for Q. However, on the day of election 15% of the voters went back on their promise to vote for P and instead voted forQ. 25% of the voters went back on their promise to vote for Q and instead voted for P. Suppose, P lost by 2 votes, then what was the total number of voters?

(A) 100 (B) 110

(C) 90 (D) 95

SOL 1.56 Let us assume total voters are 100. Thus 40 voter (i.e. 40 %) promised to vote for P and 60 (rest 60 %) promised to vote fore Q.

Now, 15% changed from P to Q (15 % out of 40)

Changed voter from P to Q $\frac{15}{100} \times 40 = 6$

Now Voter for P $40 - 6 = 34$

Also, 25% changed form Q to P (out of 60%)

Changed voter from Q to P $\frac{25}{100} \times 60 = 15$

Now Voter for P $34 + 15 = 49$

Thus P P got 49 votes and Q got 51 votes, and P lost by 2 votes, which is given. Therefore 100 voter is true value.

Hence (A) is correct option.

MCQ 1.57 Choose the most appropriate word from the options given below to complete the following sentence:

It was her view that the country's problems had been__________ by foreign technocrats, so that to invite them to come back would be counter-productive.

(A) Identified (B) ascertained

(C) Texacerbated (D) Analysed

SOL 1.57 The sentence implies that technocrats are counterproductive (negative). Only (C) can bring the same meaning.

Hence (C) is correct option

MCQ 1.58 Choose the word from the options given below that is most nearly opposite in meaning to the given word:

Frequency

(A) periodicity (B) rarity

(C) gradualness (D) persistency

SOL 1.58 Periodicity is almost similar to frequency. Gradualness means something happening with time. Persistency is endurance. Rarity is opposite to frequency.
Hence (B) is correct option.

MCQ 1.59 Choose the most appropriate word from the options given below to complete the following sentence:
Under ethical guidelines recently adopted by the Indian Medical Association, human genes are to be manipulated only to correct diseases for which________________ treatments are unsatisfactory.

(A) Similar (B) Most

(C) Uncommon (D) Available

SOL 1.59 Available is appropriate because manipulation of genes will be done when other treatments are not useful.
Hence (D) is correct option.

MCQ 1.60 The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair:
Gladiator : Arena

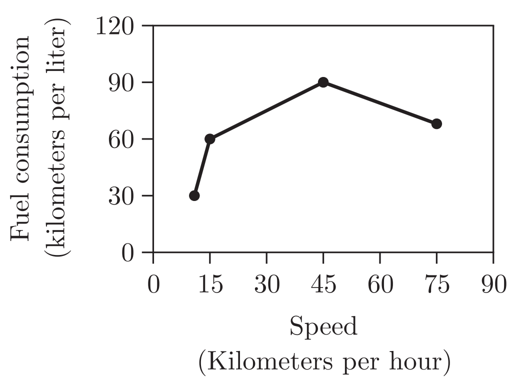
(A) dancer : stage (B) commuter: train

(C) teacher : classroom (D) lawyer : courtroom

SOL 1.60 A gladiator performs in an arena. Commutators use trains. Lawyers performs, but do not entertain like a gladiator. Similarly, teachers educate. Only dancers performs on a stage.
Hence (A) is correct option.

Q. No. 61 – 65 Carry Two Marks Each

MCQ 1.61 The fuel consumed by a motorcycle during a journey while traveling at various speeds is indicated in the graph below.



The distances covered during four laps of the journey are listed in the table below

Lap	Distance (kilometers)	Average speed (kilometers per hour)
P	15	15
Q	75	45
R	40	75
S	10	10

From the given data, we can conclude that the fuel consumed per kilometre was least during the lap

(A) P (B) Q

(C) R (D) S

SOL 1.61 Since fuel consumption/litre is asked and not total fuel consumed, only average speed is relevant. Maximum efficiency comes at 45 km/hr, So least fuel consumer per litre in lap Q

Hence (B) is correct option.

MCQ 1.62 Three friends, R, S and T shared toffee from a bowl. R took 1/3rd of the toffees, but returned four to the bowl. S took 1/4th of what was left but returned three toffees to the bowl. T took half of the remainder but returned two back into the bowl. If the bowl had 17 toffees left, how many toffees-were originally there in the bowl?

