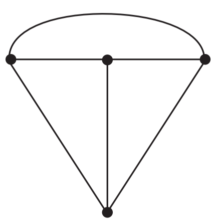
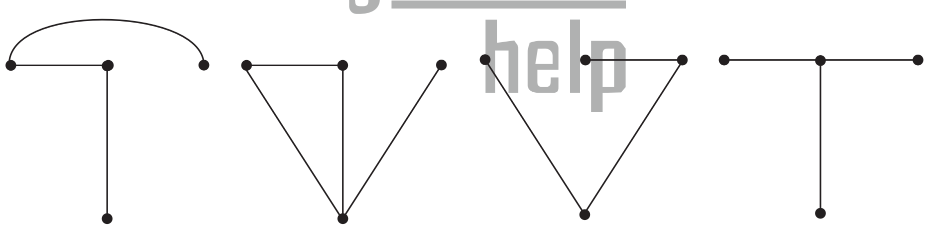
GATE EC 2004

Q.1 - 30 Carry One Mark Each

MCQ 1.1 Consider the network graph shown in the figure. Which one of the following is NOT a 'tree' of this graph ?



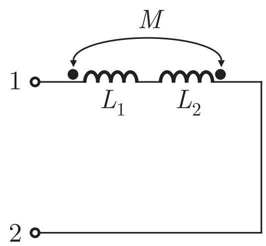


(a) (b) (c) (d)

(A) a
(B) b
(C) c
(D) d

SOL 1.1 For a tree there must not be any loop. So a, c, and d don't have any loop. Only b has loop.
Hence (B) is correct option.

MCQ 1.2 The equivalent inductance measured between the terminals 1 and 2 for the circuit shown in the figure is



(A) $L_1 + L_2 + M$ (B) $L_1 + L_2 - M$

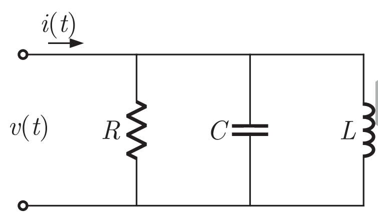
(C) $L_1 + L_2 + 2M$ (D) $L_1 + L_2 - 2M$

SOL 1.2 The sign of M is as per sign of L If current enters or exit the dotted terminals of both coil. The sign of M is opposite of L If current enters in dotted terminal of a coil and exit from the dotted terminal of other coil.

Thus $L_{eq} = L_1 + L_2 - 2M$

Hence (D) is correct option.

MCQ 1.3 The circuit shown in the figure, with $R = \frac{1}{3}\,\Omega, L = \frac{1}{4}\text{H}$ and $C = 3\,\text{F}$ has input voltage $v(t) = \sin 2t$. The resulting current $i(t)$ is



(A) $5\sin(2t + 53.1°)$ (B) $5\sin(2t - 53.1°)$

(C) $25\sin(2t + 53.1°)$ (D) $25\sin(2t - 53.1°)$

SOL 1.3 Here $\omega = 2$ and $V = 1\angle 0°$

$$Y = \frac{1}{R} + j\omega C + \frac{1}{j\omega L}$$

$$= 3 + j2 \times 3 + \frac{1}{j2 \times \frac{1}{4}} = 3 + j4$$

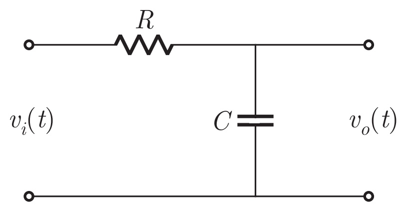
$$= 5\angle \tan^{-1}\frac{4}{3} = 5\angle 53.11°$$

$$I = V * Y = (1\angle 0°)(5\angle 53.1°) = 5\angle 53.1°$$

Thus $i(t) = 5\sin(2t + 53.1°)$

Hence (A) is correct option.

MCQ 1.4 For the circuit shown in the figure, the time constant $RC = 1$ ms. The input voltage is $v_i(t) = \sqrt{2}\sin 10^3 t$. The output voltage $v_o(t)$ is equal to



(A) $\sin(10^3 t - 45°)$ (B) $\sin(10^3 t + 45°)$

(C) $\sin(10^3 t - 53°)$ (D) $\sin(10^3 t + 53°)$

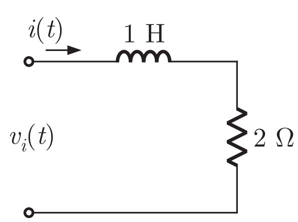
SOL 1.4 Hence (A) is correct option.

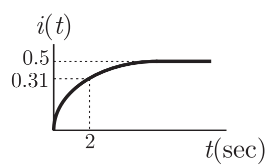
$$v_i(t) = \sqrt{2}\sin 10^3 t$$

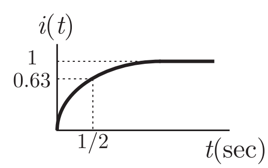
Here $\omega = 10^3$ rad and $V_i = \sqrt{2}\angle 0°$

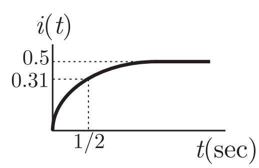
Now
$$V_0 = \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} . V_t = \frac{1}{1 + j\omega CR} V_i$$
$$= \frac{1}{1 + j \times 10^3 \times 10^{-3}} \sqrt{2}\angle 0°$$
$$= 1\angle -45°$$
$$v_0(t) = \sin(10^3 t - 45°)$$

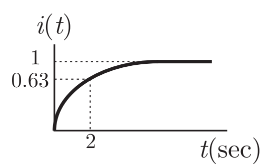
MCQ 1.5 For the $R - L$ circuit shown in the figure, the input voltage $v_i(t) = u(t)$. The current $i(t)$ is



(A) 

(B) 

(C) 

(D) 

SOL 1.5 Hence (C) is correct option.

Input voltage $v_i(t) = u(t)$

Taking laplace transform $V_i(s) = \frac{1}{s}$

Impedance $Z(s) = s + 2$

$$I(s) = \frac{V_i(s)}{s+2} = \frac{1}{s(s+2)}$$

or $$I(s) = \frac{1}{2}\left[\frac{1}{s} - \frac{1}{s+2}\right]$$

Taking inverse laplace transform

$$i(t) = \frac{1}{2}(1 - e^{-2t})\,u(t)$$

At $t = 0,\ i(t) = 0$
At $t = \frac{1}{2},\ i(t) = 0.31$
At $t = \infty,\ i(t) = 0.5$
Graph (C) satisfies all these conditions.

MCQ 1.6 The impurity commonly used for realizing the base region of a silicon $n-p-n$ transistor is

(A) Gallium (B) Indium
(C) Boron (D) Phosphorus

SOL 1.6 Trivalent impurities are used for making p type semiconductor. Boron is trivalent. Hence option (C) is correct

MCQ 1.7 If for a silicon npn transistor, the base-to-emitter voltage (V_{BE}) is 0.7 V and the collector-to-base voltage (V_{CB}) is 0.2 V, then the transistor is operating in the

(A) normal active mode (B) saturation mode
(C) inverse active mode (D) cutoff mode

SOL 1.7 Here emitter base junction is forward biased and base collector junction is reversed biased. Thus transistor is operating in normal active region.
Hence option (A) is correct.

MCQ 1.8 Consider the following statements S1 and S2.

S1 : The β of a bipolar transistor reduces if the base width is increased.

S2 : The β of a bipolar transistor increases if the dopoing concentration in the base is increased.

Which remarks of the following is correct ?

(A) S1 is FALSE and S2 is TRUE
(B) Both S1 and S2 are TRUE
(C) Both S1 and S2 are FALSE
(D) S1 is TRUE and S2 is FALSE

SOL 1.8 Hence option (D) is correct.

We have $\beta = \frac{\alpha}{1-\alpha}$

Thus $\alpha \uparrow \rightarrow \beta \uparrow$

$\alpha \downarrow \rightarrow \beta \downarrow$

If the base width increases, recombination of carrier in base region increases and α decreases & hence β decreases. If doping in base region increases, recombination of carrier in base increases and α decreases thereby decreasing β. Thus S_1 is true and S_2 is false.

MCQ 1.9 An ideal op-amp is an ideal

(A) voltage controlled current source (B) voltage controlled voltage source

(C) current controlled current source (D) current controlled voltage source

SOL 1.9 An ideal OPAMP is an ideal voltage controlled voltage source.

Hence (B) is correct option.

MCQ 1.10 Voltage series feedback (also called series-shunt feedback) results in

(A) increase in both input and output impedances

(B) decrease in both input and output impedances

(C) increase in input impedance and decrease in output impedance

(D) decrease in input impedance and increase in output impedance

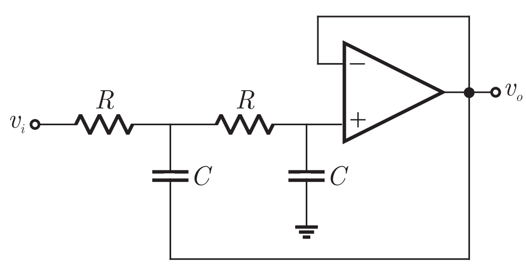
SOL 1.10 In voltage series feed back amplifier, input impedance increases by factor $(1 + A\beta)$ and output impedance decreases by the factor $(1 + A\beta)$.

$$R_{if} = R_i(1 + A\beta)$$

$$R_{of} = \frac{R_o}{(1 + A\beta)}$$

Hence (C) is correct option.

MCQ 1.11 The circuit in the figure is a



(A) low-pass filter (B) high-pass filter

(C) band-pass filter (D) band-reject filter

SOL 1.11 This is a Low pass filter, because

At $\omega = \infty$ $\quad \frac{V_0}{V_{in}} = 0$

and at $\omega = 0$ $\quad \frac{V_0}{V_{in}} = 1$

Hence (A) is correct option.

MCQ 1.12 Assuming $V_{CEsat} = 0.2$ V and $\beta = 50$, the minimum base current (I_B) required to drive the transistor in the figure to saturation is

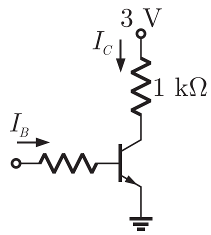


Fig Q.

(A) 56 μA (B) 140 mA

(C) 60 mA (D) 3 mA

SOL 1.12 Applying KVL we get

$$V_{CC} - I_C R_C - V_{CE} = 0$$

or $$I_C = \frac{V_{CC} - V_{CE}}{R_C} = \frac{3 - 0.2}{1k} = 2.8 \text{ mA}$$

Now $$I_B = \frac{I_C}{\beta} = \frac{2.8m}{50} = 56\ \mu\text{A}$$

Hence option (A) is correct.

MCQ 1.13 A master - slave flip flop has the characteristic that

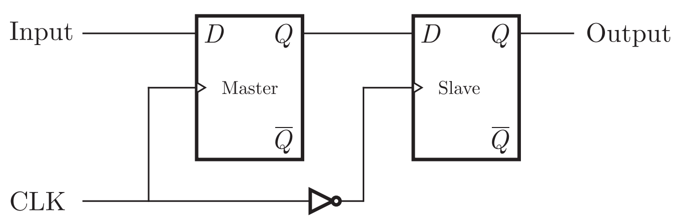
(A) change in the output immediately reflected in the output

(B) change in the output occurs when the state of the master is affected

(C) change in the output occurs when the state of the slave is affected

(D) both the master and the slave states are affected at the same time

SOL 1.13 A master slave D-flip flop is shown in the figure.



In the circuit we can see that output of flip-flop call be triggered only by transition of clock from 1 to 0 or when state of slave latch is affected.
Hence (C) is correct answer.

MCQ 1.14 The range of signed decimal numbers that can be represented by 6-bits 1's complement number is

(A) -31 to +31 (B) -63 to +63

(C) -64 to +63 (D) -32 to +31

SOL 1.14 The range of signed decimal numbers that can be represented by $n-$ bits 1's complement number is $-(2^{n-1}-1)$ to $+(2^{n-1}-1)$.

Thus for $n=6$ we have

$$\text{Range} = -(2^{6-1}-1) \text{ to } +(2^{6-1}-1)$$
$$= -31 \text{ to } +31$$

Hence (A) is correct answer.

MCQ 1.15 A digital system is required to amplify a binary-encoded audio signal. The user should be able to control the gain of the amplifier from minimum to a maximum in 100 increments. The minimum number of bits required to encode, in straight binary, is

(A) 8 (B) 6

(C) 5 (D) 7

SOL 1.15 The minimum number of bit require to encode 100 increment is

$$2^n \geq 100$$

or $$n \geq 7$$

Hence (D) is correct answer.

