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Memory based Questions & Solutions

Exam held on 07/02/2021

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SECTION - A GENERAL APTITUDE

Q.1 If $\frac{p}{q}+\frac{q}{p} = 3$ then the value of $\frac{p^2}{q^2}+\frac{q^2}{p^2}$ is _____.

Ans. (7)

Given,

$$\frac{p}{q}+\frac{q}{p} = 3$$

Squaring both sides,

$$\left(\frac{p}{q}+\frac{q}{p}\right)^2 = 3^2$$

$$\Rightarrow \quad \frac{p^2}{q^2}+\frac{q^2}{p^2}+2 = 9$$

$$\Rightarrow \quad \frac{p^2}{q^2}+\frac{q^2}{p^2} = 9 - 2 = 7$$

End of Solution

Q.2 Present population of a village is 1102500. It's increasing at a rate of 5% per year. Population of village 2 year ago was?

(a) 9,92,500 (b) 9,95,006

(c) 10,00,000 (d) 12,51,506

Ans. (c)

$$1102500 = x\left(1+\frac{5}{100}\right)^2$$

$$1102500 = x\left(\frac{21}{20}\right)^2$$

$$x = 10,00,000$$

End of Solution

Q.3 3 Coins are tossed one after the other. One coin has head on both sides, one has tail on both sides and the third one has head and tail on either sides. The probability of getting head in the second toss when first toss was head is _____.

(a) $\frac{2}{3}$ (b) $\frac{1}{3}$

(c) $\frac{1}{2}$ (d) $\frac{3}{4}$

Ans. (b)

Let $P(H_2)$ = Probability of getting head in second toss

$P(H_1)$ = Probability of getting head in first toss

$$P\left(\frac{H_2}{H_1}\right) = \frac{P(H_2 \cap H_1)}{P(H_1)}$$

$$P(H_1) = \frac{1}{3}\times\frac{1}{2}+\frac{1}{3}\times 1+\frac{1}{3}\times 0 = \frac{1}{2}$$

To get head in second toss when head came in first toss, following cases can be made

1. **Fair coin :**

$$\text{Both head coin} = \frac{1}{3}\times\frac{1}{2}\times\frac{1}{2}\times 1 = \frac{1}{12}$$

$$\text{Both tail coin} = \frac{1}{3}\times\frac{1}{2}\times\frac{1}{2}\times 0 = 0$$

2. **Both head coin :**

$$\text{Fair coin} = \frac{1}{3}\times 1\times\frac{1}{2}\times\frac{1}{2} = \frac{1}{12}$$

$$\text{Both tail coin} = 0$$

$$\therefore \quad P(H_2 \cap H_1) = \frac{1}{12}+\frac{1}{12} = \frac{1}{6}$$

$$\therefore \quad P(H_2/H_1) = \frac{1/6}{1/2} = \frac{1}{3}$$

End of Solution nnnn

Q.4 A square of 1 unit side is first cut a long its diagonals to get two triangles. Now one triangle is revolved around its shortest side to get a cone. The volume of the cone is

(a) $\frac{2\pi}{3}$ (b) 3π

(c) $\frac{\pi}{3}$ (d) $\frac{3\pi}{2}$

Ans. (c)

$$\text{Volume of cone} = \frac{1}{3}\pi r^2 h$$

$$= \frac{1}{3}\times\pi\times(1)^2\times 1 = \frac{\pi}{3}$$

End of Solution

Q.5 Nostalgia is to anticipation as _____ is to _____.

(a) past, future (b) future, past

(c) future, present (d) present, past

Ans. (b)

End of Solution

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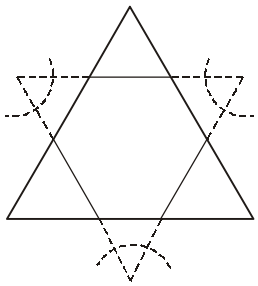
Q.6 Corners are cut from an equilateral triangle to produce a regular convex hexagon shown in figure



