GATE EC
2006

Question 1 to Q. 20 Carry one mark each

MCQ 1.1 The rank of the matrix $\begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 0 \\ 1 & 1 & 1 \end{bmatrix}$ is

(A) 0 (B) 1

(C) 2 (D) 3

SOL 1.1 Hence (C) is correct answer.

We have

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \sim \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad R_3 - R_1$$

Since one full row is zero, $\rho(A) < 3$

Now $\begin{vmatrix} 1 & 1 \\ 1 & -1 \end{vmatrix} = -2 \neq 0$, thus $\rho(A) = 2$

MCQ 1.2 $\nabla \times \nabla \times P$, where P is a vector, is equal to

(A) $P \times \nabla \times P - \nabla^2 P$ (B) $\nabla^2 P + \nabla(\nabla \times P)$

(C) $\nabla^2 P + \nabla \times P$ (D) $\nabla(\nabla \cdot P) - \nabla^2 P$

SOL 1.2 The vector Triple Product is

$\boldsymbol{A} \times (\boldsymbol{B} \times \boldsymbol{C}) = \boldsymbol{B}(\boldsymbol{A} \cdot \boldsymbol{C}) - \boldsymbol{C}(\boldsymbol{A} \cdot \boldsymbol{B})$

Thus $\nabla \times \nabla \times \boldsymbol{P} = \nabla(\nabla \cdot \boldsymbol{P}) - \boldsymbol{P}(\nabla \cdot \nabla) = \nabla(\nabla \cdot \boldsymbol{P}) - \nabla^2 \boldsymbol{P}$

Hence (D) is correct option.

MCQ 1.3 $\iint (\nabla \times P) \cdot ds$, where P is a vector, is equal to

(A) $\oint P \cdot dl$ (B) $\oint \nabla \times \nabla \times P \cdot dl$

(C) $\oint \nabla \times P \cdot dl$ (D) $\iiint \nabla \cdot P dv$

SOL 1.3 The Stokes theorem is

$$\iint (\nabla \times F) \cdot ds = \oint A \cdot dl$$

Hence (A) is correct option

MCQ 1.4 A probability density function is of the form

$$p(x) = Ke^{-\alpha|x|}, x \in (-\infty, \infty)$$

The value of K is

(A) 0.5 (B) 1

(C) 0.5α (D) α

SOL 1.4 Hence (C) is correct option.

We know $$\int_{-\infty}^{\infty} p(x)\,dx = 1$$

Thus $$\int_{-\infty}^{\infty} Ke^{-\alpha|x|}dx = 1$$

or $$\int_{-\infty}^{0} Ke^{\alpha x}\,dx + \int_{0}^{\infty} Ke^{-\alpha x}\,dx = 1$$

or $$\frac{K}{\alpha}[e^{\alpha x}]_{-\infty}^{0} + \frac{k}{(-\alpha)}[e^{-\alpha x}]_{0}^{\infty} = 1$$

or $$\frac{K}{\alpha} + \frac{K}{\alpha} = 1$$

or $$K = \frac{\alpha}{2}$$

MCQ 1.5 A solution for the differential equation $\dot{x}(t) + 2x(t) = \delta(t)$ with initial condition $x(0^-) = 0$ is

(A) $e^{-2t}u(t)$ (B) $e^{2t}u(t)$

(C) $e^{-t}u(t)$ (D) $e^{t}u(t)$

SOL 1.5 Hence (A) is correct option.

We have $\dot{x}(t) + 2x(t) = s(t)$

Taking Laplace transform both sides

$$sX(s) - x(0) + 2X(s) = 1$$

or $$sX(s) + 2X(s) = 1 \qquad \text{Since } x(0^-) = 0$$

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

Now taking inverse laplace transform we have

$$x(t) = e^{-2t}u(t)$$

MCQ 1.6 A low-pass filter having a frequency response $H(j\omega) = A(\omega)e^{j\phi(\omega)}$ does not produce any phase distortions if

(A) $A(\omega) = C\omega^3, \phi(\omega) = k\omega^3$ (B) $A(\omega) = C\omega^2, \phi(\omega) = k\omega$

(C) $A(\omega) = C\omega, \phi(\omega) = k\omega^2$ (D) $A(\omega) = C, \phi(\omega) = k\omega^{-1}$

SOL 1.6 A LPF will not produce phase distortion if phase varies linearly with frequency.

$$\phi(\omega) \propto \omega$$

i.e. $\phi(\omega) = k\omega$

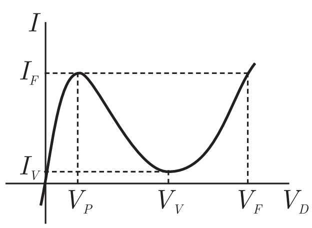
Hence (B) is correct option.

MCQ 1.7 The values of voltage (V_D) across a tunnel-diode corresponding to peak and valley currents are V_p, V_D respectively. The range of tunnel-diode voltage for V_D which the slope of its $I - V_D$ characteristics is negative would be

(A) $V_D < 0$ (B) $0 \le V_D < V_p$

(C) $V_p \le V_D < V_v$ (D) $V_D \ge V_v$

SOL 1.7 For the case of negative slope it is the negative resistance region



Hence option (C) is correct.

MCQ 1.8 The concentration of minority carriers in an extrinsic semiconductor under equilibrium is

(A) Directly proportional to doping concentration

(B) Inversely proportional to the doping concentration

(C) Directly proportional to the intrinsic concentration

(D) Inversely proportional to the intrinsic concentration

SOL 1.8 For n-type p is minority carrier concentration

$$np = n_i^2$$

$$np = \text{Constant} \qquad \text{Since } n_i \text{ is constant}$$

$$p \propto \frac{1}{n}$$

Thus p is inversely proportional to n.

Hence option (A) is correct.

MCQ 1.9 Under low level injection assumption, the injected minority carrier current for an extrinsic semiconductor is essentially the

(A) Diffusion current (B) Drift current

(C) Recombination current (D) Induced current

SOL 1.9 Diffusion current, since the drift current is negligible for minority carrier.

Hence option (A) is correct.

MCQ 1.10 The phenomenon known as "Early Effect" in a bipolar transistor refers to a reduction of the effective base-width caused by

(A) Electron - hole recombination at the base

(B) The reverse biasing of the base - collector junction

(C) The forward biasing of emitter-base junction

(D) The early removal of stored base charge during saturation-to-cut off switching

SOL 1.10 In BJT as the B-C reverse bias voltage increases, the B-C space charge region width increases which x_B (i.e. neutral base width) $> A$ change in neutral base width will change the collector current. A reduction in base width will causes the gradient in minority carrier concentration to increases, which in turn causes an increases in the diffusion current. This effect si known as base modulation as early effect.
Hence option (B) is correct.

MCQ 1.11 The input impedance (Z_i) and the output impedance (Z_0) of an ideal trans-conductance (voltage controlled current source) amplifier are

(A) $Z_i = 0, Z_0 = 0$ (B) $Z_i = 0, Z_0 = \infty$

(C) $Z_i = \infty, Z_0 = 0$ (D) $Z_i = \infty, Z_0 = \infty$

SOL 1.11 In the transconductance amplifier it is desirable to have large input impedance and large output impedance.
Hence (D) is correct option.

MCQ 1.12 An n-channel depletion MOSFET has following two points on its $I_D - V_{Gs}$ curve:
(i) $V_{GS} = 0$ at $I_D = 12$ mA and
(ii) $V_{GS} = -6$ Volts at $I_D = 0$ mA
Which of the following Q point will given the highest trans conductance gain for small signals?

(A) $V_{GS} = -6$ Volts (B) $V_{GS} = -3$ Volts

(C) $V_{GS} = 0$ Volts (D) $V_{GS} = 3$ Volts

SOL 1.12 Hence (C) is correct option.

MCQ 1.13 The number of product terms in the minimized sum-of-product expression obtained through the following K - map is (where, "d" denotes don't care states)

1	0	0	1
0	d	0	0
0	0	d	1
1	0	0	1

(A) 2 (B) 3

(C) 4 (D) 5

SOL 1.13 As shown below there are 2 terms in the minimized sum of product expression.

1	0	0	1

0	d	0	0
0	0	d	1
1	0	0	1

Hence (A) is correct answer.

MCQ 1.14 Let $x(t) \longleftrightarrow X(j\omega)$ be Fourier Transform pair. The Fourier Transform of the signal $x(5t-3)$ in terms of $X(j\omega)$ is given as

(A) $\frac{1}{5}e^{-\frac{j3\omega}{5}}X\left(\frac{j\omega}{5}\right)$ (B) $\frac{1}{5}e^{\frac{j3\omega}{5}}X\left(\frac{j\omega}{5}\right)$

(C) $\frac{1}{5}e^{-j3\omega}X\left(\frac{j\omega}{5}\right)$ (D) $\frac{1}{5}e^{j3\omega}X\left(\frac{j\omega}{5}\right)$

SOL 1.14 Hence (A) is correct answer.

$$x(t) \xleftrightarrow{F} X(j\omega)$$

Using scaling we have

$$x(5t) \xleftrightarrow{F} \frac{1}{5}X\left(\frac{j\omega}{5}\right)$$

Using shifting property we get

$$x\left[5\left(t-\frac{3}{5}\right)\right] \xleftrightarrow{F} \frac{1}{5}X\left(\frac{j\omega}{5}\right)e^{-\frac{j3\omega}{5}}$$

MCQ 1.15 The Dirac delta function $\delta(t)$ is defined as

(A) $\delta(t) = \begin{cases} 1 & t=0 \\ 0 & \text{otherwise} \end{cases}$

(B) $\delta(t) = \begin{cases} \infty & t=0 \\ 0 & \text{otherwise} \end{cases}$

(C) $\delta(t) = \begin{cases} 1 & t=0 \\ 0 & \text{otherwise} \end{cases}$ and $\int_{-\infty}^{\infty}\delta(t)\,dt = 1$

(D) $\delta(t) = \begin{cases} \infty & t=0 \\ 0 & \text{otherwise} \end{cases}$ and $\int_{-\infty}^{\infty}\delta(t)\,dt = 1$

SOL 1.15 Dirac delta function $\delta(t)$ is defined at $t=0$ and it has infinite value a $t=0$. The area of dirac delta function is unity.