MCQ 1.16 Choose the correct one from among the alternatives A, B, C, D after matching an item from Group 1 most appropriate item in Group 2.

Group 1	Group 2
P. Shift register	1. Frequency division
Q. Counter	2. Addressing in memory chips
R. Decoder	3. Serial to parallel data conversion

(A) $P-3, Q-2, R-1$ (B) $P-3, Q-1, R-2$

(C) $P-2, Q-1, R-3$ (D) $P-1, Q-2, R-2$

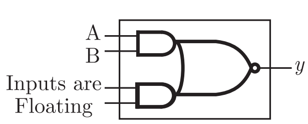
SOL 1.16 Shift Register → Serial to parallel data conversion

Counter → Frequency division

Decoder → Addressing in memory chips.

Hence (B) is correct answer.

MCQ 1.17 The figure the internal schematic of a TTL AND-OR-OR-Invert (AOI) gate. For the inputs shown in the figure, the output Y is



(A) 0 (B) 1

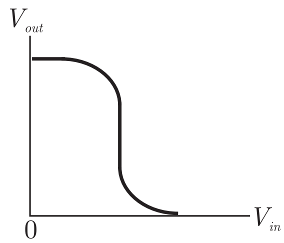
(C) AB (D) $\overline{AB}$

SOL 1.17 For the TTL family if terminal is floating, then it is at logic 1.

Thus $$Y = (\overline{AB+1}) = \overline{AB}.0 = 0$$

Hence (A) is correct answer.

MCQ 1.18 Given figure is the voltage transfer characteristic of



(A) an NOMS inverter with enhancement mode transistor as load

(B) an NMOS inverter with depletion mode transistor as load

(C) a CMOS inverter

(D) a BJT inverter

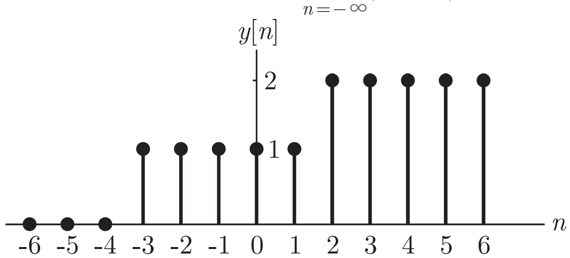
SOL 1.18 Hence option (C) is correct

MCQ 1.19 The impulse response $h[n]$ of a linear time-invariant system is given by $h[n] = u[n+3] + u[n-2) - 2n[n-7]$ where $u[n]$ is the unit step sequence. The above system is

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

(C) causal but unstable (D) unstable and not causal

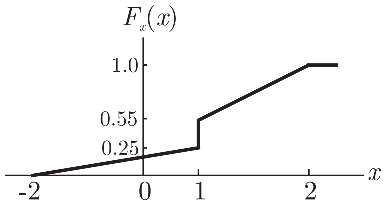
SOL 1.19 A system is stable if $\sum_{n=-\infty}^{\infty} |h(n)| < \infty$. The plot of given $h(n)$ is



Thus $$\sum_{n=-\infty}^{\infty} |h(n)| = \sum_{n=-3}^{6} |h(n)|$$
$$= 1+1+1+1+2+2+2+2+2$$
$$= 15 < \infty$$

Hence system is stable but $h(n) \neq 0$ for $n < 0$. Thus it is not causal.
Hence (A) is correct answer.

MCQ 1.20 The distribution function $F_x(x)$ of a random variable x is shown in the figure. The probability that $X = 1$ is



(A) zero
(B) 0.25
(C) 0.55
(D) 0.30

SOL 1.20 Hence (D) is correct option.

$F(x_1 \leq X < x_2) = p(X = x_2) - P(X = x_1)$

or $P(X = 1) = P(X = 1^+) - P(X = 1^-)$

$= 0.55 - 0.25 = 0.30$

MCQ 1.21 The z-transform of a system is $H(z) = \frac{z}{z-0.2}$. If the ROC is $|z| < 0.2$, then the impulse response of the system is

(A) $(0.2)^n u[n]$
(B) $(0.2)^n u[-n-1]$
(C) $-(0.2)^n u[n]$
(D) $-(0.2)^n u[-n-1]$

SOL 1.21 Hence (D) is correct answer.

$$H(z) = \frac{z}{z-0.2} \qquad |z| < 0.2$$

We know that

$$-a^n u[-n-1] \longleftrightarrow \frac{1}{1-az^{-1}} \qquad |z| < a$$

Thus $h[n] = -(0.2)^n u[-n-1]$

MCQ 1.22 The Fourier transform of a conjugate symmetric function is always

(A) imaginary
(B) conjugate anti-symmetric
(C) real
(D) conjugate symmetric

SOL 1.22 The Fourier transform of a conjugate symmetrical function is always real. Hence (C) is correct answer.

MCQ 1.23 The gain margin for the system with open-loop transfer function

$$G(s)H(s) = \frac{2(1+s)}{s^2}, \text{ is}$$

(A) ∞
(B) 0
(C) 1
(D) $-\infty$

SOL 1.23 The open loop transfer function is

$$G(s)H(s) = \frac{2(1+s)}{s^2}$$

Substituting $s = j\omega$ we have

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

$$\angle G(j\omega)H(j\omega) = -180^\circ + \tan^{-1}\omega$$

The frequency at which phase becomes -180°, is called phase crossover frequency.

Thus $-180 = -180^\circ + \tan^{-1}\omega_\phi$

or $\tan^{-1}\omega_\phi = 0$

or $\omega_\phi = 0$

The gain at $\omega_\phi = 0$ is

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

Thus gain margin is $= \frac{1}{\infty} = 0$ and in dB this is $-\infty$.

Hence (D) is correct option

MCQ 1.24 Given $G(s)H(s) = \frac{K}{s(s+1)(s+3)}$.The point of intersection of the asymptotes of the root loci with the real axis is

(A) -4 (B) 1.33

(C) -1.33 (D) 4

SOL 1.24 Centroid is the point where all asymptotes intersects.

$$\sigma = \frac{\Sigma\text{Real of Open Loop Pole} - \Sigma\text{Real Part of Open Loop Pole}}{\Sigma\text{No.of Open Loop Pole} - \Sigma\text{No.of Open Loop zero}}$$

$$= \frac{-1-3}{3} = -1.33$$

Hence (C) is correct option.

MCQ 1.25 In a PCM system, if the code word length is increased from 6 to 8 bits, the signal to quantization noise ratio improves by the factor

(A) $\frac{8}{6}$ (B) 12

(C) 16 (D) 8

SOL 1.25 When word length is 6

$$\left(\frac{S}{N}\right)_{N=6} = 2^{2\times 6} = 2^{12}$$

When word length is 8

$$\left(\frac{S}{N}\right)_{N=8} = 2^{2\times 8} = 2^{16}$$

Now $\frac{\left(\frac{S}{N}\right)_{N=8}}{\left(\frac{S}{N}\right)_{N=6}} = \frac{2^{16}}{2^{12}} = 2^4 = 16$

Thus it improves by a factor of 16.

Hence (C) is correct option.

MCQ 1.26 An AM signal is detected using an envelop detector. The carrier frequency and modulating signal frequency are 1 MHz and 2 kHz respectively. An appropriate value for the time constant of the envelop detector is

(A) 500μsec (B) 20μsec

(C) 0.2μsec (D) 1μsec

SOL 1.26 Hence (B) is correct option.

Carrier frequency $f_c = 1 \times 10^6$ Hz

Modulating frequency

$$f_m = 2 \times 10^3 \text{ Hz}$$

For an envelope detector

$$2\pi f_c > \frac{1}{Rc} > 2\pi f_m$$

$$\frac{1}{2\pi f_c} < RC < \frac{1}{2\pi f_m}$$

$$\frac{1}{2\pi f_c} < RC < \frac{1}{2\pi f_m}$$

$$\frac{1}{2\pi 10^6} < RC < \frac{1}{2 \times 10^3}$$

$$1.59 \times 10^{-7} < RC < 7.96 \times 10^{-5}$$

so, 20 μsec sec best lies in this interval.

MCQ 1.27 An AM signal and a narrow-band FM signal with identical carriers, modulating signals and modulation indices of 0.1 are added together. The resultant signal can be closely approximated by

(A) broadband FM (B) SSB with carrier

(C) DSB-SC (D) SSB without carrier

SOL 1.27 Hence (B) is correct option.

$$S_{AM}(t) = A_c[1 + 0.1\cos\omega_m t]\cos\omega_m t$$

$$s_{NBFM}(t) = A_c\cos[\omega_c t + 0.1\sin\omega_m t]$$

$$s(t) = S_{AM}(t) + S_{NB}f_m(t)$$

$$= A_c[1 + 0.1\cos\omega_m t]\cos\omega_c t + A_c\cos(\omega_c t + 0.1\sin\omega_m t)$$

$$= A_c\cos\omega_c t + A_c 0.1\cos\omega_m t\cos\omega_c t$$

$$+ A_c\cos\omega_c t\cos(0.1\sin\omega_m t) - A_c\sin\omega_c t.\sin(0.1\sin\omega_m t)$$

As $0.1\sin\omega_m t \cong +0.1$ to -0.1

so $\cos(0.1\sin\omega_m t) \approx 1$

As when θ is small $\cos\theta \approx 1$ and $\sin\theta \cong \theta$, thus

$$\sin(0.1\sin\omega_m t) = 0.1\sin\cos\omega_c t\cos\omega_m t + A_c\cos\omega_c t - A_c 0.1\sin\omega_m t\sin\omega_c t$$

$$= \underbrace{2A_c\cos\omega_c t}_{\text{cosec}} + \underbrace{0.1A_c\cos(\omega_c + \omega_m)t}_{USB}$$

Thus it is SSB with carrier.

MCQ 1.28 In the output of a DM speech encoder, the consecutive pulses are of opposite polarity during time interval $t_1 \le t \le t_2$. This indicates that during this interval

(A) the input to the modulator is essentially constant

(B) the modulator is going through slope overload

(C) the accumulator is in saturation

(D) the speech signal is being sampled at the Nyquist rate

SOL 1.28 Consecutive pulses are of same polarity when modulator is in slope overload.
Consecutive pulses are of opposite polarity when the input is constant.
Hence (A) is correct option.

MCQ 1.29 The phase velocity of an electromagnetic wave propagating in a hollow metallic rectangular waveguide in the TE_{10} mode is

(A) equal to its group velocity

(B) less than the velocity of light in free space

(C) equal to the velocity of light in free space

(D) greater than the velocity of light in free space

SOL 1.29 We know that $v_p > c > v_g$.
Hence (D) is correct option.

MCQ 1.30 Consider a lossless antenna with a directive gain of +6 dB. If 1 mW of power is fed to it the total power radiated by the antenna will be

(A) 4 mW (B) 1 mW

(C) 7 mW (D) 1/4 mW

SOL 1.30 Hence (A) is correct option.