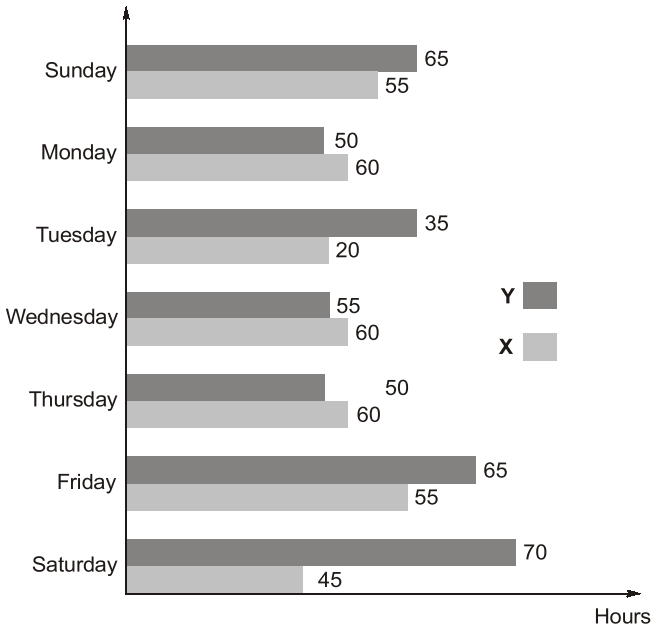
The ratio of the area of the regular convex hexagon to the area of teh original equilateral triangle is

(a) 5 : 6
(b) 3 : 4
(c) 4 : 5
(d) 2 : 3

Ans. (d)

End of Solution

Q.7 The number of minimum minutes spent by two students X and Y exercising every day in a given week are shown in the table below:



The number of days in a given week in which one of the students spent a minimum of 10% more than the other student in a given day is.

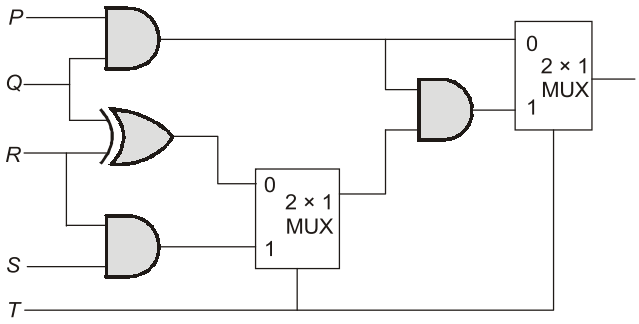
Ans. (6)

End of Solution

■■■■

SECTION - B TECHNICAL

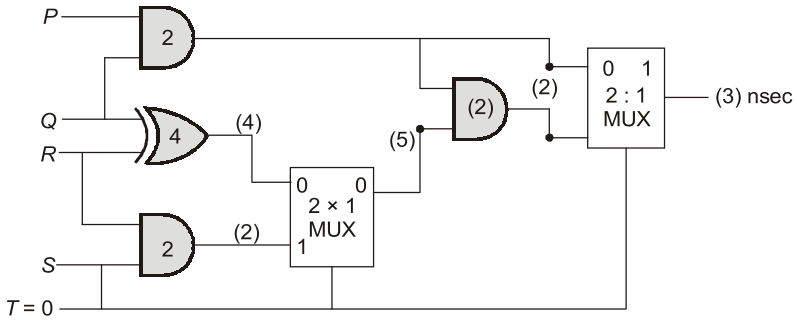
Q.1 The propagation delay of AND gate is 2ns, MUX is 1ns and XOR gate is 4ns respectively. If the inputs P, Q, R, S, T are applied simultaneously then what will be the maximum delay at the output.



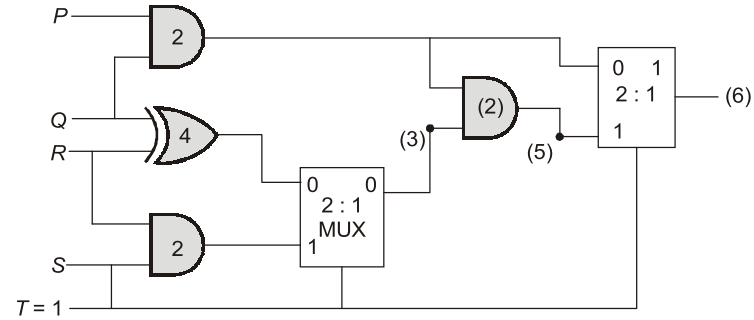
(a) 4 ns (b) 6 ns
(c) 7 ns (d) 5 ns

Ans. (b)

For $T = 0$



For $T = 1$



∴ Maximum propagation delay for the circuit is 6ns.

End of Solution

Q.2 Given $(1235)_x = (3033)_y$, where x and y is the base radix. Then the value of x and y is

(a) $x = 8;\ y = 6$
(b) $x = 9;\ y = 7$
(c) $x = 6;\ y = 4$
(d) $x = 7;\ y = 5$

Ans. (a)

$$x^3 + 2x^2 + 3x + 5 = 3y^3 + 3y + 3$$

Option (a) will satisfy the eqution.

End of Solution

Q.3 8 bit unipolar DAC has full scale output from 0 V to 7.68 V. Find the corresponding o/p voltage for 10010110 is _____V.