Hence (D) is correct option.

MCQ 1.16 If the region of convergence of $x_1[n]+x_2[n]$ is $\frac{1}{3}<|z|<\frac{2}{3}$ then the region of convergence of $x_1[n]-x_2[n]$ includes

(A) $\frac{1}{3}<|z|<3$ (B) $\frac{2}{3}<|z|<3$

(C) $\frac{3}{2}<|z|<3$ (D) $\frac{1}{3}<|z|<\frac{2}{3}$

SOL 1.16 The ROC of addition or subtraction of two functions $x_1(n)$ and $x_2(n)$ is $R_1 \cap R_2$.

We have been given ROC of addition of two function and has been asked ROC of subtraction of two function. It will be same.
Hence (D) is correct option.

MCQ 1.17 The open-loop function of a unity-gain feedback control system is given by

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

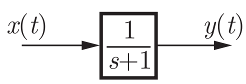
The gain margin of the system in dB is given by

(A) 0 (B) 1

(C) 20 (D) ∞

SOL 1.17 Given system is 2nd order and for 2nd order system G.M. is infinite.
Hence (D) is correct option.

MCQ 1.18 In the system shown below, $x(t) = (\sin t)\, u(t)$ In steady-state, the response $y(t)$ will be



(A) $\frac{1}{\sqrt{2}}\sin\left(t - \frac{\pi}{4}\right)$ (B) $\frac{1}{\sqrt{2}}\sin\left(t + \frac{\pi}{4}\right)$

(C) $\frac{1}{\sqrt{2}}e^{-t}\sin t$ (D) $\sin t - \cos t$

SOL 1.18 Hence (A) is correct option

As we have $x(t) = \sin t,$ thus $\omega = 1$

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

or $$H(j\omega) = \frac{1}{j\omega + 1} = \frac{1}{j+1}$$

or $$H(j\omega) = \frac{1}{\sqrt{2}}\angle - 45^\circ$$

Thus $$y(t) = \frac{1}{\sqrt{2}}\sin\left(t - \tfrac{\pi}{4}\right)$$

MCQ 1.19 The electric field of an electromagnetic wave propagation in the positive direction is given by $E = \hat{a}_x \sin(\omega t - \beta z) + \hat{a}_y \sin(\omega t - \beta z + \pi/2)$. The wave is

(A) Linearly polarized in the z $-$direction

(B) Elliptically polarized

(C) Left-hand circularly polarized

(D) Right-hand circularly polarized

SOL 1.19 Hence (C) is correct option.

We have $E = \hat{a}_{xx}\sin(\omega t - \beta z) + \hat{a}_y \sin(\omega t - \beta z + \pi/2)$
Here $|E_x| = |E_y|$ and $\phi_x = 0, \phi_y = \frac{\pi}{2}$
Phase difference is $\frac{\pi}{2}$, thus wave is left hand circularly polarized.

MCQ 1.20 A transmission line is feeding 1 watt of power to a horn antenna having a gain of 10 dB. The antenna is matched to the transmission line. The total power radiated by the horn antenna into the free space is

(A) 10 Watts (B) 1 Watts
(C) 0.1 Watts (D) 0.01 Watt

SOL 1.20 Hence (A) is correct option.

We have $10\log G = 10$ dB
or $G = 10$
Now gain $G = \frac{P_{rad}}{P_{in}}$
or $10 = \frac{P_{rad}}{1\,W}$
or $P_{rad} = 10$ Watts

Q.21 to Q.75 Carry two mark each.

MCQ 1.21 The eigenvalue and the corresponding eigenvector of 2×2 matrix are given by

Eigenvalue	Eigenvector
$\lambda_1 = 8$	$v_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$
$\lambda_2 = 4$	$v_2 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$

The matrix is

(A) $\begin{bmatrix} 6 & 2 \\ 2 & 6 \end{bmatrix}$ (B) $\begin{bmatrix} 4 & 6 \\ 6 & 4 \end{bmatrix}$
(C) $\begin{bmatrix} 2 & 4 \\ 4 & 2 \end{bmatrix}$ (D) $\begin{bmatrix} 4 & 8 \\ 8 & 4 \end{bmatrix}$

SOL 1.21 Sum of the Eigen values must be equal to the sum of element of principal diagonal of matrix.

Only matrix $\begin{bmatrix} 6 & 2 \\ 2 & 6 \end{bmatrix}$ satisfy this condition.

Hence (A) is correct answer

MCQ 1.22 For the function of a complex variable $W = \ln Z$ (where, $W = u + jv$ and $Z = x + jy$, the $u =$ constant lines get mapped in $Z-$plane as

(A) set of radial straight lines (B) set of concentric circles
(C) set of confocal hyperbolas (D) set of confocal ellipses

SOL 1.22 Hence (B) is correct answer.

We have $W = \ln z$

$$u + jv = \ln(x + jy)$$

or $e^{u+jv} = x + jy$

or $e^{u}e^{jv} = x + jy$

$e^{u}(\cos v + j\sin v) = x + jy$

Now $x = e^{u}\cos v$ and $y = e^{u}\sin v$

Thus $x^2 + y^2 = e^{2u}$ Equation of circle

MCQ 1.23 The value of the constant integral $\oint_{|z-j|=2} \frac{1}{z^2+4}$dz is positive sense is

(A) $\frac{j\pi}{2}$ (B) $-\frac{\pi}{2}$

(C) $-\frac{j\pi}{2}$ (D) $\frac{\pi}{2}$

SOL 1.23 We have

$$\oint_{|z-j|=2} \frac{1}{z^2+4}dz = \int_{|z-j|=2} \frac{1}{(z+2i)(z-2i)}dz$$

$P(0,2)$ lies inside the circle $|z-j| = 2$ and $P(0,-2)$ does not lie.

Thus By cauchy's integral formula

$$I = 2\pi i \lim_{z \to 2i}(z-2i)\frac{1}{(z+2i)(z-2i)} = \oint_C \frac{2\pi i}{2i+2i} = \frac{\pi}{2}$$

Hence (D) is correct answer.

MCQ 1.24 The integral $\int_0^{\pi}\sin^3\theta d\theta$ is given by

(A) $\frac{1}{2}$ (B) $\frac{2}{3}$

(C) $\frac{4}{3}$ (D) $\frac{8}{3}$

SOL 1.24 Hence (C) is correct option.

$$I = \int_0^{\pi}\sin^3\theta d\theta$$

$$= \int_0^{\pi}\left(\frac{3\sin\theta - \sin 3\theta}{4}\right)d\theta \qquad \sin 3\theta = 3\sin\theta - 4\sin^3\theta$$

$$= \left[\frac{-3}{4}\cos\theta\right]_0^{\pi} = \left[\frac{\omega s 3\theta}{12}\right]_0^{\pi} = \left[\frac{3}{4}+\frac{3}{4}\right] - \left[\frac{1}{12}+\frac{1}{12}\right] = \frac{4}{3}$$

MCQ 1.25 Three companies X, Y and Z supply computers to a university. The percentage of computers supplied by them and the probability of those being defective are tabulated below

Company	% of Computer Supplied	Probability of being supplied defective
X	60%	0.01
Y	30%	0.02
Z	10%	0.03

Given that a computer is defective, the probability that was supplied by Y is

(A) 0.1 (B) 0.2

(C) 0.3 (D) 0.4

SOL 1.25 Let $d \rightarrow$ defective and $y \rightarrow$ supply by Y

$$p\left(\frac{y}{d}\right) = \frac{P(y \cap d)}{P(d)}$$

$$P(y \cap d) = 0.3 \times 0.02 = 0.006$$

$$P(d) = 0.6 \times 0.1 + 0.3 \times 0.02 + 0.1 \times 0.03 = 0.015$$

$$P\left(\frac{y}{d}\right) = \frac{0.006}{0.015} = 0.4$$

Hence (D) is correct answer.

MCQ 1.26 For the matrix $\begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$ the eigenvalue corresponding to the eigenvector $\begin{bmatrix} 101 \\ 101 \end{bmatrix}$ is

(A) 2 (B) 4

(C) 6 (D) 8

SOL 1.26 Hence (C) is correct option

We have $A = \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$

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

or $\begin{bmatrix} 4-\lambda & 2 \\ 2 & 4-\lambda \end{bmatrix}\begin{bmatrix} 101 \\ 101 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

or $(101)(4-\lambda) + 2(101) = 0$

or $\lambda = 6$

MCQ 1.27 For the differential equation $\frac{d^2y}{dx^2} + k^2 y = 0$ the boundary conditions are

(i) $y = 0$ for $x = 0$ and (ii) $y = 0$ for $x = a$

The form of non-zero solutions of y (where m varies over all integers) are

(A) $y = \sum_m A_m \sin \frac{m\pi x}{a}$ (B) $y = \sum_m A_m \cos \frac{m\pi x}{a}$

(C) $y = \sum_m A_m x^{\frac{m\pi}{a}}$ (D) $y = \sum_m A_m e^{-\frac{m\pi x}{a}}$

SOL 1.27 Hence (A) is correct answer.

We have $$\frac{d^2y}{dx^2} + k^2 y = 0$$

or $$D^2 y + k^2 y = 0$$

The AE is $$m^2 + k^2 = 0$$

The solution of AE is $m = \pm ik$

Thus $y = A\sin kx + B\cos kx$

From $x = 0$, $y = 0$ we get $B = 0$ and $x = a, y = 0$ we get

$$A\sin ka = 0$$

or $$\sin ka = 0$$

$$k = \frac{m\pi x}{a}$$

Thus $$y = \sum_m A_m \sin\left(\frac{m\pi x}{a}\right)$$

MCQ 1.28 Consider the function $f(t)$ having Laplace transform

$$F(s) = \frac{\omega_0}{s^2 + \omega_0^2}\mathrm{Re}[s] > 0$$

The final value of $f(t)$ would be

(A) 0 (B) 1

(C) $-1 \leq f(\infty) \leq 1$ (D) ∞

SOL 1.28 Hence (C) is correct answer.

$$F(s) = \frac{\omega_0}{s^2 + \omega^2}$$

$$L^{-1}F(s) = \sin\omega_o t$$

$$f(t) = \sin\omega_o t$$

Thus the final value is $-1 \leq f(\infty) \leq 1$

MCQ 1.29 As x increased from $-\infty$ to ∞, the function $f(x) = \frac{e^x}{1 + e^x}$

(A) monotonically increases

(B) monotonically decreases

(C) increases to a maximum value and then decreases

(D) decreases to a minimum value and then increases

SOL 1.29 Hence (A) is correct answer.