We have $G_D(\theta,\phi) = \frac{4\pi U(\theta,\phi)}{P_{rad}}$

For lossless antenna

$$P_{rad} = P_{in}$$

Here we have $P_{rad} = P_{in} = 1$ mW

and $10\log G_D(\theta,\phi) = 6$ dB

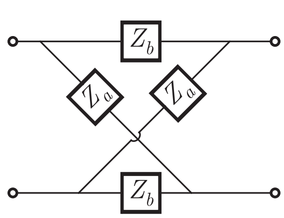
or $G_D(\theta,\phi) = 3.98$

Thus the total power radiated by antenna is

$$4\pi U(\theta,\phi) = P_{rad}\, G_D(\theta,\phi) = 1 \text{ m} \times 3.98 = 3.98 \text{ mW}$$

Q.31 - 90 Carry Two Marks Each

MCQ 1.31 For the lattice shown in the figure, $Z_a = j2\,\Omega$ and $Z_b = 2\,\Omega$. The values of the open circuit impedance parameters $[z] = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$ are



(A) $\begin{bmatrix} 1-j & 1+j \\ 1+j & 1+j \end{bmatrix}$ (B) $\begin{bmatrix} 1-j & 1+j \\ -1+j & 1-j \end{bmatrix}$

(C) $\begin{bmatrix} 1+j & 1+j \\ 1-j & 1-j \end{bmatrix}$ (D) $\begin{bmatrix} 1+j & -1+j \\ -1+j & 1+j \end{bmatrix}$

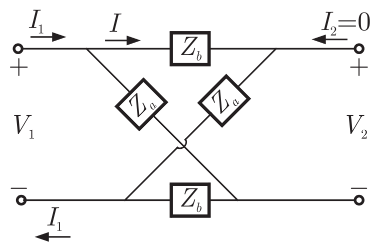
SOL 1.31 We know that

$$V_1 = z_{11}I_1 + z_{12}I_2$$
$$V_2 = z_{11}I_1 + z_{22}I_2$$

where $$z_{11} = \frac{V_1}{I_1}\Big|_{I_2=0}$$

$$z_{21} = \frac{V_2}{I_1}\Big|_{I_1=0}$$

Consider the given lattice network, when $I_2 = 0$. There is two similar path in the circuit for the current I_1. So $I = \frac{1}{2}I_1$



For z_{11} applying KVL at input port we get

$$V_1 = I(Z_a + Z_b)$$

Thus $$V_1 = \frac{1}{2}I_1(Z_a + Z_b)$$

$$z_{11} = \frac{1}{2}(Z_a + Z_b)$$

For Z_{21} applying KVL at output port we get

$$V_2 = Z_a\frac{I_1}{2} - Z_b\frac{I_1}{2}$$

Thus $$V_2 = \frac{1}{2}I_1(Z_a - Z_b)$$

$$z_{21} = \frac{1}{2}(Z_a - Z_b)$$

For this circuit $z_{11} = z_{22}$ and $z_{12} = z_{21}$. Thus

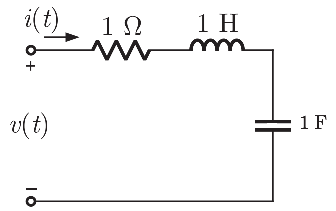
$$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} \frac{Z_a + Z_b}{2} & \frac{Z_a - Z_b}{2} \\ \frac{Z_a - Z_b}{2} & \frac{Z_a + Z_b}{2} \end{bmatrix}$$

Here $Z_a = 2j$ and $Z_b = 2\Omega$

Thus $$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} 1+j & j-1 \\ j-1 & 1+j \end{bmatrix}$$

Hence (D) is correct option.

MCQ 1.32 The circuit shown in the figure has initial current $i_L(0^-) = 1$ A through the inductor and an initial voltage $v_C(0^-) = -1$ V across the capacitor. For input $v(t) = u(t)$, the Laplace transform of the current $i(t)$ for $t \geq 0$ is



(A) $\frac{s}{s^2 + s + 1}$ (B) $\frac{s+2}{s^2 + s + 1}$

(C) $\frac{s-2}{s^2 + s + 1}$ (D) $\frac{1}{s^2 + s + 1}$

SOL 1.32 Applying KVL,

$$v(t) = Ri(t) + \frac{Ldi(t)}{dt} + \frac{1}{C}\int_0^\infty i(t)\,dt$$

Taking L.T. on both sides,

$$V(s) = RI(s) + LsI(s) - Li(0^+) + \frac{I(s)}{sC} + \frac{v_c(0^+)}{sC}$$

$$v(t) = u(t) \text{ thus } V(s) = \frac{1}{s}$$

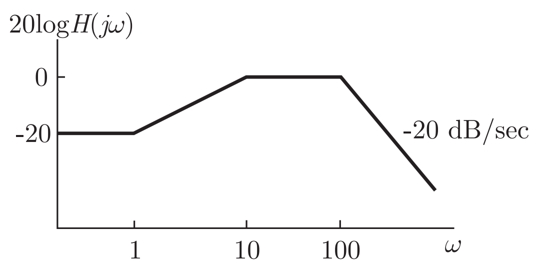
Hence $$\frac{1}{s} = I(s) + sI(s) - 1 + \frac{I(s)}{s} - \frac{1}{s}$$

$$\frac{2}{s} + 1 = \frac{I(s)}{s}[s^2 + s + 1]$$

or $$I(s) = \frac{s+2}{s^2 + s + 1}$$

Hence (B) is correct option.

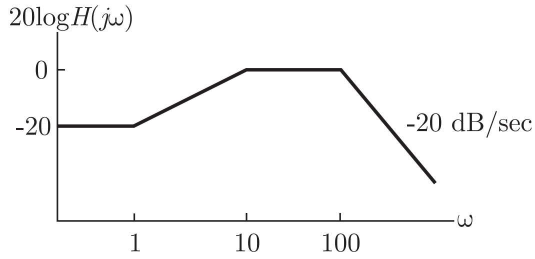
MCQ 1.33 Consider the Bode magnitude plot shown in the fig. The transfer function $H(s)$ is



(A) $\frac{(s+10)}{(s+1)(s+100)}$ (B) $\frac{10(s+1)}{(s+10)(s+100)}$

(C) $\frac{10^2(s+1)}{(s+10)(s+100)}$ (D) $\frac{10^3(s+100)}{(s+1)(s+10)}$

SOL 1.33 The given bode plot is shown below



At $\omega = 1$ change in slope is +20 dB → 1 zero at $\omega = 1$
At $\omega = 10$ change in slope is -20 dB → 1 poles at $\omega = 10$
At $\omega = 100$ change in slope is -20 dB → 1 poles at $\omega = 100$

Thus $T(s) = \dfrac{K(s+1)}{(\frac{s}{10}+1)(\frac{s}{100}+1)}$

Now $20\log_{10}K = -20 \rightarrow K = 0.1$

Thus $T(s) = \dfrac{0.1(s+1)}{(\frac{s}{10}+1)(\frac{s}{100}+1)} = \dfrac{100(s+1)}{(s+10)(s+100)}$

Hence (C) is correct option.

MCQ 1.34 The transfer function $H(s) = \dfrac{V_o(s)}{V_i(s)}$ of an RLC circuit is given by

$$H(s) = \frac{10^6}{s^2 + 20s + 10^6}$$

The Quality factor (Q-factor) of this circuit is

(A) 25 (B) 50

(C) 100 (D) 5000

SOL 1.34 Characteristics equation is

$s^2 + 20s + 10^6 = 0$

Comparing with $s^2 + 2\xi\omega_n s + \omega_n^2 = 0$ we have

$$\omega_n = \sqrt{10^6} = 10^3$$

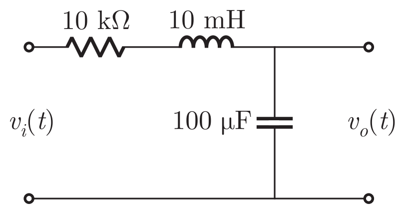
$$2\xi\omega = 20$$

Thus $2\xi = \dfrac{20}{10^3} = 0.02$

Now $Q = \dfrac{1}{2\xi} = \dfrac{1}{0.02} = 50$

Hence (B) is correct option.

MCQ 1.35 For the circuit shown in the figure, the initial conditions are zero. Its transfer function $H(s) = \dfrac{V_c(s)}{V_i(s)}$ is



(A) $\frac{1}{s^2+10^6 s+10^6}$ (B) $\frac{10^6}{s^2+10^3 s+10^6}$

(C) $\frac{10^3}{s^2+10^3 s+10^6}$ (D) $\frac{10^6}{s^2+10^6 s+10^6}$

SOL 1.35 Hence (D) is correct option.

$$H(s) = \frac{V_0(s)}{V_i(s)}$$

$$= \frac{\frac{1}{sC}}{R+sL+\frac{1}{sC}} = \frac{1}{s^2LC+sCR+1}$$

$$= \frac{1}{s^2(10^{-2}\times 10^{-4})+s(10^{-4}\times 10^4)+1}$$

$$= \frac{1}{10^{-6}s^2+s+1} = \frac{10^6}{s^2+10^6 s+10^6}$$

MCQ 1.36 A system described by the following differential equation $\frac{d^2y}{dt^2}+3\frac{dy}{dt}+2y = x(t)$ is initially at rest. For input $x(t) = 2u(t)$, the output $y(t)$ is

(A) $(1-2e^{-t}+e^{-2t})\,u(t)$ (B) $(1+2e^{-t}-2e^{-2t})\,u(t)$

(C) $(0.5+e^{-t}+1.5e^{-2t})\,u(t)$ (D) $(0.5+2e^{-t}+2e^{-2t})\,u(t)$

SOL 1.36 Hence Correct Option is (A)

Given, $$\frac{d^2y}{dt^2}+3\frac{dy}{dt}+2y = x(t)$$

Taking Laplace Transformation both sides, we have

$$[s^2+3s+2]\,Y(s) = X(s) = \frac{2}{s}$$

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

Increasing Laplace transformation gives,

$$y(t) = (1-2e^{-t}+e^{-2t})u(t)$$

MCQ 1.37 Consider the following statements S1 and S2

S1 : At the resonant frequency the impedance of a series RLC circuit is zero.

S2 : In a parallel GLC circuit, increasing the conductance G results in increase in its Q factor.

Which one of the following is correct?
(A) S1 is FALSE and S2 is TRUE
(B) Both S1 and S2 are TRUE
(C) S1 is TRUE and S2 is FALSE
(D) Both S1 and S2 are FALSE

SOL 1.37 Impedance of series RLC circuit at resonant frequency is minimum, not zero. Actually imaginary part is zero.

$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right)$$

At resonance $\omega L - \frac{1}{\omega C} = 0$ and $Z = R$ that is purely resistive. Thus S_1 is false

Now quality factor $Q = R\sqrt{\frac{C}{L}}$

Since $G = \frac{1}{R}$, $Q = \frac{1}{G}\sqrt{\frac{C}{L}}$

If $G\uparrow$ then $Q\downarrow$ provided C and L are constant. Thus S_2 is also false.
Hence (D) is correct option.

MCQ 1.38 In an abrupt $p-n$ junction, the doping concentrations on the $p-$side and n-side are $N_A = 9\times10^{16}$ /cm³ respectively. The $p-n$ junction is reverse biased and the total depletion width is 3 μm. The depletion width on the $p-$side is
(A) 2.7 μm
(B) 0.3 μm
(C) 2.25 μm
(D) 0.75 μm

SOL 1.38 We know that

$$W_p N_A = W_n N_D$$

or $$W_p = \frac{W_n\times N_D}{N_A} = \frac{3\,\mu\times10^{16}}{9\times10^{16}} = 0.3\,\mu\text{m}$$

Hence option (B) is correct.

MCQ 1.39 The resistivity of a uniformly doped $n-$type silicon sample is 0.5Ω - mc. If the electron mobility (μ_n) is 1250 cm²/V-sec and the charge of an electron is 1.6×10^{-19} Coulomb, the donor impurity concentration (N_D) in the sample is
(A) 2×10^{16}/cm³
(B) 1×10^{16}/cm³
(C) 2.5×10^{15}/cm³
(D) 5×10^{15}/cm³

SOL 1.39 Hence option (B) is correct.

Conductivity $\sigma = nqu_n$

or resistivity $\rho = \frac{1}{\sigma} = \frac{1}{nq\mu_n}$

Thus $n = \frac{1}{q\rho\mu_n} = \frac{1}{1.6\times10^{-19}\times0.5\times1250} = 10^{16}/\text{cm}^3$

For n type semiconductor $n = N_D$

MCQ 1.40 Consider an abrupt $p-n$ junction. Let V_{bi} be the built-in potential of this junction and V_R be the applied reverse bias. If the junction capacitance (C_j) is 1 pF for $V_{bi}+V_R=1$ V, then for $V_{bi}+V_R=4$ V, C_j will be

(A) 4 pF (B) 2 pF

(C) 0.25 pF (D) 0.5 pF

SOL 1.40 We know that

$$C_j=\left[\frac{e\varepsilon_S N_A N_D}{2(V_{bi}+V_R)(N_A+N_D)}\right]^{\frac{1}{2}}$$

Thus $$C_j\propto\sqrt{\frac{1}{(V_{bi}+V_R)}}$$

Now $$\frac{C_{j2}}{C_{j1}}=\sqrt{\frac{(V_{bi}+V_R)_1}{(V_{bi}+V_R)_2}}=\sqrt{\frac{1}{4}}=\frac{1}{2}$$

or $$C_{j2}=\frac{C_{j1}}{2}=\frac{1}{2}=0.5\text{ pF}$$

Hence option (D) is correct.

MCQ 1.41 Consider the following statements Sq and S2.

S1 : The threshold voltage (V_T) of MOS capacitor decreases with increase in gate oxide thickness.

S2 : The threshold voltage (V_T) of a MOS capacitor decreases with increase in substrate doping concentration.

Which Marks of the following is correct ?

(A) S1 is FALSE and S2 is TRUE

(B) Both S1 and S2 are TRUE

(C) Both S1 and S2 are FALSE

(D) S1 is TRUE and S2 is FALSE

SOL 1.41 Increase in gate oxide thickness makes difficult to induce charges in channel. Thus V_T increases if we increases gate oxide thickness. Hence S_1 is false.