(A) 38 (B) 31

(C) 48 (D) 41

SOL 1.62 Let total no of toffees be x. The following table shows the all calculations.

	Friend	Bowl Status
	$= \frac{x}{3} - 4$	$= \frac{2x}{3} + 4$
	$= \frac{1}{4}\left[\frac{2x}{3} + 4\right] - 3$ $= \frac{x}{6} + 1 - 3 = \frac{x}{6} - 2$	$= \frac{2x}{3} + 4 - \frac{x}{6} + 2$ $= \frac{x}{2} + 6$
	$= \frac{1}{2}\left(\frac{x}{2} + 6\right) - 2$ $= \frac{x}{4} + 1$	$= \frac{x}{2} + 6 - \frac{x}{4} - 1$ $= \frac{x}{4} + 5$

Now, $\frac{x}{4} + 5 = 17$

or $\frac{x}{4} = 17 - 5 = 12$

$x = 12 \times 4 = 48$

Hence (C) is correct option.

MCQ 1.63 Given that $f(y) = \frac{|y|}{y}$, and q is any non-zero real number, the value of $|f(q) - f(-q)|$ is

(A) 0 (B) -1

(C) 1 (D) 2

SOL 1.63 Hence (D) is correct option.

$$f(y) = \frac{|y|}{y}$$

Now $$f(-y) = \frac{|-y|}{y} = -f(y)$$

or $$|f(q) - f(-q)| = |2f(q)| = 2$$

MCQ 1.64 The sum of n terms of the series $4 + 44 + 444 + ...$ is

(A) $(4/81)[10^{n+1} - 9n - 1]$ (B) $(4/81)[10^{n-1} - 9n - 1]$

(C) $(4/81)[10^{n+1} - 9n - 10]$ (D) $(4/81)[10^{n} - 9n - 10]$

SOL 1.64 Hence (C) is correct option.

$$4 + 44 + 444 + ... 4(1 + 11 + 111 + ...)$$

$$= \frac{4}{9}(9 + 99 + 999 + ...)$$

$$= \frac{4}{9}[(10 - 1) + (100 - 1) + ...]$$

$$= \frac{4}{9}[10(1 + 10 + 10^2 + 10^3) - n]$$

$$= \frac{4}{9}\left[10 \times \frac{10^n - 1}{10 - 1} - n\right]$$

$$= \frac{4}{81}[10^{n+1} - 10 - 9n]$$

MCQ 1.65 The horse has played a little known but very important role in the field of medicine. Horses were injected with toxins of diseases until their blood built up immunities. Then a serum was made from their blood. Serums to fight with diphtheria and tetanus were developed this way.

It can be inferred from the passage that horses were

(A) given immunity to diseases

(B) generally quite immune to diseases

(C) given medicines to fight toxins

(D) given diphtheria and tetanus serums

SOL 1.65 Option B fits the sentence, as they built up immunities which helped humans

create serums from their blood.
Hence (B) is correct option.

Answer Sheet

1.	(C)	13.	(A)	25.	(A)	37.	(D)	49.	(C)	61.	(B)
2.	(C)	14.	(C)	26.	(A)	38.	(B)	50.	(C)	62.	(C)
3.	(D)	15.	(B)	27.	(A)	39.	(B)	51.	(D)	63.	(D)
4.	(B)	16.	(A)	28.	(A)	40.	(B)	52.	(A)	64.	(C)
5.	(B)	17.	(A)	29.	(A)	41.	(C)	53.	(B)	65.	(B)
6.	(A)	18.	(C)	30.	(D)	42.	(B)	54.	(D)		
7.	(B)	19.	(A)	31.	(C)	43.	(C)	55.	(D)		
8.	(A)	20.	(D)	32.	(D)	44.	(D)	56.	(A)		
9.	(C)	21.	(D)	33.	(D)	45.	(A)	57.	(C)		
10.	(B)	22.	(D)	34.	(*)	46.	(B)	58.	(B)		
11.	(A)	23.	(A)	35.	(B)	47.	(C)	59.	(D)		
12.	(D)	24.	(C)	36.	(C)	48.	(B)	60.	(A)		

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