We have $f(x) = \frac{e^x}{1 + e^x}$

For $x \to \infty$, the value of $f(x)$ monotonically increases.

MCQ 1.30 A two-port network is represented by $ABCD$ parameters given by

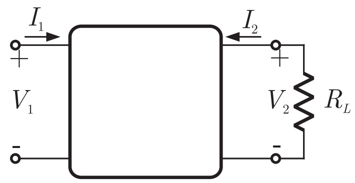
$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}\begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

If port-2 is terminated by R_L, the input impedance seen at port-1 is given by

(A) $\frac{A+BR_L}{C+DR_L}$ (B) $\frac{AR_L+C}{BR_L+D}$

(C) $\frac{DR_L+A}{BR_L+C}$ (D) $\frac{B+AR_L}{D+CR_L}$

SOL 1.30 The network is shown in figure below.



Now $V_1 = AV_2 - BI_2$ ...(1)

and $I_1 = CV_2 - DI_2$ ...(2)

also $V_2 = -I_2R_L$ ...(3)

From (1) and (2) we get

Thus $\frac{V_1}{I_1} = \frac{AV_2 - BI_2}{CV_2 - DI_2}$

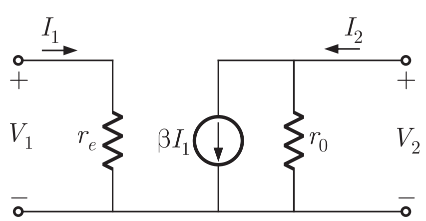
Substituting value of V_2 from (3) we get

Input Impedance $Z_{in} = \frac{-A\times I_2R_L - BI_2}{-C\times I_2R_L - DI_2}$

or $Z_{in} = \frac{AR_L+B}{CR_L+D}$

Hence (D) is correct option.

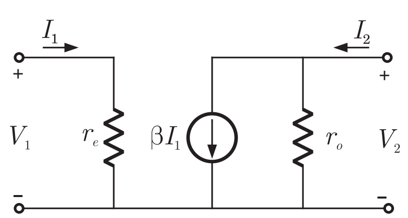
MCQ 1.31 In the two port network shown in the figure below, Z_{12} and Z_{21} and respectively



(A) r_e and βr_0 (B) 0 and $-\beta r_0$

(C) 0 and βr_o (D) r_e and $-\beta r_0$

SOL 1.31 The circuit is as shown below.



At input port $\quad V_1 = r_e I_1$

At output port $\quad V_2 = r_0(I_2 - \beta I_1) = - r_0 \beta I_1 + r_0 I_2$

Comparing standard equation

$$V_1 = z_{11} I_1 + z_{12} I_2$$
$$V_2 = z_{21} I_1 + z_{22} I_2$$
$$z_{12} = 0 \text{ and } z_{21} = - r_0 \beta$$

Hence (B) is correct option.

MCQ 1.32 The first and the last critical frequencies (singularities) of a driving point impedance function of a passive network having two kinds of elements, are a pole and a zero respectively. The above property will be satisfied by

(A) RL network only
(B) RC network only
(C) LC network only
(D) RC as well as RL networks

SOL 1.32 For series RC network input impedance is

$$Z_{ins} = \frac{1}{sC} + R = \frac{1 + sRC}{sC}$$

Thus pole is at origin and zero is at $-\frac{1}{RC}$

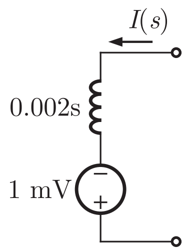
For parallel RC network input impedance is

$$Z_{in} = \frac{\frac{1}{sC} R}{\frac{1}{sC} + R} = \frac{sC}{1 + sRC}$$

Thus pole is at $-\frac{1}{RC}$ and zero is at infinity.

Hence (B) is correct option.

MCQ 1.33 A 2 mH inductor with some initial current can be represented as shown below, where s is the Laplace Transform variable. The value of initial current is



(A) 0.5 A
(B) 2.0 A
(C) 1.0 A
(D) 0.0 A

SOL 1.33 Hence (A) is correct option.

We know $\quad v = \frac{Ldi}{dt}$

Taking laplace transform we get

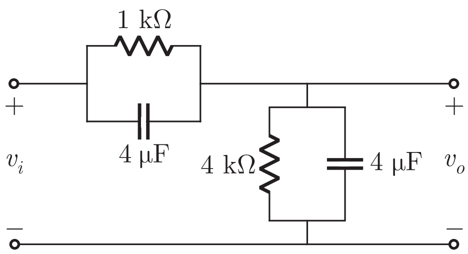
$$V(s) = sLI(s) - Li(0^+)$$

As per given in question

$$-Li(0^+) = -1 \text{ mV}$$

Thus $$i(0^+) = \frac{1\,\text{mV}}{2\,\text{mH}} = 0.5 \text{ A}$$

MCQ 1.34 In the figure shown below, assume that all the capacitors are initially uncharged. If $v_i(t) = 10u(t)$ Volts, $v_o(t)$ is given by



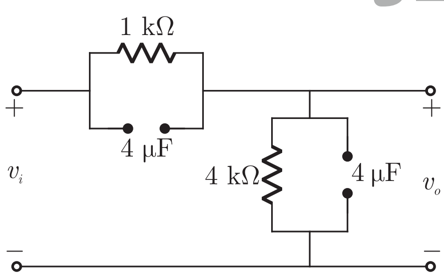
(A) $8e^{-t/0.004}$ Volts (B) $8(1 - e^{-t/0.004})$ Volts

(C) $8u(t)$ Volts (D) 8 Volts

SOL 1.34 At initial all voltage are zero. So output is also zero.

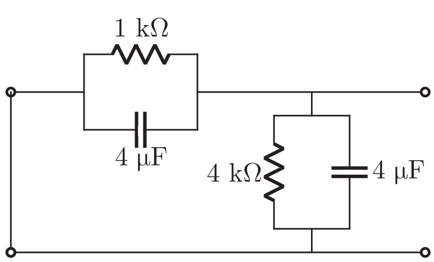
Thus $v_0(0^+) = 0$

At steady state capacitor act as open circuit.



Thus, $$v_0(\infty) = \frac{4}{5} \times v_i = \frac{4}{5} \times 10 = 8$$

The equivalent resistance and capacitance can be calculate after killing all source



$$R_{eq} = 1 \| 4 = 0.8 \text{ k}\Omega$$
$$C_{eq} = 4 \| 1 = 5 \ \mu\text{F}$$
$$\tau = R_{eq} C_{eq} = 0.8\text{k}\Omega \times 5\mu\text{F} = 4 \text{ ms}$$
$$v_0(t) = v_0(\infty) - [v_0(\infty) - v_0(0^+)]\, e^{-t/\tau}$$

$$= 8 - (8 - 0)\, e^{-t/0.004}$$
$$v_0(t) = 8(1 - e^{-t/0.004}) \text{ Volts}$$

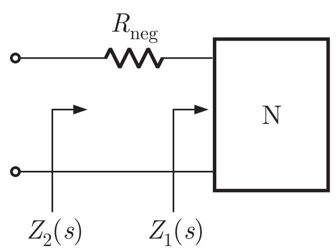
Hence (B) is correct option.

MCQ 1.35 Consider two transfer functions $G_1(s) = \frac{1}{s^2 + as + b}$ and $G_2(s) = \frac{s}{s^2 + as + b}$ The 3-dB bandwidths of their frequency responses are, respectively

(A) $\sqrt{a^2 - 4b}, \sqrt{a^2 + 4b}$
(B) $\sqrt{a^2 + 4b}, \sqrt{a^2 - 4b}$
(C) $\sqrt{a^2 - 4b}, \sqrt{a^2 - 4b}$
(D) $\sqrt{a^2 + 4b}, \sqrt{a^2 + 4b}$

SOL 1.35 Hence (D) is correct option.

MCQ 1.36 A negative resistance R_{neg} is connected to a passive network N having driving point impedance as shown below. For $Z_2(s)$ to be positive real,



(A) $|R_{\text{neg}}| \le \text{Re}\, Z_1(j\omega), \forall \omega$
(B) $|R_{\text{neg}}| \le |Z_1(j\omega)|, \forall \omega$
(C) $|R_{\text{neg}}| \le \text{Im}\, Z_1(j\omega), \forall \omega$
(D) $|R_{\text{neg}}| \le \angle Z_1(j\omega), \forall \omega$

SOL 1.36 Hence (A) is correct option.

Here $\quad Z_2(s) = R_{neg} + Z_1(s)$

or $\quad Z_2(s) = R_{neg} + \text{Re}\, Z_1(s) + j\text{Im}\, Z_1(s)$

For $Z_2(s)$ to be positive real, $\text{Re}\, Z_2(s) \ge 0$

Thus $R_{neg} + \text{Re}\, Z_1(s) \ge 0$

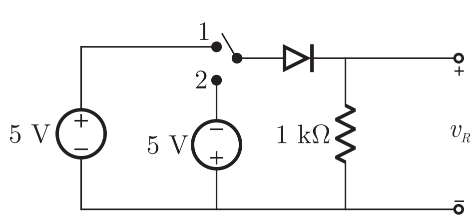
or $\quad \text{Re}\, Z_1(s) \ge - R_{neg}$

But R_{neg} is negative quantity and $-R_{neg}$ is positive quantity. Therefore

$\quad \text{Re}\, Z_1(s) \ge |R_{neg}|$

or $\quad |R_{neg}| \le \text{Re}\, Z_1(j\omega) \quad$ For all ω.