Increase in substrate doping concentration require more gate voltage because initially induce charges will get combine in substrate. Thus V_T increases if we increase substrate doping concentration. Hence S_2 is false.

Hence option (C) is correct.

MCQ 1.42 The drain of an n-channel MOSFET is shorted to the gate so that $V_{GS}=V_{DS}$. The threshold voltage (V_T) of the MOSFET is 1 V. If the drain current (I_D) is 1 mA for $V_{GS}=2$ V, then for $V_{GS}=3$ V, I_D is

(A) 2 mA (B) 3 mA

(C) 9 mA (D) 4 mA

SOL 1.42 We know that

$$I_D = K(V_{GS} - V_T)^2$$

Thus $$\frac{I_{DS}}{I_{DI}} = \frac{(V_{GS2} - V_T)^2}{(V_{GS1} - V_T)^2}$$

Substituting the values we have

$$\frac{I_{D2}}{I_{D1}} = \frac{(3-1)^2}{(2-1)^2} = 4$$

or $$I_{D2} = 4I_{DI} = 4 \text{ mA}$$

Hence option (D) is correct.

MCQ 1.43 The longest wavelength that can be absorbed by silicon, which has the bandgap of 1.12 eV, is 1.1 μm. If the longest wavelength that can be absorbed by another material is 0.87 μm, then bandgap of this material is

(A) 1.416 A/cm²
(B) 0.886 eV
(C) 0.854 eV
(D) 0.706 eV

SOL 1.43 Hence option (A) is correct.

$$E_g \propto \frac{1}{\lambda}$$

Thus $$\frac{E_{g2}}{E_{g1}} = \frac{\lambda_1}{\lambda_2} = \frac{1.1}{0.87}$$

or $$E_{g2} = \frac{1.1}{0.87} \times 1.12 = 1.416 \text{ eV}$$

MCQ 1.44 The neutral base width of a bipolar transistor, biased in the active region, is 0.5 μ m. The maximum electron concentration and the diffusion constant in the base are 10^{14}/cm³ and $D_n = 25$ cm²/sec respectively. Assuming negligible recombination in the base, the collector current density is (the electron charge is 1.6×10^{-19} Coulomb)

(A) 800 A/cm²
(B) 8 A/cm²
(C) 200 A/cm²
(D) 2 A/cm²

SOL 1.44 Concentration gradient

$$\frac{dn}{dx} = \frac{10^{14}}{0.5 \times 10^{-4}} = 2 \times 10^{18}$$

$$q = 1.6 \times 10^{-19}\, C$$

$$D_n = 25$$

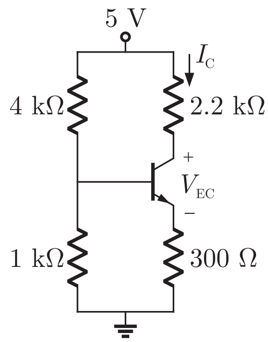
$$\frac{dn}{dx} = \frac{10^{14}}{0.5 \times 10^{-4}}$$

$$J_C = qD_n \frac{dn}{dx}$$

$$= 1.6 \times 10^{-19} \times 25 \times 2 \times 10^{18} = 8 \text{ A/cm}^2$$

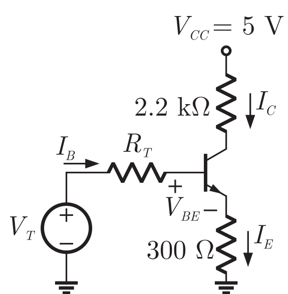
Hence option (B) is correct.

MCQ 1.45 Assume that the β of transistor is extremely large and $V_{BE} = 0.7\,V, I_C$ and V_{CE} in the circuit shown in the figure



(A) $I_C = 1\,\text{mA}, V_{CE} = 4.7$ V
(B) $I_C = 0.5$ mA, $V_{CE} = 3.75$ V
(C) $I_C = 1$ mA, $V_{CE} = 2.5$ V
(D) $I_C = 0.5$ mA, $V_{CE} = 3.9$ V

SOL 1.45 The thevenin equivalent is shown below



$$V_T = \frac{R_1}{R_1 + R_2} V_C = \frac{1}{4+1} \times 5 = 1 \quad \text{V}$$

Since β is large is large, $I_C \approx I_E,\ I_B \approx 0$ and

$$I_E = \frac{V_T - V_{BE}}{R_E} = \frac{1 - 0.7}{300} = 3 \text{ mA}$$

Now
$$\begin{aligned} V_{CE} &= 5 - 2.2\text{k}I_C - 300 I_E \\ &= 5 - 2.2\text{k} \times 1\text{m} - 300 \times 1\text{m} \\ &= 2.5 \text{ V} \end{aligned}$$

Hence (C) is correct option

MCQ 1.46 A bipolar transistor is operating in the active region with a collector current of 1 mA. Assuming that the β of the transistor is 100 and the thermal voltage (V_T) is 25 mV, the transconductance (g_m) and the input resistance (r_π) of the transistor in the common emitter configuration, are

(A) $g_m = 25$ mA/V and $r_\pi = 15.625\,\text{k}\Omega$
(B) $g_m = 40$ mA/V and $r_\pi = 4.0$ kΩ
(C) $g_m = 25$ mA/V and $r_\pi = 2.5$ k Ω
(D) $g_m = 40$ mA/V and $r_\pi = 2.5$ kΩ

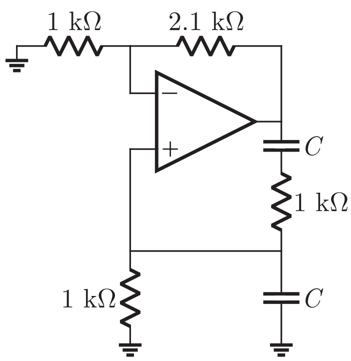
SOL 1.46 When $|I_C| >> |I_{CO}|$

$$g_m = \frac{|I_C|}{V_T} = \frac{1\text{mA}}{25\text{mV}} = 0.04 = 40 \text{ mA/V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{40 \times 10^{-3}} = 2.5 \text{ k}\Omega$$

Hence (D) is correct option.

MCQ 1.47 The value of C required for sinusoidal oscillations of frequency 1 kHz in the circuit of the figure is



(A) $\frac{1}{2\pi}$ µF (B) 2π µF

(C) $\frac{1}{2\pi\sqrt{6}}$ µF (D) $2\pi\sqrt{6}$ µF]

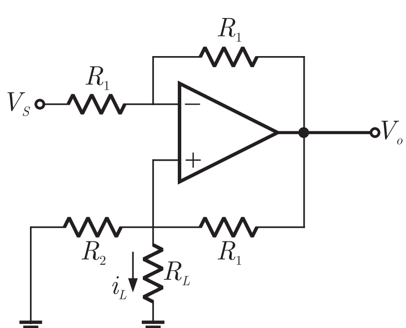
SOL 1.47 The given circuit is wein bridge oscillator. The frequency of oscillation is

$$2\pi f = \frac{1}{RC}$$

or $$C = \frac{1}{2\pi Rf} = \frac{1}{2\pi \times 10^3 \times 10^3} = \frac{1}{2\pi}\mu$$

Hence (A) is correct option.

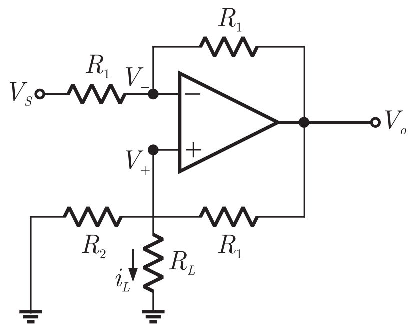
MCQ 1.48 In the op-amp circuit given in the figure, the load current i_L is



(A) $-\frac{V_s}{R_2}$ (B) $\frac{V_s}{R_2}$

(C) $-\frac{V_s}{R_L}$ (D) $\frac{V_s}{R_1}$

SOL 1.48 The circuit is as shown below



We know that for ideal OPAMP

$$V_- = V_+$$

Applying KCL at inverting terminal

$$\frac{V_- - V_s}{R_1} + \frac{V_- - V_0}{R_1} = 0$$

or $$2V_- - V_o = V_s \quad ...(1)$$

Applying KCL at non-inverting terminal

$$\frac{V_+}{R_2} + I_L + \frac{V_+ - V_o}{R_2} = 0$$

or $$2V_+ - V_o + I_L R_2 = 0 \quad ...(2)$$

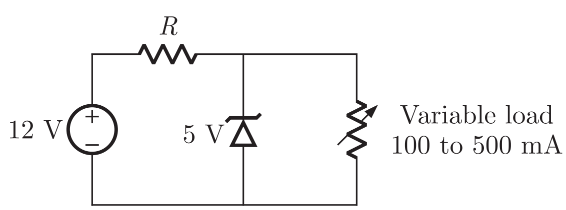
Since $V_- = V_+$, from (1) and (2) we have

$$V_s + I_L R_2 = 0$$

or $$I_L = -\frac{V_s}{R_2}$$

Hence (A) is correct option.

MCQ 1.49 In the voltage regulator shown in the figure, the load current can vary from 100 mA to 500 mA. Assuming that the Zener diode is ideal (i.e., the Zener knee current is negligibly small and Zener resistance is zero in the breakdown region), the value of R is



(A) $7\,\Omega$ (B) $70\,\Omega$

(C) $\frac{70}{3}\,\Omega$ (D) $14\,\Omega$

SOL 1.49 If I_Z is negligible the load current is

$$\frac{12 - V_z}{R} = I_L$$

as per given condition

$$100 \text{ mA} \le \frac{12 - V_Z}{R} \le 500 \text{ mA}$$

At $I_L = 100$ mA $\frac{12-5}{R} = 100$ mA $\qquad V_Z = 5$ V

or $\qquad R = 70\Omega$

At $I_L = 500$ mA $\frac{12-5}{R} = 500$ mA $\qquad V_Z = 5$ V

or $\qquad R = 14\,\Omega$

Thus taking minimum we get

$$R = 14\,\Omega$$

Hence (D) is correct option.

MCQ 1.50 In a full-wave rectifier using two ideal diodes, V_{dc} and V_m are the dc and peak values of the voltage respectively across a resistive load. If PIV is the peak inverse voltage of the diode, then the appropriate relationships for this rectifier are

(A) $V_{dc} = \frac{V_m}{\pi},\ PIV = 2V_m$ (B) $I_{dc} = 2\frac{V_m}{\pi},\ PIV = 2V_m$

(C) $V_{dc} = 2\frac{V_m}{\pi},\ PIV = V_m$ (D) $V_{dc}\frac{V_m}{\pi},\ PIV = V_m$

SOL 1.50 Hence (B) is correct option.

MCQ 1.51 The minimum number of 2- to -1 multiplexers required to realize a 4- to -1 multiplexers is

(A) 1 (B) 2

(C) 3 (D) 4

SOL 1.51 Number of MUX is $\frac{4}{3} = 2$ and $\frac{2}{2} = 1$. Thus the total number 3 multiplexers is required.

Hence (C) is correct answer.

MCQ 1.52 The Boolean expression $AC + B\overline{C}$ is equivalent to

(A) $\overline{A}C + B\overline{C} + AC$ (B) $\overline{B}C + AC + B\overline{C} + \overline{A}C\overline{B}$

(C) $AC + B\overline{C} + \overline{B}C + ABC$ (D) $ABC + \overline{A}B\overline{C} + AB\overline{C} + A\overline{B}C$

SOL 1.52 Hence (D) is correct answer.

$$\begin{aligned} AC + B\overline{C} &= AC1 + B\overline{C}1 \\ &= AC(B + \overline{B}) + B\overline{C}(A + \overline{A}) \\ &= ACB + AC\overline{B} + B\overline{C}A + B\overline{C}\,\overline{A} \end{aligned}$$

MCQ 1.53 11001, 1001, 111001 correspond to the 2's complement representation of which one of the following sets of number

(A) 25,9, and 57 respectively (B) -6, -6, and -6 respectively

(C) -7, -7 and -7 respectively (D) -25, -9 and -57 respectively

SOL 1.53 Hence (C) is correct answer.

11001	1001	111001
00110	0110	000110
+1	+1	+1
00111	0111	000111
7	7	7

Thus 2's complement of 11001, 1001 and 111001 is 7. So the number given in the question are 2's complement correspond to -7.

MCQ 1.54 The 8255 Programmable Peripheral Interface is used as described below.

(i) An A/D converter is interface to a microprocessor through an 8255.

The conversion is initiated by a signal from the 8255 on Port C. A signal on Port C causes data to be stobed into Port A.