MCQ 1.37 In the circuit shown below, the switch was connected to position 1 at $t < 0$ and at $t = 0$, it is changed to position 2. Assume that the diode has zero voltage drop and a storage time t_s. For $0 < t \le t_s$, v_R is given by (all in Volts)



(A) $v_R = -5$ (B) $v_R = +5$

(C) $0 \leq v_R < 5$ (D) $-5 \leq v_R < 0$

SOL 1.37 For $t < 0$ diode forward biased and $V_R = 5$. At $t = 0$ diode abruptly changes to reverse biased and current across resistor must be 0. But in storage time $0 < t < t_s$ diode retain its resistance of forward biased. Thus for $0 < t < t_s$ it will be ON and

$$V_R = -5 \text{ V}$$

Hence option (A) is correct.

MCQ 1.38 The majority carriers in an n-type semiconductor have an average drift velocity v in a direction perpendicular to a uniform magnetic field B. The electric field E induced due to Hall effect acts in the direction

(A) $v \times B$ (B) $B \times v$

(C) along v (D) opposite to v

SOL 1.38 According to Hall effect the direction of electric field is same as that of direction of force exerted.

$$E = -v \times B$$

or $$E = B \times v$$

Hence option (B) is correct.

MCQ 1.39 Find the correct match between Group 1 and Group 2

Group 1	Group 2
E - Varactor diode	1. Voltage reference
F - PIN diode	2. High frequency switch
G - Zener diode	3. Tuned circuits
H - Schottky diode	4. Current controlled attenuator

(A) E - 4, F - 2, G - 1, H - 3

(B) E - 3, F - 4, G - 1, H - 3

(C) E - 2, F - 4, G - 1, H - 2

(D) E - 1, F - 3, G - 2, H - 4

SOL 1.39 The varacter diode is used in tuned circuit as it can provide frequently stability.
PIN diode is used as a current controlled attenuator.
Zener diode is used in regulated voltage supply or fixed voltage reference.
Schottkey diode has metal-semiconductor function so it has fast switching action so it is used as high frequency switch

Varactor diode : Tuned circuits
PIN Diode : Current controlled attenuator
Zener diode : Voltage reference
Schottky diode : High frequency switch

Hence option (B) is correct.

MCQ 1.40 A heavily doped n- type semiconductor has the following data:

Hole-electron ratio : 0.4
Doping concentration : 4.2×10^{8} atoms/m³
Intrinsic concentration : 1.5×10^{4} atoms/m³

The ratio of conductance of the $n-$type semiconductor to that of the intrinsic semiconductor of same material and ate same temperature is given by

(A) 0.00005 (B) 2000
(C) 10000 (D) 20000

SOL 1.40 Hence option (D) is correct

We have $\dfrac{\mu_P}{\mu_n} = 0.4$

Conductance of n type semiconductor

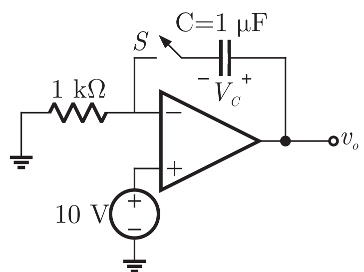
$$\sigma_n = nq\mu_n$$

Conductance of intrinsic semiconductor

$$\sigma_i = n_i q(\mu_n + \mu_p)$$

Ratio is
$$\frac{\sigma_n}{\sigma_i} = \frac{n\mu_n}{n_i(\mu_n+\mu_p)} = \frac{n}{n_i(1+\frac{\mu_p}{\mu_n})}$$
$$= \frac{4.2\times10^{8}}{1.5\times10^{4}(1+0.4)} = 2\times10^{4}$$

MCQ 1.41 For the circuit shown in the following figure, the capacitor C is initially uncharged. At $t=0$ the switch S is closed. The V_c across the capacitor at $t=1$ millisecond is In the figure shown above, the OP-AMP is supplied with $\pm15\,V$.



(A) 0 Volt (B) 6.3 Volt
(C) 9.45 Volts (D) 10 Volts

SOL 1.41 The voltage at inverting terminal is

$$V_- = V_+ = 10\text{ V}$$

Here note that current through the capacitor is constant and that is

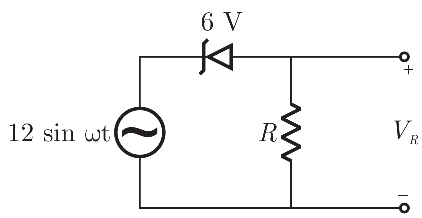
$$I = \frac{V_-}{1\text{k}} = \frac{10}{1\text{k}} = 10\text{ mA}$$

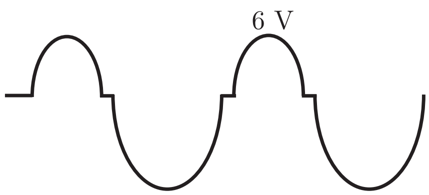
Thus the voltage across capacitor at $t=1$ msec is

$$V_C = \frac{1}{C}\int_0^{1m} Idt = \frac{1}{1\mu}\int_0^{1m} 10mdt = 10^4\int_0^{\text{Im}} dt = 10\text{ V}$$

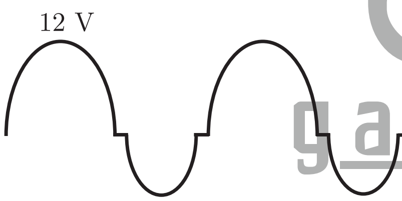
Hence (D) is correct option.

MCQ 1.42 For the circuit shown below, assume that the zener diode is ideal with a breakdown voltage of 6 volts. The waveform observed across R is



(A) 

(B) 

(C) 

(D) 

SOL 1.42 In forward bias Zener diode works as normal diode.
Thus for negative cycle of input Zener diode is forward biased and it conducts giving $V_R = V_{in}$.
For positive cycle of input Zener diode is reversed biased
when $0 < V_{in} < 6$, Diode is OFF and $V_R = 0$
when $V_{in} > 6$ Diode conducts and voltage across diode is 6 V. Thus voltage across is resistor is

$$V_R = V_{in} - 6$$

Only option (B) satisfy this condition.
Hence (A) is correct option.

MCQ 1.43 A new Binary Coded Pentary (BCP) number system is proposed in which every digit of a base-5 number is represented by its corresponding 3-bit binary code. For example, the base-5 number 24 will be represented by its BCP code 010100. In this numbering system, the *BCP* code 10001001101 corresponds of the following number is base-5 system

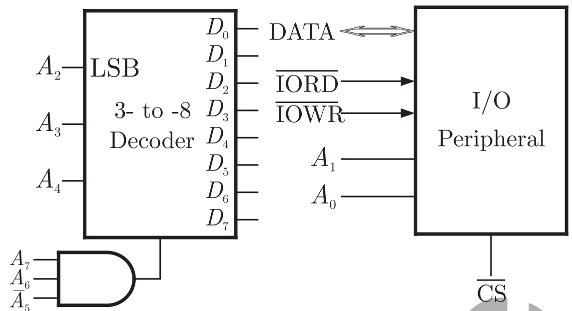
(A) 423 (B) 1324

(C) 2201 (D) 4231

SOL 1.43 Hence (D) is correct answer.

$\underbrace{100}_{4}\underbrace{010}_{2}\underbrace{011}_{3}\underbrace{001}_{1}$

MCQ 1.44 An I/O peripheral device shown in Fig. (b) below is to be interfaced to an 8085 microprocessor. To select the I/O device in the I/O address range D4 H - D7 H, its chip-select ($\overline{CS}$) should be connected to the output of the decoder shown in as below :

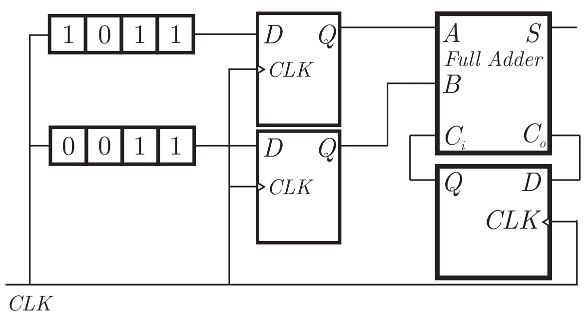


(A) output 7 (B) output 5

(C) output 2 (D) output 0

SOL 1.44 The output is taken from the 5th line.
Hence (B) is correct answer.

MCQ 1.45 For the circuit shown in figures below, two 4 - bit parallel - in serial - out shift registers loaded with the data shown are used to feed the data to a full adder. Initially, all the flip - flops are in clear state. After applying two clock pulse, the output of the full-adder should be



(A) $S = 0,\ C_0 = 0$ (B) $S = 0,\ C_0 = 1$

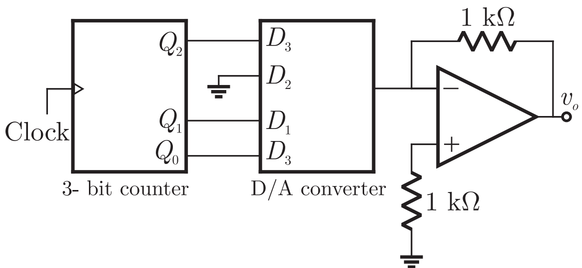
(C) $S = 1,\ C_0 = 0$ (D) $S = 1,\ C_0 = 1$

SOL 1.45 After applying two clock poles, the outputs of the full adder is $S = 1$, $C_0 = 1$

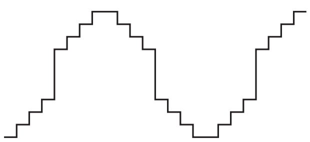
	A	B	C_i	S	C_o
1st	1	0	0	0	1
2nd	1	1	1	1	1

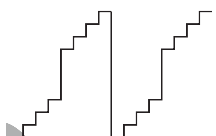
Hence (D) is correct answer.