(ii) Two computers exchange data using a pair of 8255s. Port A works as a bidirectional data port supported by appropriate handshaking signals.

The appropriate modes of operation of the 8255 for (i) and (ii) would be

(A) Mode 0 for (i) and Mode 1 for (ii)

(B) Mode 1 for (i) and Mode 2 for (ii)

(C) Mode for (i) and Mode 0 for (ii)

(D) Mode 2 for (i) and Mode 1 for (ii)

SOL 1.54 For 8255, various modes are described as following.

Mode 1 : Input or output with hand shake

In this mode following actions are executed

1. Two port (A & B) function as 8 - bit input output ports.
2. Each port uses three lines from C as a hand shake signal
3. Input & output data are latched.

Form (ii) the mode is 1.

Mode 2 : Bi-directional data transfer

This mode is used to transfer data between two computer. In this mode port A can be configured as bidirectional port. Port A uses five signal from port C as hand shake signal.

For (1), mode is 2

Hence (D) is correct answer.

MCQ 1.55 The number of memory cycles required to execute the following 8085 instructions

(i) LDA 3000 H

(ii) LXI D, FOF1H

would be

(A) 2 for (i) and 2 for (ii)
(B) 4 for (i) and 3 for (ii)
(C) 3 for (i) and 3 for (ii)
(D) 3 for (i) and 4 for (ii)

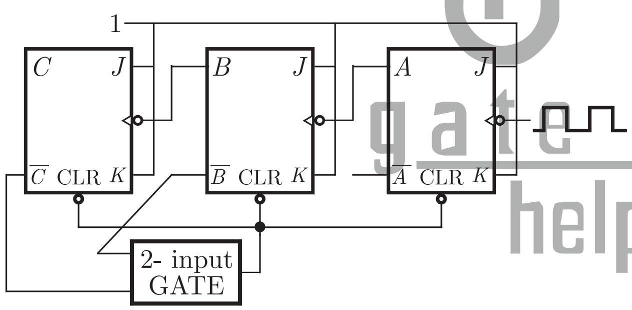
SOL 1.55 LDA 16 bit ⇒ Load accumulator directly this instruction copies data byte from memory location (specified within the instruction) the accumulator.
It takes 4 memory cycle-as following.
1. in instruction fetch
2. in reading 16 bit address
1. in copying data from memory to accumulator

LXI D, $(F0F1)_4$ ⇒ It copies 16 bit data into register pair D and E.

It takes 3 memory cycles.

Hence (B) is correct answer.

MCQ 1.56 In the modulo-6 ripple counter shown in figure, the output of the 2- input gate is used to clear the J-K flip-flop
The 2-input gate is



(A) a NAND gate
(B) a NOR gate
(C) an OR gate
(D) a AND gare

SOL 1.56 In the modulo - 6 ripple counter at the end of sixth pulse (i.e. after 101 or at 110) all states must be cleared. Thus when CB is 11 the all states must be cleared. The input to 2-input gate is $\overline{C}$ and $\overline{B}$ and the desired output should be low since the CLEAR is active low
Thus when $\overline{C}$ and $\overline{B}$ are 0, 0, then output must be 0. In all other case the output must be 1. OR gate can implement this functions.
Hence (C) is correct answer.

MCQ 1.57 Consider the sequence of 8085 instructions given below

```
LXI H, 9258
MOV A, M
CMA
MOV M, A
```

Which one of the following is performed by this sequence ?
(A) Contents of location 9258 are moved to the accumulator

(B) Contents of location 9258 are compared with the contents of the accumulator

(C) Contents of location 8529 are complemented and stored in location 8529

(D) Contents of location 5892 are complemented and stored in location 5892

SOL 1.57 Hence (A) is correct answer.

```
LXI H, 9258H     ; 9258H → HL
MOV A, M         ; (9258H) → A
CMa              ; Ā → A
MOV M, A         ; A → M
```

This program complement the data of memory location 9258H.

MCQ 1.58 A Boolean function f of two variables x and y is defined as follows :

$f(0,0) = f(0,1) = f(1,1) = 1; f(1,0) = 0$

Assuming complements of x and y are not available, a minimum cost solution for realizing f using only 2-input NOR gates and 2- input OR gates (each having unit cost) would have a total cost of

(A) 1 unit (B) 4 unit

(C) 3 unit (D) 2 unit

SOL 1.58 Hence (D) is correct answer.

We have $f(x,y) = \overline{x}\overline{y} + \overline{x}y + xy = \overline{x}(\overline{y} + y) + xy = \overline{x} + xy$

or $f(x,y) = \overline{x} + y$

Here compliments are not available, so to get $\overline{x}$ we use NOR gate. Thus desired circuit require 1 unit OR and 1 unit NOR gate giving total cost 2 unit.

MCQ 1.59 It is desired to multiply the numbers 0AH by 0BH and store the result in the accumulator. The numbers are available in registers B and C respectively. A part of the 8085 program for this purpose is given below :

```
        MVI A, 00H
LOOP    ------
        ------
        -----
        HLT
        END
```

The sequence of instructions to complete the program would be

(A) JNX LOOP, ADD B, DCR C

(B) ADD B, JNZ LOOP, DCR C

(C) DCR C, JNZ LOOP, ADD B

(D) ADD B, DCR C, JNZ LOOP

SOL 1.59 Hence (D) is correct answer.

```
     MVI A, 00H     ; Clear accumulator
LOOP ADD B          ; Add the contents of B to A
```

```
        DCR C          ; Decrement C
JNZ     LOOP           ; If C is not zero jump to loop
        HLT
        END
```

This instruction set add the contents of B to accumulator to contents of C times. Hence (D) is correct answer.

MCQ 1.60 A 1 kHz sinusoidal signal is ideally sampled at 1500 samples/sec and the sampled signal is passed through an ideal low-pass filter with cut-off frequency 800 Hz. The output signal has the frequency.

(A) zero Hz (B) 0.75 kHz

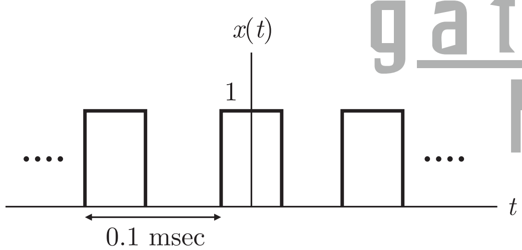
(C) 0.5 kHz (D) 0.25 kHz

SOL 1.60 Hence Correct Option is (C)

Here $f_s = 1500$ samples/sec, $f_m =$ kHz

The sampled frequency are 2.5 kHz, 0.5 kHz, Since LPF has cut-off frequency 800 Hz, then only output signal of frequency 0.5 kHz would pass through it

MCQ 1.61 A rectangular pulse train $s(t)$ as shown in the figure is convolved with the signal $\cos^2(4p \times 10^3 t)$. The convolved signal will be a



(A) DC (B) 12 kHz sinusoid

(C) 8 kHz sinusoid (D) 14 kHz sinusoid

SOL 1.61 Hence Correct Option is (D)

$$S(t) = \frac{1}{T_s}[1 + 2\cos\omega_s t + 2\cos 2\omega_s t + ...]$$

$$\cos^2 4\pi \times 10^3 t = \frac{(1 + \cos 8\pi \times 10^3 t)}{2}$$

$$\omega_s = \frac{2\pi}{0.1 \times 10^{-3}} = 2\pi \times 10 \times 10^3$$

$$S(t) * x(t) = \int_{-\infty}^{\infty} S(\tau) \times (\tau - t)\,d\tau$$

$$= \int_{-\infty}^{\infty} 10 \times 10^3 [1 + 2\cos\omega_s t + 2\cos 2\omega_s t + ...]\,dt$$

$$\times \frac{[1 + \cos 8\pi \times 10^3 t]}{2}$$

So, frequencies present will be $f_s \pm f_m, 2f_s \pm 3f_s \pm f_m; f_s = 10\,\text{kHz}$

$$f_m = \frac{8\pi \times 10^3}{2\pi} = 4\,\text{kHz}$$

Hence 14 kHz sinusoidal signal will be present

MCQ 1.62 Consider the sequence $x[n] = [-4 - j5\ \underset{\uparrow}{1 + j2}\ 5]$. The conjugate anti-symmetric part of the sequence is

(A) $[-4 - j2.5,\ j2,\ 4 - j2.5]$ (B) $[-j2.5,\ 1,\ j2.5]$

(C) $[-j2.5,\ j2,\ 0]$ (D) $[-4,\ 1,\ 4]$

SOL 1.62 Hence (A) is correct answer.

We have $x(n) = [-4 - j5,\quad \underset{\uparrow}{1 + 2j},\quad 4]$

$$x^*(n) = [-4 + j5,\quad \underset{\uparrow}{1 - 2j},\quad 4]$$

$$x^*(-n) = [4,\quad \underset{\uparrow}{1 - 2j},\quad -4 + j5]$$

$$x_{cas}(n) = \frac{x(n) - x^*(-n)}{2}$$

$$= [-4 - j\tfrac{5}{2},\quad \underset{\uparrow}{2j},\quad 4 - j\tfrac{5}{2}]$$

MCQ 1.63 A causal LTI system is described by the difference equation

$$2y[n] = \alpha y[n-2] - 2x[n] + \beta x[n-1]$$

The system is stable only if

(A) $|\alpha| = 2, |\beta| < 2$ (B) $|\alpha| > 2, |\beta| > 2$

(C) $|\alpha| < 2$, any value of β (D) $|\beta| < 2$, any value of α

SOL 1.63 Hence (C) is correct answer.

We have $2y(n) = \alpha y(n-2) - 2x(n) + \beta x(n-1)$

Taking z transform we get

$$2Y(z) = \alpha Y(z) z^{-2} - 2X(z) + \beta X(z) z^{-1}$$

or $$\frac{Y(z)}{X(z)} = \left(\frac{\beta z^{-1} - 2}{2 - \alpha z^{-2}}\right) \quad \text{...(i)}$$

or $$H(z) = \frac{z(\frac{\beta}{2} - z)}{(z^2 - \frac{\alpha}{2})}$$

It has poles at $\pm\sqrt{\alpha/2}$ and zero at 0 and $\beta/2$. For a stable system poles must lie inside the unit circle of z plane. Thus

$$\left|\sqrt{\frac{\alpha}{2}}\right| < 1$$

or $$|\alpha| < 2$$

But zero can lie anywhere in plane. Thus, β can be of any value.

MCQ 1.64 A causal system having the transfer function $H(s) = 1/(s+2)$ is excited with $10u(t)$. The time at which the output reaches 99% of its steady state value is

(A) 2.7 sec
(B) 2.5 sec
(C) 2.3 sec
(D) 2.1 sec

SOL 1.64 Hence (C) is correct option.

We have $r(t) = 10u(t)$

or $R(s) = \frac{10}{s}$

Now $H(s) = \frac{1}{s+2}$

$$C(s) = H(s)\cdot R(s) = \frac{1}{s+2}\cdot\frac{10}{s}\frac{10}{s(s+2)}$$

or $C(s) = \frac{5}{s} - \frac{5}{s+2}$

$$c(t) = 5[1-e^{-2t}]$$

The steady state value of $c(t)$ is 5. It will reach 99% of steady state value reaches at t, where

$$5[1-e^{-2t}] = 0.99\times 5$$

or $1-e^{-2t} = 0.99$

$$e^{-2t} = 0.1$$

or $-2t = \ln 0.1$

or $t = 2.3\,\text{sec}$

MCQ 1.65 The impulse response $h[n]$ of a linear time invariant system is given as

$$h[n] = \begin{cases} -2\sqrt{2} & n = 1, -1 \\ 4\sqrt{2} & n = 2, -2 \\ 0 & \text{otherwise} \end{cases}$$

If the input to the above system is the sequence $e^{j\pi n/4}$, then the output is

(A) $4\sqrt{2}\,e^{j\pi n/4}$
(B) $4\sqrt{2}\,e^{-j\pi n/4}$
(C) $4e^{j\pi n/4}$
(D) $-4e^{j\pi n/4}$

SOL 1.65 Hence (D) is correct answer.

We have $x(n) = e^{j\pi n/4}$

and $h(n) = 4\sqrt{2}\,\delta(n+2) - 2\sqrt{2}\,\delta(n+1) - 2\sqrt{2}\,\delta(n-1) + 4\sqrt{2}\,\delta(n-2)$

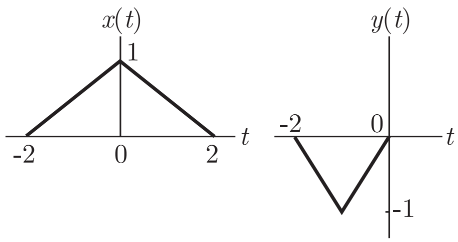
Now
$$y(n) = x(n)^*\ h(n)$$
$$= \sum_{k=-\infty}^{\infty} x(n-k)\,h(k) = \sum_{k=-2}^{2} x(n-k)\,h(k)$$

or
$$y(n) = x(n+2)\,h(-2) + x(n+1)\,h(-1) + x(n-1)\,h(1) + x(n-2)\,h(2)$$
$$= 4\sqrt{2}\,e^{j\frac{\pi}{4}(n+2)} - 2\sqrt{2}\,e^{j\frac{\pi}{4}(n+1)} - 2\sqrt{2}\,e^{j\frac{\pi}{4}(n-1)} + 4\sqrt{2}\,e^{j\frac{\pi}{4}(n-2)}$$

$$= 4\sqrt{2}\left[e^{j\frac{\pi}{4}(n+2)} + e^{j\frac{\pi}{4}(n-2)}\right] - 2\sqrt{2}\left[e^{j\frac{\pi}{4}(n+1)} + e^{j\frac{\pi}{4}(n-1)}\right]$$
$$= 4\sqrt{2}\, e^{j\frac{\pi}{4}n}\left[e^{j\frac{\pi}{2}} + e^{-j\frac{\pi}{2}}\right] - 2\sqrt{2}\, e^{j\frac{\pi}{2}n}\left[e^{j\frac{\pi}{4}} + e^{-j\frac{\pi}{4}}\right]$$
$$= 4\sqrt{2}\, e^{j\frac{\pi}{4}n}[0] - 2\sqrt{2}\, e^{j\frac{\pi}{4}n}\left[2\cos\tfrac{\pi}{4}\right]$$

or $$y(n) = -4e^{j\frac{\pi}{4}n}$$

MCQ 1.66 Let $x(t)$ and $y(t)$ with Fourier transforms $F(f)$ and $Y(f)$ respectively be related as shown in Fig. Then $Y(f)$ is



(A) $-\frac{1}{2}X(f/2)\,e^{-j\pi f}$ (B) $-\frac{1}{2}X(f/2)\,e^{j2\pi f}$

(C) $-X(f/2)\,e^{j2\pi f}$ (D) $-X(f/2)\,e^{-j2\pi f}$

SOL 1.66 From given graph the relation in $x(t)$ and $y(t)$ is

$$y(t) = -x[2(t+1)]$$
$$x(t) \xleftrightarrow{F} X(f)$$

Using scaling we have

$$x(at) \xleftrightarrow{F} \frac{1}{|a|}X\left(\frac{f}{a}\right)$$

Thus $$x(2t) \xleftrightarrow{F} \frac{1}{2}X\left(\frac{f}{2}\right)$$

Using shifting property we ge

$$x(t-t_0) = e^{-j2\pi f t_0}X(f)$$

Thus $$x[2(t+1)] \xleftrightarrow{F} e^{-j2\pi f(-1)}\frac{1}{2}X\left(\frac{f}{2}\right) = \frac{e^{j2\pi f}}{2}X\left(\frac{f}{2}\right)$$

$$-x[2(t+1)] \xleftrightarrow{F} -\frac{e^{j2\pi f}}{2}X\left(\frac{f}{2}\right)$$

Hence (B) is correct answer.

MCQ 1.67 A system has poles at 0.1 Hz, 1 Hz and 80 Hz; zeros at 5 Hz, 100 Hz and 200 Hz. The approximate phase of the system response at 20 Hz is

(A) $-90°$ (B) $0°$

(C) $90°$ (D) $-180°$

SOL 1.67 Approximate (comparable to $90°$) phase shift are

Due to pole at 0.01 Hz $\rightarrow -90°$

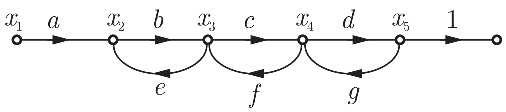
Due to pole at 80 Hz $\rightarrow -90°$

Due to pole at 80 Hz $\rightarrow 0$

Due to zero at 5 Hz $\rightarrow 90°$

Due to zero at 100 Hz $\rightarrow 0$
Due to zero at 200 Hz $\rightarrow 0$
Thus approximate total $-90°$ phase shift is provided.
Hence (A) is correct option.

MCQ 1.68 Consider the signal flow graph shown in Fig. The gain $\frac{x_5}{x_1}$ is



(A) $\frac{1-(be+cf+dg)}{abcd}$ (B) $\frac{bedg}{1-(be+cf+dg)}$

(C) $\frac{abcd}{1-(be+cf+dg)+bedg}$ (D) $\frac{1-(be+cf+dg)+bedg}{abcd}$

SOL 1.68 Mason Gain Formula

$$T(s) = \frac{\Sigma p_k \Delta_k}{\Delta}$$

In given SFG there is only one forward path and 3 possible loop.

$$p_1 = abcd$$
$$\Delta_1 = 1$$

$\Delta = 1 -$ (sum of indivudual loops) - (Sum of two non touching loops)

$$= 1 - (L_1 + L_2 + L_3) + (L_1 L_3)$$

Non touching loop are L_1 and L_3 where

$$L_1 L_2 = bedg$$

Thus
$$\frac{C(s)}{R(s)} = \frac{p_1 \Delta_1}{1-(be+cf+dg)+bedg}$$
$$= \frac{abcd}{1-(be+cf+dg)+bedg}$$

Hence (C) is correct option

MCQ 1.69 If $A = \begin{bmatrix} -2 & 2 \\ 1 & -3 \end{bmatrix}$, then $\sin At$ is

(A) $\frac{1}{3}\begin{bmatrix} \sin(-4t) + 2\sin(-t) & -2\sin(-4t) + 2\sin(-t) \\ -\sin(-4t) + \sin(-t) & 2\sin(-4t) + \sin(-t) \end{bmatrix}$

(B) $\begin{bmatrix} \sin(-2t) & \sin(2t) \\ \sin(t) & \sin(-3t) \end{bmatrix}$

(C) $\frac{1}{3}\begin{bmatrix} \sin(4t) + 2\sin(t) & 2\sin(-4t) - 2\sin(-t) \\ -\sin(-4t) + \sin(t) & 2\sin(4t) + \sin(t) \end{bmatrix}$

(D) $\frac{1}{3}\begin{bmatrix} \cos(-t) + 2\cos(t) & 2\cos(-4t) + 2\cos(-t) \\ -\cos(-4t) + \cos(-t) & -2\cos(-4t) + \cos(t) \end{bmatrix}$

SOL 1.69 Hence (A) is correct option

We have $A = \begin{bmatrix} -2 & 2 \\ 1 & -3 \end{bmatrix}$

Characteristic equation is

$$[\lambda I - A] = 0$$

or $$\begin{vmatrix} \lambda + 2 & -2 \\ -1 & \lambda + 3 \end{vmatrix} = 0$$

or $$(\lambda + 2)(\lambda + 3) - 2 = 0$$

or $$\lambda^2 + 5\lambda + 4 = 0$$

Thus $\lambda_1 = -4$ and $\lambda_2 = -1$

Eigen values are -4 and -1.

Eigen vectors for $\lambda_1 = -4$

$$(\lambda_1 I - A) X_1 = 0$$

or $$\begin{bmatrix} \lambda_1 + 2 & -2 \\ 1 & \lambda_1 + 3 \end{bmatrix} \begin{bmatrix} x_{11} \\ x_{21} \end{bmatrix} = 0$$

$$\begin{bmatrix} -2 & -2 \\ -1 & -1 \end{bmatrix} \begin{bmatrix} x_{11} \\ x_{21} \end{bmatrix} = 0$$

or $$-2x_{11} - 2x_{21} = 0$$

or $$x_{11} + x_{21} = 0$$

We have only one independent equation $x_{11} = -x_{21}$.

Let $x_{21} = K$, then $x_{11} = -K$, the Eigen vector will be

$$\begin{bmatrix} x_{11} \\ x_{21} \end{bmatrix} = \begin{bmatrix} -K \\ K \end{bmatrix} = K \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

Now Eigen vector for $\lambda_2 = -1$

$$(\lambda_2 I - A) X_2 = 0$$

or $$\begin{bmatrix} \lambda_2 + 2 & -2 \\ -1 & \lambda_2 + 3 \end{bmatrix} \begin{bmatrix} x_{12} \\ x_{22} \end{bmatrix} = 0$$

or $$\begin{bmatrix} 1 & -2 \\ -1 & 2 \end{bmatrix} \begin{bmatrix} x_{12} \\ x_{22} \end{bmatrix} = 0$$

We have only one independent equation $x_{12} = 2x_{22}$

Let $x_{22} = K$, then $x_{12} = 2K$. Thus Eigen vector will be

$$\begin{bmatrix} x_{12} \\ x_{22} \end{bmatrix} = \begin{bmatrix} 2K \\ K \end{bmatrix} = K \begin{bmatrix} 2 \\ 1 \end{bmatrix}$$

Digonalizing matrix

$$M = \begin{bmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{bmatrix} = \begin{bmatrix} -1 & 2 \\ 1 & 1 \end{bmatrix}$$

Now $$M^{-1} = \left(\frac{-1}{3}\right) \begin{bmatrix} 1 & -2 \\ -1 & -1 \end{bmatrix}$$

Now Diagonal matrix of $\sin At$ is D where

$$D = \begin{bmatrix} \sin(\lambda_1 t) & 0 \\ 0 & \sin(\lambda_2 t) \end{bmatrix} = \begin{bmatrix} \sin(-4t) & 0 \\ 0 & \sin(\lambda_2 t) \end{bmatrix}$$

Now matrix$B = \sin At = MDM^{-1}$

$$= -\left(\frac{1}{3}\right)\begin{bmatrix} -1 & 2 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} \sin(-4t) & 0 \\ 0 & \sin(-t) \end{bmatrix}\begin{bmatrix} 1 & -2 \\ -1 & -1 \end{bmatrix}$$

$$= -\left(\frac{1}{3}\right)\begin{bmatrix} -\sin(-4t) - 2\sin(-t) & 2\sin(-4t) - 2\sin(-t) \\ \sin(-4t) + 2\sin(t) & -2\sin(-4t) - \sin(-t) \end{bmatrix}$$

$$= -\left(\frac{1}{3}\right)\begin{bmatrix} -\sin(-4t) - 2\sin(-t) & 2\sin(-4t) - 2\sin(-t) \\ \sin(-4t) - \sin(-t) & -2\sin(-4t) + 2\sin(-t) \end{bmatrix}$$

$$= \left(\frac{1}{3}\right)\begin{bmatrix} \sin(-4t) + 2\sin(-t) & -2\sin(-4t) + 2\sin(-t) \\ -\sin(-4t + \sin(-t) & 2\sin(-4t) + \sin(-t) \end{bmatrix}s$$

MCQ 1.70 The open-loop transfer function of a unity feedback system is

$$G(s) = \frac{K}{s(s^2 + s + 2)(s + 3)}$$

The range of K for which the system is stable is

(A) $\frac{21}{4} > K > 0$

(B) $13 > K > 0$

(C) $\frac{21}{4} < K < \infty$

(D) $-6 < K < \infty$

SOL 1.70 For ufb system the characteristic equation is

$$1 + G(s) = 0$$

$$1 + \frac{K^{1 + G(s)}}{s(s^2 + 2s + 2)(s + 3)} = 0$$

$$s^4 + 4s^3 + 5s^2 + 6s + K = 0$$

The routh table is shown below. For system to be stable,

$$0 < K \text{ and } 0 < \frac{(21 - 4K)}{2/7}$$

This gives$0 < K < \frac{21}{4}$

s^4	1	5	K
s^3	4	6	0
s^2	$\frac{7}{2}$	K	
s^1	$\frac{21-4K}{7/2}$	0	
s^0	K		

Hence (A) is correct option

MCQ 1.71 For the polynomial $P(s) = s^2 + s^4 + 2s^3 + 2s^2 + 3s + 15$ the number of roots which lie in the right half of the s −plane is

(A) 4
(B) 2
(C) 3
(D) 1

SOL 1.71 Hence (B) is correct option.

We have $P(s) = s^5 + s^4 + 2s^3 + 3s + 15$

The routh table is shown below.