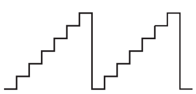
MCQ 1.46 A 4 - bit D/A converter is connected to a free - running 3 - big UP counter, as shown in the following figure. Which of the following waveforms will be observed at V_0 ?

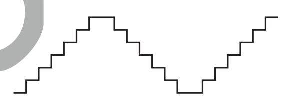


In the figure shown above, the ground has been shown by the symbol ∇

(A) 

(B) 

(C) 

(D) 

SOL 1.46 In this the diode D_2 is connected to the ground. The following table shows the state of counter and D/A converter

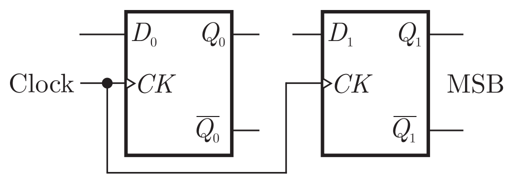
$Q_2\,Q_1\,Q0$	$D_3=Q_2$	$D_2=0$	$D_1=Q_1$	$D_0=Q_0$	V_o
000	0	0	0	0	0
001	0	0	0	1	1
010	0	0	1	0	2
011	0	0	1	1	3
100	1	0	0	0	8
101	1	0	0	1	9
110	1	0	1	0	10
111	1	0	1	1	11
000	0	0	0	0	0
001	0	0	0	1	1

Thus option (B) is correct

MCQ 1.47 Two D - flip - flops, as shown below, are to be connected as a synchronous counter that goes through the following sequence

$00 \rightarrow 01 \rightarrow 11 \rightarrow 10 \rightarrow 00 \rightarrow \dots$

The inputs D_0 and D_1 respectively should be connected as,



(A) $\overline{Q}_1$ and Q_0 (B) $\overline{Q}_0$ and Q_1

(C) $\overline{Q}_1 Q_0$ and $\overline{Q}_1 Q_0$ (D) $\overline{Q}_1 \overline{Q}_0$ and $Q_1 Q_0$

SOL 1.47 The inputs D_0 and D_1 respectively should be connected as $\overline{Q}_1$ and Q_0 where $Q_0 \rightarrow D_1$ and $\overline{Q}_1 \rightarrow D_0$

Hence (A) is correct answer.

MCQ 1.48 Following is the segment of a 8085 assembly language program

```
        LXI SP, EFFF H
        CALL 3000 H
        :
        :
        :
3000 H LXI H, 3CF4
        PUSH PSW
        SPHL
        POP PSW
        RET
```

On completion of RET execution, the contents of SP is

(A) 3CF0 H (B) 3CF8 H

(C) EFFD H (D) EFFF H

SOL 1.48

```
LXI, EFFF H            ; Load SP with data EFFH
        CALL 3000 H    ; Jump to location 3000 H
        :
        :
        :
3000H LXI H, 3CF4      ; Load HL with data 3CF4H
        PUSH PSW       ; Store contnets of PSW to Stack
        POP PSW        ; Restore contents of PSW from stack
        PRE            ; stop
```

Before instruction SPHL the contents of SP is 3CF4H.

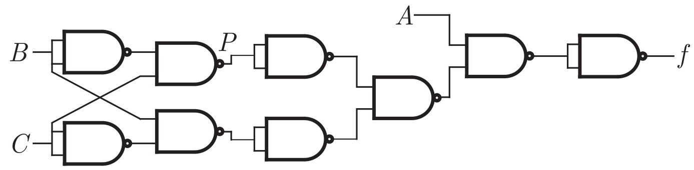
After execution of POP PSW, SP + 2 → SP

After execution of RET, SP + 2 → SP

Thus the contents of SP will be 3CF4H + 4 = 3CF8H

Hence (B) is correct answer.

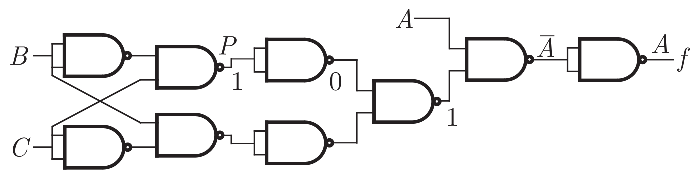
MCQ 1.49 The point P in the following figure is stuck at 1. The output f will be



(A) $AB\overline{C}$ (B) $\overline{A}$

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

SOL 1.49 If the point P is stuck at 1, then output f is equal to A



Hence (D) is correct answer.

MCQ 1.50 A signal $m(t)$ with bandwidth 500 Hz is first multiplied by a signal $g(t)$ where

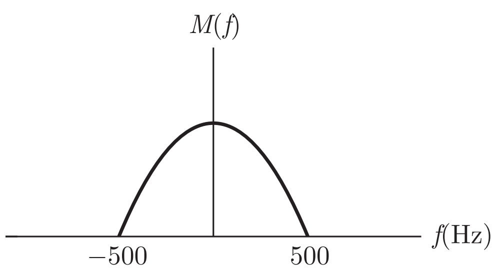
$$g(t) = \sum_{R=-\infty}^{\infty}(-1)^k\delta(t-0.5\times10^{-4}k)$$

The resulting signal is then passed through an ideal lowpass filter with bandwidth 1 kHz. The output of the lowpass filter would be

(A) $\delta(t)$ (B) $m(t)$

(C) 0 (D) $m(t)\delta(t)$

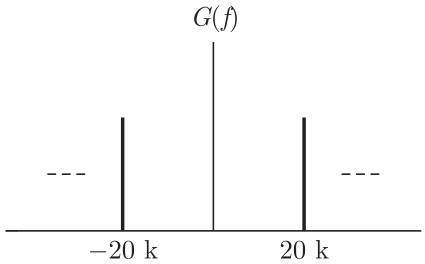
SOL 1.50 Let $m(t)$ is a low pass signal, whose frequency spectra is shown below



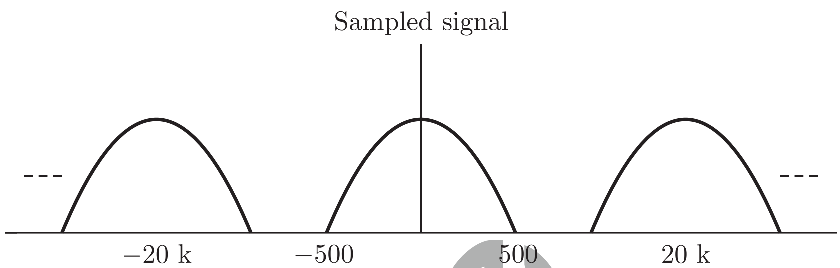
Fourier transform of $g(t)$

$$G(t) = \frac{1}{0.5\times10^{-4}}\sum_{k=-\infty}^{\infty}\delta(f-20\times10^3k)$$

Spectrum of $G(f)$ is shown below



Now when $m(t)$ is sampled with above signal the spectrum of sampled signal will look like.



When sampled signal is passed through a LP filter of BW 1 kHz, only $m(t)$ will remain.
Hence (B) is correct option.

MCQ 1.51 The minimum sampling frequency (in samples/sec) required to reconstruct the following signal from its samples without distortion

$$x(t)=5\left(\frac{\sin 2\pi 100t}{\pi t}\right)^3+7\left(\frac{\sin 2\pi 100t}{\pi t}\right)^2 \text{ would be}$$

(A) 2×10^3 (B) 4×10^3

(C) 6×10^3 (D) 8×10^3

SOL 1.51 The highest frequency signal in $x(t)$ is $1000\times3=3$ kHz if expression is expanded. Thus minimum frequency requirement is

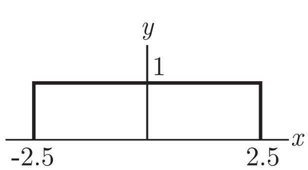
$$f=2\times3\times10^3=6\times10^3 \text{ Hz}$$

Hence (C) is correct option.

MCQ 1.52 A uniformly distributed random variable X with probability density function

$$f_x(x)=\frac{1}{10}pu(x+5)-u(x-5)]$$

where $u(.)$ is the unit step function is passed through a transformation given in the figure below. The probability density function of the transformed random variable Y would be



(A) $f_y(y) = \frac{1}{5}[u(y+2.5) - u(y-2.25)]$

(B) $f_y(y) = 0.5\delta(y) + 0.5\delta(y-1)$

(C) $f_y(y) = 0.25\delta(y+2.5) + 0.25\delta(y-2.5) + 5\delta(y)$

(D) $f_y(y) = 0.25\delta(y+2.5) + 0.25\delta(y-2.5) + \frac{1}{10}[u(y+2.5) - u(y-2.5)]$

SOL 1.52 Hence (B) is correct option.

MCQ 1.53 A system with input $x[n]$ and output $y[n]$ is given as $y[n] = (\sin\frac{5}{6}\pi n)\,x[n]$. The system is

(A) linear, stable and invertible

(B) non-linear, stable and non-invertible

(C) linear, stable and non-invertible

(D) linear, unstable and invertible

SOL 1.53 Hence (C) is correct answer.

$$y(n) = \left(\sin\frac{5}{6}\pi n\right)x(n)$$

Let $x(n) = \delta(n)$

Now $y(n) = \sin 0 = 0$ (bounded) BIBO stable

MCQ 1.54 The unit step response of a system starting from rest is given by $c(t) = 1 - e^{-2t}$ for $t \geq 0$. The transfer function of the system is

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

(B) $\frac{2}{2+s}$

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

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

SOL 1.54 Hence (B) is correct answer.