If $\varepsilon \to 0^+$ then $\frac{2\varepsilon + 12}{\varepsilon}$ is positive and $\frac{-15\varepsilon^2 - 24\varepsilon - 144}{2\varepsilon + 12}$ is negative. Thus there are two sign change in first column. Hence system has 2 root on RHS of plane.

s^5	1	2	3
s^4	1	2	15
s^3	ε	-12	0
s^2	$\frac{2\varepsilon+12}{\varepsilon}$	15	0
s^1	$\frac{-15\varepsilon^2 - 24\varepsilon - 144}{2\varepsilon + 12}$		
s^0	0		

MCQ 1.72 The state variable equations of a system are : $\dot{x}_1 = -3x_1 - x_2 = u, \dot{x}_2 = 2x_1$ and $y = x_1 + u$. The system is

(A) controllable but not observable

(B) observable but not controllable

(C) neither controllable nor observable

(D) controllable and observable

SOL 1.72 Hence (D) is correct option.

We have $\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} -3 & -1 \\ 2 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$

and $Y = [1 \ \ 0]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 2 \end{bmatrix} u$

Here $A = \begin{bmatrix} -3 & -1 \\ 2 & 0 \end{bmatrix}$, $B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ and $C = [1 \ \ 0]$

The controllability matrix is

$$Q_C = [B \ \ AB]$$

$$= \begin{bmatrix} 1 & -3 \\ 0 & 2 \end{bmatrix}$$

$\det Q_C \neq 0$ Thus controllable

The observability matrix is

$$Q_0 = [C^T \quad A^T C^T] = \begin{bmatrix} 1 & -3 \\ 0 & -1 \end{bmatrix} \neq 0$$

$\det Q_0 \neq 0$ Thus observable

MCQ 1.73 Given $A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, the state transition matrix e^{At} is given by

(A) $\begin{bmatrix} 0 & e^{-t} \\ e^{-t} & 0 \end{bmatrix}$

(B) $\begin{bmatrix} e^t & 0 \\ 0 & e^t \end{bmatrix}$

(C) $\begin{bmatrix} e^{-t} & 0 \\ 0 & e^{-t} \end{bmatrix}$

(D) $\begin{bmatrix} 0 & e^t \\ e^t & 0 \end{bmatrix}$

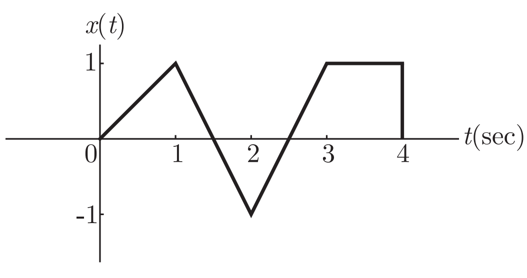
SOL 1.73 Hence (B) is correct option.

$$(sI - A) = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} s-1 & 0 \\ 0 & s-1 \end{bmatrix}$$

$$(sI - A)^{-1} = \frac{1}{(s-1)^2}\begin{bmatrix} (s-1) & 0 \\ 0 & (s-1) \end{bmatrix} = \begin{bmatrix} \frac{1}{s-1} & 0 \\ 0 & \frac{1}{s-1} \end{bmatrix}$$

$$e^{At} = L^{-1}[(sI - A)]^{-1} = \begin{bmatrix} e^t & 0 \\ 0 & e^t \end{bmatrix}$$

MCQ 1.74 Consider the signal $x(t)$ shown in Fig. Let $h(t)$ denote the impulse response of the filter matched to $x(t)$, with $h(t)$ being non-zero only in the interval 0 to 4 sec. The slope of $h(t)$ in the interval $3 < t < 4$ sec is



(A) $\frac{1}{2}\,\text{sec}^{-1}$

(B) $-1\,\text{sec}^{-1}$

(C) $-\frac{1}{2}\,\text{sec}^{-1}$

(D) $1\,\text{sec}^{-1}$

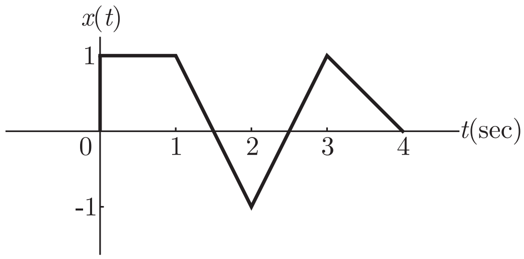
SOL 1.74 The impulse response of matched filter is

$$h(t) = x(T - t)$$

Since here $T = 4$, thus

$$h(t) = x(4 - t)$$

The graph of $h(t)$ is as shown below.



From graph it may be easily seen that slope between $3 < t < 4$ is -1.
Hence (B) is correct option.

MCQ 1.75 A 1 mW video signal having a bandwidth of 100 MHz is transmitted to a receiver through cable that has 40 dB loss. If the effective one-side noise spectral density at the receiver is 10^{-20} Watt/Hz, then the signal-to-noise ratio at the receiver is

(A) 50 dB
(B) 30 dB
(C) 40 dB
(D) 60 dB

SOL 1.75 The SNR at transmitter is

$$SNR_{tr} = \frac{P_{tr}}{\mathbb{N}B}$$

$$\frac{10^{-3}}{10^{-20} \times 100 \times 10^{6}} = 10^{9}$$

In dB $SNR_{tr} = 10 \log 10^{9} = 90$ dB

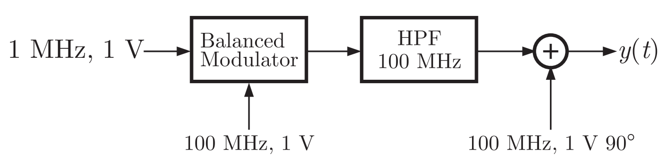
Cable Loss $= 40$ db

At receiver after cable loss we have

$$SNR_{Rc} = 90 - 40 = 50 \text{ dB}$$

Hence (A) is correct option.

MCQ 1.76 A 100 MHz carrier of 1 V amplitude and a 1 MHz modulating signal of 1 V amplitude are fed to a balanced modulator. The ourput of the modulator is passed through an ideal high-pass filter with cut-off frequency of 100 MHz. The output of the filter is added with 100 MHz signal of 1 V amplitude and 90° phase shift as shown in the figure. The envelope of the resultant signal is



(A) constant
(B) $\sqrt{1 + \sin(2\pi \times 10^{6} t)}$
(C) $\sqrt{\frac{5}{4} - \sin(2\pi - 10^{6} t)}$
(D) $\sqrt{\frac{5}{4} + \cos(2\pi \times 10^{6} t)}$

SOL 1.76 Hence (C) is correct option.

We have $f_c = 100 \text{ MHz} = 100 \times 10^{6}$ and $f_m = 1 \text{ MHz}$

$= 1 \times 10^{6}$

The output of balanced modulator is

$$V_{BM}(t) = [\cos\omega_c t][\cos\omega_c t]$$
$$= \frac{1}{2}[\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$$

If $V_{BM}(t)$ is passed through HPF of cut off frequency $f_H = 100\times 10^6$, then only $(\omega_c + \omega_m)$ passes and output of HPF is

$$V_{HP}(t) = \frac{1}{2}\cos(\omega_c + \omega_m)t$$

Now $$V_0(t) = V_{HP}(t) + \sin(2\pi\times 100\times 10^6)t$$

$$= \frac{1}{2}\cos[2\pi 100\times 10^6 + 2\pi\times 1\times 10^6 t] + \sin(2\pi\times 100\times 10^6)t$$

$$= \frac{1}{2}\cos[2\pi 10^8 + 2\pi 10^6 t] + \sin(2\pi 10^8)t$$

$$= \frac{1}{2}[\cos(2\pi 10^8 t)t\cos(2\pi 10^6 t)] - \sin[2\pi 10^8 t\sin(2\pi 10^6 t) + \sin 2\pi 10^8 t]$$

$$= \frac{1}{2}\cos(2\pi 10^6 t)\cos 2\pi 10^8 t + \left(1 - \frac{1}{2}\sin 2\pi 10^6 t\right)\sin 2\pi 10^8 t$$

This signal is in form

$$= A\cos 2\pi 10^8 t + B\sin 2\pi 10^8 t$$

The envelope of this signal is

$$= \sqrt{A^2 + B^2}$$

$$= \sqrt{\left(\frac{1}{2}\cos(2\pi 10^6 t)\right)^2 + \left(1 - \frac{1}{2}\sin(2\pi 10^6 t)\right)^2}$$

$$= \sqrt{\frac{1}{4}\cos^2(2\pi 10^6 t) + 1 + \frac{1}{4}\sin^2(2\pi 10^6 t) - \sin(2\pi 10^6 t)}$$

$$= \sqrt{\frac{1}{4} + 1 - \sin(2\pi 10^6 t)}$$

$$= \sqrt{\frac{5}{4} - \sin(2\pi 10^6 t)}$$

MCQ 1.77 Two sinusoidal signals of same amplitude and frequencies 10 kHz and 10.1 kHz are added together. The combined signal is given to an ideal frequency detector. The output of the detector is

(A) 0.1 kHz sinusoid (B) 20.1 kHz sinusoid

(C) a linear function of time (D) a constant

SOL 1.77 Hence (A) is correct option.

$$s(t) = A\cos[2\pi 10\times 10^3 t] + A\cos[2\pi 10.1\times 10^3 t]$$

Here $$T_1 = \frac{1}{10\times 10^3} = 100\mu\sec$$

and $$T_2 = \frac{1}{10.1\times 10^3} = 99\mu\sec$$

Period of added signal will be LCM $[T_1, T_2]$

Thus $T = LCM[100, 99] = 9900\mu\text{sec}$

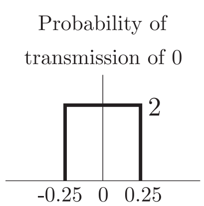
Thus frequency $f = \dfrac{1}{9900\mu} = 0.1 \text{ kHz}$

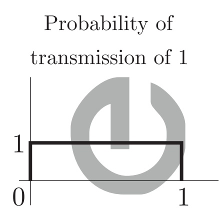
MCQ 1.78 Consider a binary digital communication system with equally likely 0's and 1's. When binary 0 is transmitted the detector input can lie between the levels -0.25 V and $+0.25$ V with equl probability : when binary 1 is transmitted, the voltage at the detector can have any value between 0 and 1 V with equal probability. If the detector has a threshold of 0.2 V (i.e., if the received signal is greater than 0.2 V, the bit is taken as 1), the average bit error probability is

(A) 0.15 (B) 0.2

(C) 0.05 (D) 0.5

SOL 1.78 The pdf of transmission of 0 and 1 will be as shown below :





Probability of error of 1

$$P(0 \le X \le 0.2) = 0.2$$

Probability of error of 0 :

$$P(0.2 \le X \le 0.25) = 0.05 \times 2 = 0.1$$

$$\text{Average error} = \frac{P(0 \le X \le 0.2) + P(0.2 \le X \le 0.25)}{2}$$

$$= \frac{0.2 + 0.1}{0} = 0.15$$

Hence (A) is correct option.

MCQ 1.79 A random variable X with uniform density in the interval 0 to 1 is quantized as follows :

If $0 \le X \le 0.3$, $x_q = 0$

If $0.3 < X \le 1$, $x_q = 0.7$

where x_q is the quantized value of X.

The root-mean square value of the quantization noise is

(A) 0.573 (B) 0.198

(C) 2.205 (D) 0.266

SOL 1.79 Hence (B) is correct option.

The square mean value is

$$\sigma^2 = \int_{-\infty}^{\infty} (x - x_q)^2 f(x)\, dx$$

$$= \int_0^1 (x - x_q)^2 f(x)\,dx$$
$$= \int_0^{0.3} (x-0)^2 f(x)\,dx + \int_{0.3}^{0.1} (x-0.7)^2 f(x)\,dx$$
$$= \left[\frac{x^3}{3}\right]_0^{0.3} + \left[\frac{x^3}{3} + 0.49x - 14\frac{x^2}{2}\right]_{0.3}^{1}$$

or $\sigma^2 = 0.039$

$$\text{RMS} = \sqrt{\sigma^2} = \sqrt{0.039} = 0.198$$

MCQ 1.80 Choose the current one from among the alternative A, B, C, D after matching an item from Group 1 with the most appropriate item in Group 2.

Group 1	Group 2
1. FM	P. Slope overload
2. DM	Q. μ-law
3. PSK	R. Envelope detector
4. PCM	S. Hilbert transform
	T. Hilbert transform
	U. Matched filter

(A) 1 - T, 2 - P, 3 - U, 4 - S
(B) 1 - S, 2 - U, 3 - P, 4 - T
(C) 1 - S, 2 - P, 3 - U, 4 - Q
(D) 1 - U, 2 - R, 3 - S, 4 - Q

SOL 1.80 Hence (C) is correct option.