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

Taking laplace transform

$$C(s) = \frac{C(s)}{U(s)} = \frac{2}{s(s+2)} \times s = \frac{2}{s+2}$$

MCQ 1.55 The Nyquist plot of $G(j\omega)H(j\omega)$for a closed loop control system, passes through $(-1, j0)$ point in the GH plane. The gain margin of the system in dB is equal to

(A) infinite

(B) greater than zero

(C) less than zero

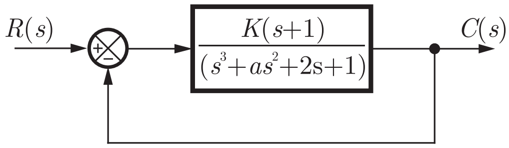
(D) zero

SOL 1.55 If the Nyquist polt of $G(j\omega)H(j\omega)$ for a closed loop system pass through $(-1, j0)$ point, the gain margin is 1 and in dB

$$GM = -20\log 1$$
$$= 0 \text{ dB}$$

Hence (D) is correct option.

MCQ 1.56 The positive values of K and a so that the system shown in the figures below oscillates at a frequency of 2 rad/sec respectively are



(A) 1, 0.75 (B) 2, 0.75

(C) 1, 1 (D) 2, 2

SOL 1.56 The characteristics equation is

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

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

$$s^3 + as^2 + (2+K)s + K + 1 = 0$$

The Routh Table is shown below. For system to be oscillatory stable

$$\frac{a(2+K) - (K+1)}{a} = 0$$

or $$a = \frac{K+1}{K+2} \quad \text{...(1)}$$

Then we have

$$as^2 + K + 1 = 0$$

At 2 rad/sec we have

$$s = j\omega \rightarrow s^2 = -\omega^2 = -4,$$

Thus $$-4a + K + 1 = 0 \quad \text{...(2)}$$

Solving (i) and (ii) we get $K = 2$ and $a = 0.75$.

s^3	1	$2+K$
s^2	a	$1+K$
s^1	$\frac{(1+K)a-(1+K)}{a}$	
s^0	$1+K$	

Hence (B) is correct option.

MCQ 1.57 The unit impulse response of a system is $f(t) = e^{-t}, t \geq 0$. For this system the steady-state value of the output for unit step input is equal to

(A) -1 (B) 0

(C) 1 (D) ∞

SOL 1.57 Hence (C) is correct answer.

$$h(t) = e^{-t} \xrightarrow{L} H(s) = \frac{1}{s+1}$$

$$x(t) = u(t) \xrightarrow{L} X(s) = \frac{1}{s}$$

$$Y(s) = H(s)X(s) = \frac{1}{s+1} \times \frac{1}{s} = \frac{1}{s} - \frac{1}{s+1}$$

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

In steady state i.e. $t \to \infty$, $y(\infty) = 1$

MCQ 1.58 The transfer function of a phase lead compensator is given by $G_c(s) = \frac{1+3Ts}{1+Ts}$ where $T > 0$ The maximum phase shift provide by such a compensator is

(A) $\frac{\pi}{2}$ (B) $\frac{\pi}{3}$

(C) $\frac{\pi}{4}$ (D) $\frac{\pi}{6}$

SOL 1.58 The transfer function of given compensator is

$$G_c(s) = \frac{1+3Ts}{1+Ts} \qquad T > 0$$

Comparing with

$$G_c(s) = \frac{1+aTs}{1+Ts} \text{ we get } a = 3$$

The maximum phase sift is

$$\phi_{\max} = \tan^{-1}\frac{a-1}{2\sqrt{a}}$$

$$= \tan^{-1}\frac{3-1}{2\sqrt{3}} = \tan^{-1}\frac{1}{\sqrt{3}}$$

or $\phi_{\max} = \frac{\pi}{6}$

Hence (D) is correct option.

MCQ 1.59 A linear system is described by the following state equation

$$\dot{X}(t) = AX(t) + BU(t), A = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$$

The state transition matrix of the system is

(A) $\begin{bmatrix} \cos t & \sin t \\ -\sin t & \cos t \end{bmatrix}$ (B) $\begin{bmatrix} -\cos t & \sin t \\ -\sin t & -\cos t \end{bmatrix}$

(C) $\begin{bmatrix} -\cos t & -\sin t \\ -\sin t & \cos t \end{bmatrix}$ (D) $\begin{bmatrix} \cos t & -\sin t \\ \cos t & \sin t \end{bmatrix}$

SOL 1.59 Hence (A) is correct option.

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

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

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

MCQ 1.60 The minimum step-size required for a Delta-Modulator operating at 32k samples/sec to track the signal (here $u(t)$ is the unit-step function)

$$x(t) = 125[u(t) - u(t-1) + (250t)[u(t-1) - u(t-2)]$$

so that slope-overload is avoided, would be

(A) 2^{-10} (B) 2^{-8}

(C) 2^{-6} (D) 2^{-4}

SOL 1.60 We have

$$x(t) = 125t[u(t) - u(t-1)] + (250 - 125t)[u(t-1) - u(t-2)]$$

The slope of expression $x(t)$ is 125 and sampling frequency f_s is 32×1000 samples/sec.

Let $\triangle$ be the step size, then to avoid slope overload

$$\frac{\triangle}{T_s} \geq \text{slope } x(t)$$

$$\triangle f_c \geq \text{slope } x(t)$$

$$\triangle \times 32000 \geq 125$$

$$\triangle \geq \frac{125}{32000}$$

$$\triangle = 2^{-8}$$

Hence (B) is correct option.

MCQ 1.61 A zero-mean white Gaussian noise is passes through an ideal lowpass filter of bandwidth 10 kHz. The output is then uniformly sampled with sampling period $t_s = 0.03$ msec. The samples so obtained would be

(A) correlated (B) statistically independent

(C) uncorrelated (D) orthogonal

SOL 1.61 The sampling frequency is

$$f_s = \frac{1}{0.03\text{m}} = 33 \text{ kHz}$$

Since $f_s \geq 2f_m$, the signal can be recovered and are correlated.

Hence (A) is correct option.

MCQ 1.62 A source generates three symbols with probabilities 0.25, 0.25, 0.50 at a rate of 3000 symbols per second. Assuming independent generation of symbols, the most efficient source encoder would have average bit rate is

(A) 6000 bits/sec (B) 4500 bits/sec

(C) 3000 bits/sec (D) 1500 bits/sec

SOL 1.62 Hence (B) is correct option.

We have $p_1 = 0.25$, $p_2 = 0.25$ and $p_3 = 0.5$

$$H = \sum_{i=1}^{3} p_1 \log_2 \frac{1}{p_1} \text{ bits/symbol}$$

$$= p_1 \log_2 \frac{1}{p_1} + p_2 \log_2 \frac{1}{p_2} + p_3 \log_2 \frac{1}{p_3}$$
$$= 0.25 \log_2 \frac{1}{0.25} + 0.25 \log_2 \frac{1}{0.25} + 0.5 \log_2 \frac{1}{0.5}$$
$$= 0.25 \log_2 4 + 0.25 \log_2 4 + 0.5 \log_2 2$$
$$= 0.5 + 0.5 + \frac{1}{2} = \frac{3}{2} \text{ bits/symbol}$$

$$R_b = 3000 \text{ symbol/sec}$$

Average bit rate $= R_b H$

$$= \frac{3}{2} \times 3000 = 4500 \text{ bits/sec}$$

MCQ 1.63 The diagonal clipping in Amplitude Demodulation (using envelop detector) can be avoided it RC time-constant of the envelope detector satisfies the following condition, (here W is message bandwidth and ω is carrier frequency both in rad/sec)

(A) $RC < \frac{1}{W}$

(B) $RC > \frac{1}{W}$

(C) $RC < \frac{1}{\omega}$

(D) $RC > \frac{1}{\omega}$

SOL 1.63 The diagonal clipping in AM using envelop detector can be avoided if

$$\frac{1}{\omega_c} << RC < \frac{1}{W}$$

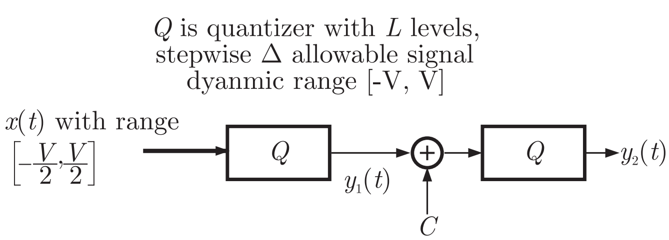
But from $\frac{1}{RC} \geq \frac{W\mu \sin Wt}{1 + \mu \cos Wt}$

We can say that RC depends on W, thus

$$RC < \frac{1}{W}$$

Hence (A) is correct option.

MCQ 1.64 In the following figure the minimum value of the constant "C", which is to be added to $y_1(t)$ such that $y_1(t)$ and $y_2(t)$ are different , is



(A) Δ

(B) $\frac{\Delta}{2}$

(C) $\frac{\Delta^2}{12}$

(D) $\frac{\Delta}{L}$

SOL 1.64 When $\triangle/2$ is added to $y(t)$ then signal will move to next quantization level. Otherwise if they have step size less than $\frac{\triangle}{2}$ then they will be on the same quantization level.
Hence (B) is correct option.

MCQ 1.65 A message signal with bandwidth 10 kHz is Lower-Side Band SSB modulated with carrier frequency $f_{c1} = 10^6$ Hz. The resulting signal is then passed through a Narrow-Band Frequency Modulator with carrier frequency $f_{c2} = 10^9$ Hz.
The bandwidth of the output would be

(A) 4×10^4 Hz (B) 2×10^6 Hz

(C) 2×10^9 Hz (D) 2×10^{10} Hz

SOL 1.65 After the SSB modulation the frequency of signal will be $f_c - f_m$ i.e.
$1000 - 10$ kHz≈ 1000 kHz
The bandwidth of FM is

$$BW = 2(\beta + 1)\triangle f$$

For $NBFM \beta << 1$, thus

$$BW_{NBFM} \approx 2\triangle f = 2(10^9 - 10^6) \approx 2 \times 10^9$$

Hence (C) is correct option.

MCQ 1.66 A medium of relative permittivity $\varepsilon_{r2} = 2$ forms an interface with free - space. A point source of electromagnetic energy is located in the medium at a depth of 1 meter from the interface. Due to the total internal reflection, the transmitted beam has a circular cross-section over the interface. The area of the beam cross-section at the interface is given by

(A) 2π m² (B) π^2 m²

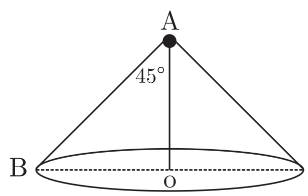
(C) $\frac{\pi}{2}$ m² (D) π m²

SOL 1.66 Hence (D) is correct option

$$\sin\theta = \frac{1}{\sqrt{\varepsilon_r}} = \frac{1}{\sqrt{2}}$$

or $$\theta = 45^\circ = \frac{\pi}{4}$$

The configuration is shown below. Here A is point source.



Now $AO = 1$ m

From geometry $BO = 1$ m

Thus area $= \pi r^2 = \pi \times OB = \pi$ m²

MCQ 1.67 A medium is divide into regions I and II about $x = 0$ plane, as shown in the figure below.

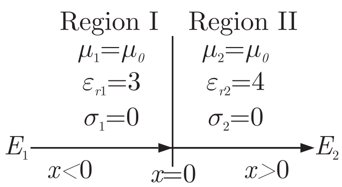


Fig Q.67

An electromagnetic wave with electric field $E_1 = 4\hat{a}_x + 3\hat{a}_y + 5\hat{a}_z$ is incident normally on the interface from region I. The electric file E_2 in region II at the interface is

(A) $E_2 = E_1$

(B) $4\hat{a}_x + 0.75\hat{a}_y - 1.25\hat{a}_z$

(C) $3\hat{a}_x + 3\hat{a}_y + 5\hat{a}_z$

(D) $-3\hat{a}_x + 3\hat{a}_y + 5\hat{a}_z$

SOL 1.67 Hence (C) is correct option.

We have $E_1 = 4u_x + 3u_y + 5u_z$

Since for dielectric material at the boundary, tangential component of electric field are equal

$$E_{21} = E_{1t} = 3\hat{a}_y + 5\hat{a}_z$$

at the boundary, normal component of displacement vector are equal

i.e. $D_{n2} = D_{n1}$

or $\varepsilon_2 E_{2n} = \varepsilon_1 E_{1n}$

or $4\varepsilon_o E_{2n} = 3\varepsilon_o 4\hat{a}_z$

or $E_{2n} = 3\hat{a}_x$

Thus $E_2 = E_{2t} + E_{2a} = 3\hat{a}_x + 3\hat{a}_y + 5\hat{a}_z$

MCQ 1.68 When a planes wave traveling in free-space is incident normally on a medium having the fraction of power transmitted into the medium is given by

(A) $\frac{8}{9}$

(B) $\frac{1}{2}$

(C) $\frac{1}{3}$

(D) $\frac{5}{6}$

SOL 1.68 Hence (A) is correct option

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{\sqrt{\frac{\mu_o}{\varepsilon_o \varepsilon_r}} - \sqrt{\frac{\mu_o}{\varepsilon_o}}}{\sqrt{\frac{\mu_o}{\varepsilon_o \varepsilon_r}} + \sqrt{\frac{\mu_o}{\varepsilon_o}}} = \frac{1 + \sqrt{\varepsilon_r}}{1 + \sqrt{\varepsilon_r}} = \frac{1 - \sqrt{4}}{1 + \sqrt{4}} = -\frac{1}{3}$$

The transmitted power is

$$P_t = (1 - \Gamma^2) P_i = 1 - \frac{1}{9} = \frac{8}{9}$$

or $$\frac{P_t}{P_i} = \frac{8}{9}$$

MCQ 1.69 A rectangular wave guide having TE_{10} mode as dominant mode is having a cut off frequency 18 GHz for the mode TE_{30}. The inner broad - wall dimension of the rectangular wave guide is

(A) $\frac{5}{3}$ cm (B) 5 cm

(C) $\frac{5}{2}$ cm (D) 10 cm

SOL 1.69 The cut-off frequency is

$$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{m}{b}\right)^2}$$

Since the mode is TE_{30}, $m = 3$ and $n = 0$

$$f_c = \frac{c}{2}\frac{m}{a}$$

or $$18 \times 10^9 = \frac{3 \times 10^8}{2}\frac{3}{a}$$

or $$a = \frac{1}{40}\text{ m} = \frac{5}{2}\text{ cm}$$

Hence (C) is correct option.

MCQ 1.70 A mast antenna consisting of a 50 meter long vertical conductor operates over a perfectly conducting ground plane. It is base-fed at a frequency of 600 kHz. The radiation resistance of the antenna is Ohms is

(A) $\frac{2\pi^2}{5}$ (B) $\frac{\pi^2}{5}$

(C) $\frac{4\pi^2}{5}$ (D) $20\pi^2$

SOL 1.70 Since antenna is installed at conducting ground,

$$R_{rad} = 80\pi^2\left(\frac{dl}{\lambda}\right)^2 = 80\pi^2\left(\frac{50}{0.5 \times 10^3}\right)^2 = \frac{4\pi^2}{5}\Omega$$

Hence (C) is correct option.

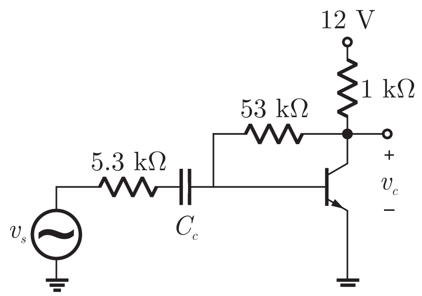
Common Data for Questions 71, 72 and 73 :

In the transistor amplifier circuit shown in the figure below, the transistor has the following parameters:

$$\beta_{DC} = 60,\ V_{BE} = 0.7\,V, h_{ie} \to \infty$$

The capacitance C_C can be assumed to be infinite.

In the figure above, the ground has been shown by the symbol ∇

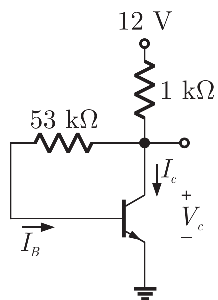


MCQ 1.71 Under the DC conditions, the collector-or-emitter voltage drop is

(A) 4.8 Volts (B) 5.3 Volts

(C) 6.0 Volts (D) 6.6 Volts

SOL 1.71 The circuit under DC condition is shown in fig below



Applying KVL we have

$$V_{CC} - R_C(I_C + I_B) - V_{CE} = 0 \quad ...(1)$$

and $$V_{CC} - R_B I_B - V_{BE} = 0 \quad ...(2)$$

Substituting $I_C = \beta I_B$ in (1) we have

$$V_{CC} - R_C(\beta I_B + I_B) - V_{CE} = 0 \quad ...(3)$$

Solving (2) and (3) we get

$$V_{CE} = V_{CC} - \frac{V_{CC} - V_{BE}}{1 + \frac{R_B}{R_C(1+\beta)}} \quad ...(4)$$

Now substituting values we get

$$V_{CE} = 12 - \frac{12 - 0.7}{1 + \frac{53}{1 + (1 + 60)}} = 5.95 \text{ V}$$

Hence (C) is correct option.

MCQ 1.72 If β_{DC} is increased by 10%, the collector-to-emitter voltage drop

(A) increases by less than or equal to 10%

(B) decreases by less than or equal to 10%

(C) increase by more than 10%

(D) decreases by more than 10%

SOL 1.72 Hence (B) is correct option.

We have $\beta' = \frac{110}{100} \times 60 = 66$

Substituting $\beta' = 66$ with other values in (iv) in previous solutions

$$V_{CE} = 12 - \frac{12 - 0.7}{1 + \frac{53}{1 + (1 + 66)}} = 5.29 \text{ V}$$

Thus change is $= \frac{5.29 - 59.5}{5.95} \times 100 = - 4.3\%$

MCQ 1.73 The small-signal gain of the amplifier $\frac{v_c}{v_s}$ is

(A) -10
(B) -5.3
(C) 5.3
(D) 10

SOL 1.73 Hence (A) is correct option.

Common Data for Questions 74, 75 :

Let $g(t) = p(t)*(pt)$, where * denotes convolution & $p(t) = u(t) - u(t-1) \lim_{z \to \infty}$ with $u(t)$ being the unit step function

MCQ 1.74 The impulse response of filter matched to the signal $s(t) = g(t) - \delta(1 - 2)* \, g(t)$ is given as :

(A) $s(1 - t)$
(B) $-s(1 - t)$
(C) $-s(t)$
(D) $s(t)$

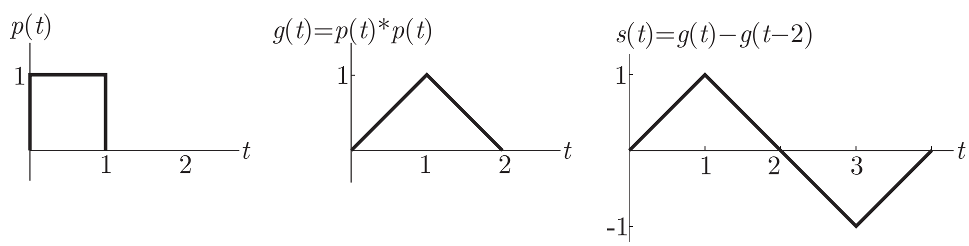
SOL 1.74 Hence (A) is correct option.

We have $p(t) = u(t) - u(t-1)$

$g(t) = p(t)* \, p(t)$

$s(t) = g(t) - \delta(t-2)* \, g(t) = g(t) - g(t-2)$

All signal are shown in figure below :



The impulse response of matched filter is

$$h(t) = s(T - t) = s(1 - t)$$

Here T is the time where output SNR is maximum.

MCQ 1.75 An Amplitude Modulated signal is given as

$x_{AM}(t) = 100[p(t) + 0.5g(t)]\cos\omega_c t$

in the interval $0 \le t \le 1$. One set of possible values of modulating signal and modulation index would be

(A) $t, 0.5$ (B) $t, 1.0$
(C) $t, 2.0$ (D) $t^2, 0.5$

SOL 1.75 Hence (A) is correct option.