FM $\longrightarrow$ Capture effect
DM $\longrightarrow$ Slope over load
PSK $\longrightarrow$ Matched filter
PCM $\longrightarrow$ μ − law

MCQ 1.81 Three analog signals, having bandwidths 1200 Hz, 600 Hz and 600 Hz, are sampled at their respective Nyquist rates, encoded with 12 bit words, and time division multiplexed. The bit rate for the multiplexed. The bit rate for the multiplexed signal is

(A) 115.2 kbps
(B) 28.8 kbps
(C) 57.6 kbps
(D) 38.4 kbps

SOL 1.81 Since $f_s = 2f_m$, the signal frequency and sampling frequency are as follows

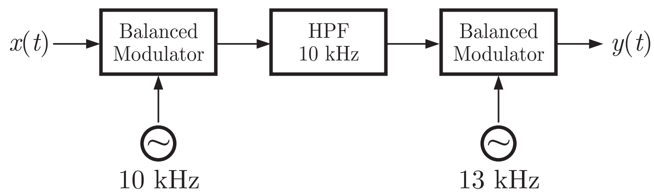
$f_{m1} = 1200$ Hz $\longrightarrow$ 2400 samples per sec
$f_{m2} = 600$ Hz $\longrightarrow$ 1200 samples per sec
$f_{m3} = 600$ Hz $\longrightarrow$ 1200 samples per sec

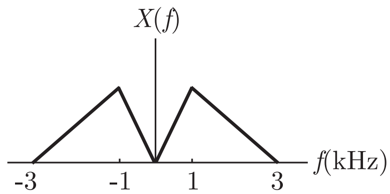
Thus by time division multiplexing total 4800 samples per second will be sent. Since each sample require 12 bit, total 4800×12 bits per second will be sent

Thus bit rate $R_b = 4800 \times 12 = 57.6$ kbps

Hence (C) is correct option.

MCQ 1.82 Consider a system shown in the figure. Let $X(f)$ and $Y(f)$ and denote the Fourier transforms of $x(t)$ and $y(t)$ respectively. The ideal HPF has the cutoff frequency 10 kHz.





The positive frequencies where $Y(f)$ has spectral peaks are

(A) 1 kHz and 24 kHz (B) 2 kHz and 244 kHz

(C) 1 kHz and 14 kHz (D) 2 kHz and 14 kHz

SOL 1.82 The input signal $X(f)$ has the peak at 1 kHz and -1 kHz. After balanced modulator the output will have peak at $f_c \pm 1$ kHz i.e. :

$$10 \pm 1 \longrightarrow 11 \text{ and } 9 \text{ kHz}$$
$$10 \pm (-1) \longrightarrow 9 \text{ and } 11 \text{ kHz}$$

9 kHz will be filtered out by HPF of 10 kHz. Thus 11 kHz will remain. After passing through 13 kHz balanced modulator signal will have 13 ± 11 kHz signal i.e. 2 and 24 kHz.

Thus peak of $Y(f)$ are at 2 kHz and 24 kHz.

Hence (B) is correct option.

MCQ 1.83 A parallel plate air-filled capacitor has plate area of 10^{-4} m² and plate separation of 10^{-3} m. It is connect - ed to a 0.5 V, 3.6 GHz source. The magnitude of the displacement current is ($\varepsilon = \frac{1}{36\pi}10^{-9}$ F/m)

(A) 10 mA (B) 100 mA

(C) 10 A (D) 1.59 mA

SOL 1.83 The capacitance is

$$C = \frac{\varepsilon_o A}{d} = \frac{8.85 \times 10^{-12} \times 10^{-4}}{10^{-3}} = 8.85 \times 10^{-13}$$

The charge on capacitor is

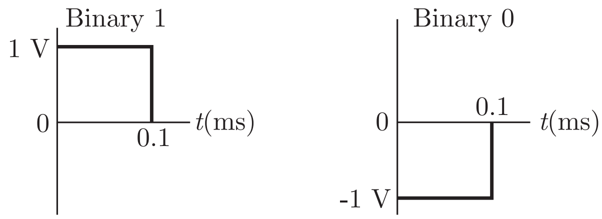
$$Q = CV = 8.85 \times 10^{-13} = 4.427 \times 10^{-13}$$

Displacement current in one cycle

$$I = \frac{Q}{T} = fQ = 4.427 \times 10^{-13} \times 3.6 \times 10^{9} = 1.59 \text{ mA}$$

Hence (D) is correct option.

MCQ 1.84 A source produces binary data at the rate of 10 kbps. The binary symbols are represented as shown in the figure given below.



The source output is transmitted using two modulation schemes, namely Binary PSK (BPSK) and Quadrature PSK (QPSK). Let B_1 and B_2 be the bandwidth requirements of BPSK and QPSK respectively. Assume that the bandwidth of he above rectangular pulses is 10 kHz, B_1 and B_2 are

(A) $B_1 = 20\text{ kHz}, B_2 = 20\text{ kHz}$ (B) $B_1 = 10\text{ kHz}, B_2 = 20\text{ kHz}$

(C) $B_1 = 20\text{ kHz}, B_2 = 10\text{ kHz}$ (D) $B_1 = 20\text{ kHz}, B_2 = 10\text{ kHz}$

SOL 1.84 The required bandwidth of M array PSK is

$$BW = \frac{2R_b}{n}$$

where $2^n = M$ and R_b is bit rate

For BPSK, $M = 2 = 2^n \longrightarrow n = 1$

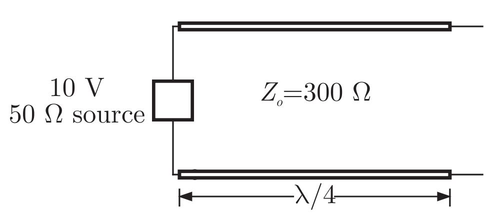
Thus $B_1 = \frac{2R_b}{1} = 2 \times 10 = 20\text{ kHz}$

For QPSK, $M = 4 = 2^n \longrightarrow n = 2$

Thus $B_2 = \frac{2R_b}{2} = 10\text{ kHz}$

Hence (C) is correct option.

MCQ 1.85 Consider a 300 Ω, quarter - wave long (at 1 GHz) transmission line as shown in Fig. It is connected to a 10 V, 50 Ω source at one end and is left open circuited at the other end. The magnitude of the voltage at the open circuit end of the line is



(A) 10 V (B) 5 V

(C) 60 V (D) 60/7 V

SOL 1.85 Hence (C) is correct option.

$$\frac{V_L}{V_{in}} = \frac{Z_O}{Z_{in}}$$

or $$V_L = \frac{Z_O}{Z_{in}} V_{in} = \frac{10 \times 300}{50} = 60 \text{ V}$$

MCQ 1.86 In a microwave test bench, why is the microwave signal amplitude modulated at 1 kHz

(A) To increase the sensitivity of measurement

(B) To transmit the signal to a far-off place

(C) To study amplitude modulations

(D) Because crystal detector fails at microwave frequencies

SOL 1.86 Hence (D) is correct option.

MCQ 1.87 If $\vec{E} = (\hat{a}_x + j\hat{a}_y)\, e^{jkz - k\omega t}$ and $\vec{H} = (k/\omega\mu)(\hat{a}_y + k\hat{a}_x)\, e^{jkz - j\omega t}$, the time-averaged Poynting vector is

(A) null vector

(B) $(k/\omega\mu)\,\hat{a}_z$

(C) $(2k/\omega\mu)\,\hat{a}_z$

(D) $(k/2\omega\mu)\,\hat{a}_z$

SOL 1.87 Hence (A) is correct option.

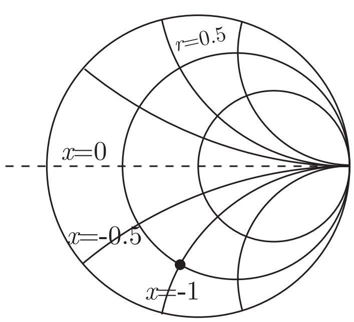
$$R_{avg} = \frac{1}{2}\mathrm{Re}[\vec{E} \times \vec{H}^*]$$

$$\vec{E} \times \vec{H}^* = (\hat{a}_x + j\hat{a}_y)\, e^{jkz - j\omega t} \times \frac{k}{\omega\mu}(-j\hat{a}_x + \hat{a}_y)\, e^{-jkz + j\omega t}$$

$$= \hat{a}_z\left[\frac{k}{\omega\mu} - (-j)(j)\frac{k}{\omega\mu}\right] = 0$$

Thus $$R_{avg} = \frac{1}{2}\mathrm{Re}[\vec{E} \times \vec{H}^*] = 0$$

MCQ 1.88 Consider an impedance $Z = R + jX$ marked with point P in an impedance Smith chart as shown in Fig. The movement from point P along a constant resistance circle in the clockwise direction by an angle 45° is equivalent to



(A) adding an inductance in series with Z

(B) adding a capacitance in series with Z

(C) adding an inductance in shunt across Z

(D) adding a capacitance in shunt across Z

SOL 1.88 Suppose at point P impedance is

$$Z = r + j(-1)$$

If we move in constant resistance circle from point P in clockwise direction by an angle 45°, the reactance magnitude increase. Let us consider a point Q at 45° from point P in clockwise direction. It's impedance is

$$Z_1 = r - 0.5j$$

or $$Z_1 = Z + 0.5j$$

Thus movement on constant r - circle by an $\angle 45°$ in CW direction is the addition of inductance in series with Z.

Hence (A) is correct option.

MCQ 1.89 A plane electromagnetic wave propagating in free space is incident normally on a large slab of loss-less, non-magnetic, dielectric material with $\varepsilon > \varepsilon_0$. Maxima and minima are observed when the electric field is measured in front of the slab. The maximum electric field is found to be 5 times the minimum field. The intrinsic impedance of the medium should be

(A) $120\pi\,\Omega$ (B) $60\pi\,\Omega$

(C) $600\pi\,\Omega$ (D) $24\pi\,\Omega$

SOL 1.89 Hence (D) is correct option.

We have $$\text{VSWR} = \frac{E_{max}}{E_{min}} = 5 = \frac{1 + |\Gamma|}{1 + |\Gamma|}$$

or $$|\Gamma| = \frac{2}{3}$$

Thus $$\Gamma = -\frac{2}{3}$$

Now $$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$$

or $$-\frac{2}{3} = \frac{\eta_2 - 120\pi}{\eta_2 + 120\pi}$$

or $$\eta_2 = 24\pi$$

MCQ 1.90 A lossless transmission line is terminated in a load which reflects a part of the incident power. The measured VSWR is 2. The percentage of the power that is reflected back is

(A) 57.73 (B) 33.33

(C) 0.11 (D) 11.11

SOL 1.90 Hence (D) is correct option.

The VSWR $$2 = \frac{1 - |\Gamma|}{1 + |\Gamma|}$$

or $$|\Gamma| = \frac{1}{3}$$

Thus $\frac{P_{ref}}{P_{inc}} = |\Gamma|^2 = \frac{1}{9}$

or $P_{ref} = \frac{P_{inc}}{9}$

i.e. 11.11% of incident power is reflected.

Answer Sheet

1.	(B)	19.	(A)	37.	(D)	55.	(B)	73.	(B)
2.	(D)	20.	(D)	38.	(B)	56.	(C)	74.	(B)
3.	(A)	21.	(D)	39.	(B)	57.	(A)	75.	(A)
4.	(A)	22.	(C)	40.	(D)	58.	(D)	76.	(C)
5.	(C)	23.	(D)	41.	(C)	59.	(D)	77.	(A)
6.	(C)	24.	(C)	42.	(D)	60.	(C)	78.	(A)
7.	(A)	25.	(C)	43.	(A)	61.	(D)	79.	(B)
8.	(D)	26.	(B)	44.	(B)	62.	(A)	80.	(C)
9.	(B)	27.	(B)	45.	(C)	63.	(C)	81.	(C)
10.	(C)	28.	(A)	46.	(D)	64.	(C)	82.	(B)
11.	(A)	29.	(D)	47.	(A)	65.	(D)	83.	(D)
12.	(A)	30.	(A)	48.	(A)	66.	(B)	84.	(C)
13.	(C)	31.	(D)	49.	(D)	67.	(A)	85.	(C)
14.	(A)	32.	(B)	50.	(B)	68.	(C)	86.	(D)
15.	(D)	33.	(C)	51.	(C)	69.	(A)	87.	(A)
16.	(B)	34.	(B)	52.	(D)	70	(A)	88.	(A)
17.	(A)	35.	(D)	53.	(C)	71	(B)	89.	(D)
18.	(C)	36.	(A)	54.	(D)	72	(D)	90.	(D)