We have $x_{AM}(t) = 10[P(t) + 0.5g(t)]\cos\omega_c t$

where $p(t) = u(t) - u(t-1)$

and $g(t) = r(t) - 2r(t-1) + r(t-2)$

For desired interval $0 \le t \le 1$, $p(t) = 1$ and $g(t) = t$, Thus we have,

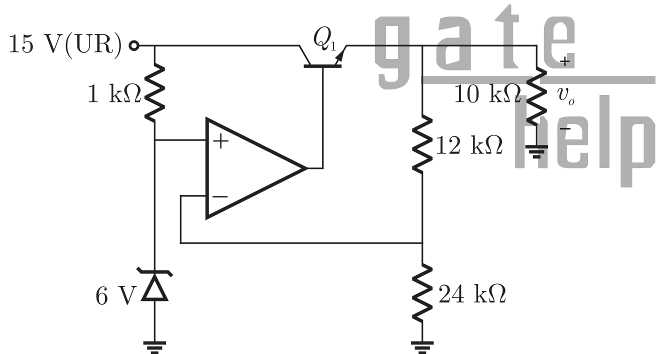
$$x_{AM}(t) = 100(1 - 0.5t)\cos\omega_c t$$

Hence modulation index is 0.5

Linked Answer Question : Q.76 to Q.85. Carry two marks each.

Statement for Linked Answer Questions 76 & 77:

A regulated power supply, shown in figure below, has an unregulated input (UR) of 15 Volts and generates a regulated output V_{out}. Use the component values shown in the figure.



In the figure above, the ground has been shown by the symbol ∇

MCQ 1.76 The power dissipation across the transistor Q1 shown in the figure is

(A) 4.8 Watts (B) 5.0 Watts
(C) 5.4 Watts (D) 6.0 Watts

SOL 1.76 The Zener diode is in breakdown region, thus

$$V_+ = V_Z = 6 \text{ V} = V_{in}$$

We know that $V_o = V_{in}\left(1 + \frac{R_f}{R_1}\right)$

or $V_{out} = V_o = 6\left(1 + \frac{12k}{24k}\right) = 9 \text{ V}$

The current in 12 kΩ branch is negligible as comparison to 10 Ω. Thus Current

$$I_C \approx I_E \approx = \frac{V_{out}}{R_L} = \frac{9}{10} = 0.9 \text{ A}$$

Now $V_{CE} = 15 - 9 = 6$ V

The power dissipated in transistor is

$$P = V_{CE} I_C = 6 \times 0.9 = 5.4 \text{ W}$$

Hence (C) is correct option.

MCQ 1.77 If the unregulated voltage increases by 20%, the power dissipation across the transistor Q1

(A) increases by 20%
(B) increases by 50%
(C) remains unchanged
(D) decreases by 20%

SOL 1.77 If the unregulated voltage increase by 20%, them the unregulated voltage is 18 V, but the $V_Z = V_{in} = 6$ remain same and hence V_{out} and I_C remain same. There will be change in V_{CE}

Thus, $V_{CE} - 18 - 9 = 9$ V

$I_C = 0.9$ A

Power dissipation $P = V_{CE} I_C = 9 \times 0.9 = 8.1$ W

Thus % increase in power is

$$\frac{8.1 - 5.4}{5.4} \times 100 = 50\%$$

Hence (B) is correct option.

Common Data for Question 78 and 79 :

The following two question refer to wide sense stationary stochastic process

MCQ 1.78 It is desired to generate a stochastic process (as voltage process) with power spectral density $S(\omega) = 16/(16 + \omega^2)$ by driving a Linear-Time-Invariant system by zero mean white noise (As voltage process) with power spectral density being constant equal to 1. The system which can perform the desired task could be

(A) first order lowpass R-L filter

(B) first order highpass R-C filter

(C) tuned L-C filter

(D) series R-L-C filter

SOL 1.78 Hence (A) is correct option.

We know that $S_{YY}(\omega) = |H(\omega)|^2 . S_{XX}(\omega)$

Now $S_{YY}(\omega) = \dfrac{16}{16 + \omega^2}$ and $S_{XX}(\omega) = 1$ white noise

Thus $\dfrac{16}{16 + \omega^2} = |H(\omega)|^2$

or $|H(\omega)| = \dfrac{4}{\sqrt{16 + \omega^2}}$

or $H(s) = \dfrac{4}{4 + s}$

which is a first order low pass RL filter.

MCQ 1.79 The parameters of the system obtained in previous Q would be

(A) first order R-L lowpass filter would have $R = 4\Omega$ $L = 1H$

(B) first order R-C highpass filter would have $R = 4\Omega$ $C = 0.25F$

(C) tuned L-C filter would have $L = 4H$ $C = 4F$

(D) series R-L-C lowpass filter would have $R = 1\Omega$, $L = 4H$, $C = 4F$

SOL 1.79 Hence (A) is correct option.

We have $$\frac{R}{R + sL} = \frac{4}{4 + s}$$

or $$\frac{\frac{R}{L}}{\frac{R}{L} + s} = \frac{4}{4 + s}$$

Comparing we get $L = 1$ H and $R = 4\Omega$

Common Data for Question 80 and 81 :

Consider the following Amplitude Modulated (AM) signal, where $f_m < B$

$X_{AM}(t) = 10(1 + 0.5\sin 2\pi f_m t)\cos 2\pi f_c t$

MCQ 1.80 The average side-band power for the AM signal given above is

(A) 25 (B) 12.5

(C) 6.25 (D) 3.125

SOL 1.80 Hence (C) is correct option.

We have $$x_{AM}(t) = 10(1 + 0.5\sin 2\pi f_m t)\cos 2\pi f_c t$$

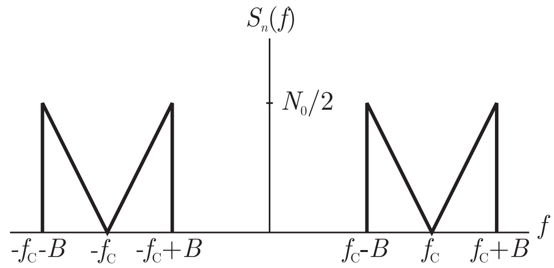
The modulation index is 0.5

Carrier power $$P_c = \frac{(10)^2}{2} = 50$$

Side band power $$P_s = \frac{(10)^2}{2} = 50$$

Side band power $$P_s = \frac{m^2 P_c}{2} = \frac{(0.5)^2(50)}{2} = 6.25$$

MCQ 1.81 The AM signal gets added to a noise with Power Spectral Density $S_n(f)$ given in the figure below. The ratio of average sideband power to mean noise power would be :



(A) $\frac{25}{8N_0B}$ (B) $\frac{25}{4N_0B}$

(C) $\frac{25}{2N_0B}$ (D) $\frac{25}{N_0B}$

SOL 1.81 Hence (B) is correct option.

Mean noise power = Area under the PSD curve

$$= 4\left[\frac{1}{2}\times B\times\frac{N_o}{2}\right] = BN_o$$

The ratio of average sideband power to mean noise power is

$$\frac{\text{Side Band Power}}{\text{Noise Power}} = \frac{6.25}{N_0B} = \frac{25}{4N_oB}$$

Statement for Linked Answer Questions 82 and 83 :

Consider a unity - gain feedback control system whose open - loop transfer function is : $G(s) = \frac{as+1}{s^2}$

MCQ 1.82 The value of a so that the system has a phase - margin equal to $\frac{\pi}{4}$ is approximately equal to

(A) 2.40 (B) 1.40

(C) 0.84 (D) 0.74

SOL 1.82 Hence (C) is correct option.

We have $G(s) = \frac{as+1}{s^2}$

$$\angle G(j\omega) = \tan^{-1}(\omega a) - \pi$$

Since PM is $\frac{\pi}{4}$ i.e. 45°, thus

$$\frac{\pi}{4} = \pi + \angle G(j\omega_g)\,\omega_g \rightarrow \text{Gain cross over Frequency}$$

or $\frac{\pi}{4} = \pi + \tan^{-1}(\omega_g a) - \pi$

or $\frac{\pi}{4} = \tan^{-1}(\omega_g a)$

or $a\omega_g = 1$

At gain crossover frequency $|G(j\omega_g)| = 1$

Thus $\frac{\sqrt{1+a^2\omega_g^2}}{\omega_g^2} = 1$

or $\sqrt{1+1} = \omega_g^2$ (as $a\omega_g = 1$)

or $\omega_g = (2)^{\frac{1}{4}}$

MCQ 1.83 With the value of a set for a phase - margin of $\frac{\pi}{4}$, the value of unit - impulse response of the open - loop system at $t = 1$ second is equal to

(A) 3.40 (B) 2.40

(C) 1.84 (D) 1.74

SOL 1.83 For $a = 0.84$ we have

$$G(s) = \frac{0.84s + 1}{s^2}$$

Due to ufb system $H(s) = 1$ and due to unit impulse response $R(s) = 1$, thus

$$C(s) = G(s)\,R(s) = G(s)$$

$$= \frac{0.84s + 1}{s^2} = \frac{1}{s^2} + \frac{0.84}{s}$$

Taking inverse laplace transform

$$c(t) = (t + 0.84)\,u(t)$$

At $t = 1$, $\quad c(1\,\text{sec}) = 1 + 0.84 = 1.84$

Hence (C) is correct option.

Statement for Linked Answer Questions 84 and 85

A 30 Volts battery with zero source resistance is connected to a coaxial line of characteristic impedance of 50 Ohms at $t = 0$ second and terminated in an unknown resistive load. The line length is such that it takes $400\,\mu\text{s}$ for an electromagnetic wave to travel from source end to load end and vice-versa. At $t = 400\,\mu\text{s}$, the voltage at the load end is found to be 40 Volts.

MCQ 1.84 The load resistance is

(A) 25 Ohms (B) 50 Ohms

(C) 75 Ohms (D) 100 Ohms

SOL 1.84 Correct Option (D)

MCQ 1.85 The steady-state current through the load resistance is

(A) 1.2 Amps (B) 0.3 Amps

(C) 0.6 Amps (D) 0.4 Amps

SOL 1.85 Correct Option is (B)

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