Ans. (4.5)

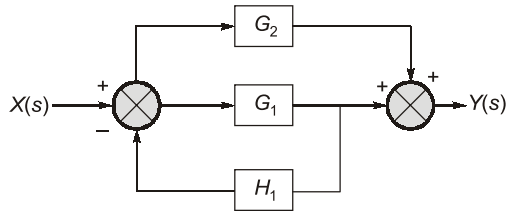
Given: $V_{ps} = 7.68$ V
$n = 8$ bit

$$\text{Resolution } (k) = \frac{V_{FS}}{2^n - 1} = \frac{7.68}{2^8 - 1} = 0.03$$

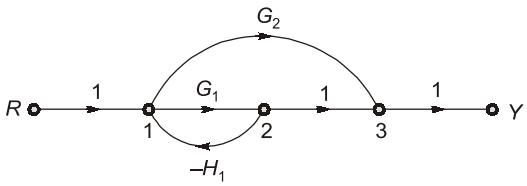
Now, $V_{DAC} = k \times \{\text{Decimal equivalent}\}$
$= 0.03 \times \{150\}$
$= 4.5$ V

End of Solution

Q.4 Transfer function of the following block diagram:



Ans.

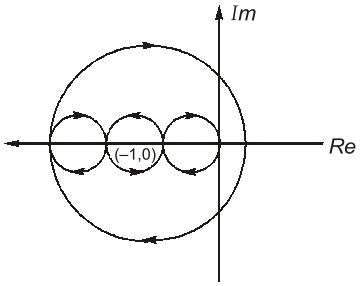


$$\frac{Y}{R} = \frac{G_1(1-0) + G_2(1-0)}{1-[-G_1H_1]}$$

$$= \frac{G_1 + G_2}{1 + G_1H_1}$$

End of Solution

Q.5 Given $G(s)\,H(s)$ is



$G(s)\,H(s)$ has one zero in right side of s-plane. The number of closed loop poles in right side s-plane is:

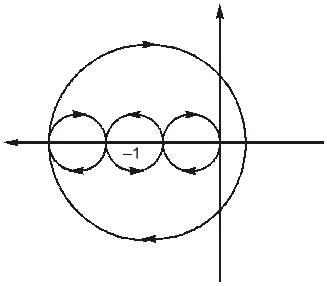
(a) 0 (b) 2

(c) 3 (d) 4

Ans. **(a)**

Given that GH has one zero in RHS

$\therefore \quad P = 0$



$\therefore \quad N = 1 - 1 = 0$

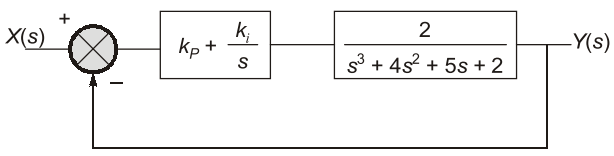
$N = P$

$P - N = 0$

Hence, NO closed loop poles in RHS.

End of Solution

Q.6 A unity feedback system that uses (PI) controller is shown in the figure. The stability of the overall system to controlled by tunning the PI control parameter K_P and K_I. The max. Value of K_I that can be chosen so as to keep the overall system stable or, in the worst case, marginally stable is _____.



Ans. (3.125)

$$GH = \left(\frac{sk_p + k_i}{s}\right)\left(\frac{2}{s^3 + 4s^2 + 5s + 2}\right)$$

$$q(s) = s^4 + 4s^3 + 5s^2 + s(2 + 2k_p) + 2k_i$$

Necessary: $k_p > -1;\ k_i > 0$

S^4	1	5	$2k_i$
S^3	4	$2 + 2k_p$	
S^2	$\frac{18 - 2k_p}{4}$	$2k_i$	
S^1	$\frac{(18 - 2k_p)(2 + 2k_p)}{18 - 2k_p}$		
S^0	$2k_i$		

Sufficient:

$$\frac{18 - 2k_p}{4} > 0$$

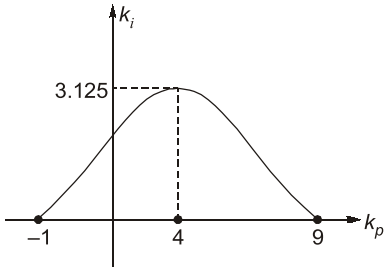
$$\Rightarrow \quad k_p < 9$$

$$\therefore \quad -1 < k_p < 9$$

$$(18 - 2k_p)(2 + 2k_p) - 32k_i > 0$$

$$32k_i < 36 + 32k_p - 4k_p^2$$

$$\therefore \quad 0 < k_i < \frac{36 + 32k_p - 4k_p^2}{32}$$



If $k_p = -1 \Rightarrow k_i = 0$

If $k_p = 9 \Rightarrow k_i = 0$

$$\therefore \quad \frac{dk_i}{dk_p} = 0$$

$$\Rightarrow \quad 32 - 8k_p = 0 = 0 \Rightarrow k_p = 4$$

$\therefore$ For $k_p = 4$, k_i is maximum, which is

$$k_i = \frac{36 + 32 \times 4 - 64}{32} = 3.125$$

For $k_p = 4$, $k_i < 3.125$ for stability

$$\therefore \quad k_{i\,\max} = 3.125$$

End of Solution

Q.7 An antenna with a directive gain of 6 dB is radiating a total power of 16 kW. The amplitude of the electric field in free space at a distance of 8 km from the antenna in the direction of 6 dB gain is _____ V/m.

Ans. (0.244)

$$G_d(\text{dB}) = 10\log_{10}(G_d)$$
$$\Rightarrow \quad 6 = 10\log_{10} G_d$$
$$\Rightarrow \quad G_d = 10^{0.6}$$
$$G_d = 3.981$$
$$E_m = \frac{\sqrt{60 G_d P_{rad}}}{r}$$
$$E_m = \frac{\sqrt{60(16\times10^3)(3.981)}}{8\times10^3} = 0.244 \text{ (V/m)}$$

End of Solution

Q.8 For a vector field $D = \rho\cos^2\phi a\rho + z^2 \sin\phi a_\phi$ in a cylindrical coordinate system (ρ, ϕ, z) with unit vector a_ρ, a_ϕ and a_z, the net flux D (in coulomb) leaving the closed surface of the cylinder $(\rho = 3,\ 0 \le z \le 2)$ is _____.

Ans. (56.55)

Method 1: $\vec{D} = \rho\cos^2\phi\hat{a}_\rho + z^2\sin\phi\hat{a}_\phi$

Electric flux crossing the closed surface is

$$\psi = \oiint \vec{D}\cdot\vec{dS} = \iiint(\vec{\nabla}\cdot\vec{D})dv$$
$$\vec{\nabla}\cdot\vec{D} = \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho D_\rho) + \frac{1}{\rho}\frac{\partial D_\phi}{\partial\phi} + \frac{\partial D_z}{\partial z}$$
$$= \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho\rho\cos^2\phi) + \frac{1}{\rho}\frac{\partial}{\partial\phi}(z^2\sin\phi) + 0$$
$$= \frac{1}{\rho}(2\rho)\cos^2\phi + \frac{1}{\rho}z^2\cos\phi = 2\cos^2\phi + \frac{z^2}{\rho}\cos\phi$$
$$\iiint(\vec{\nabla}\cdot\vec{D})dv = \iiint 2\cos^2\phi(\rho d\rho d\phi dz) + \iiint\left(\frac{z^2}{\rho}\cos\phi\right)\rho d\rho d\phi dz$$
$$= 2\int_{\rho=0}^{3}\rho d\rho\int_{\phi=0}^{2\pi}\left(\frac{1+\cos2\phi}{2}\right)d\phi\int_{z=0}^{2}dz + \int_{\rho=0}^{2}d\rho\int_{\phi=0}^{2\pi}\cos\phi d\phi\int_{z=0}^{2}z^2dz$$
$$= 2\left(\frac{\rho^2}{2}\right)_{\rho=0}^{3}\frac{1}{2}(2\pi)(z)_{z=0}^{2} + 0$$
$$= 2\left(\frac{3^2}{2}\right)\pi(2) = 18\pi \text{ (Coulomb)} = 56.55 \text{ (coulomb)}$$

Method 2: Electric flux crossing the closed surface is

$$\psi = \oiint \vec{D}\cdot\vec{dS}$$

Electric flux crossing $\rho = 3$ cylindrical surface is

$$\psi|_{\rho=3} = \oiint (\rho\cos^2\phi\hat{a}_\rho)\cdot(\rho d\phi dz)\hat{a}_\rho$$

$$= 3^2\int_{\phi=0}^{2\pi}\cos^2\phi d\phi\int_{z=0}^{2} dz$$

$$= 9\frac{1}{2}(2\pi)(2) = 18\pi(\text{coulomb}) = 56.55\ (\text{coulomb})$$

End of Solution

Q.9 A standard air-filled rectangular wave guide with dimension $a = 8$ cm, $b = 4$ cm, operated at 3.4 GHz. For the dominant mode of wave propagation, the phase velocity of the signal is v_p. The value of v_p/c, is _____.

Ans. (1.198)

$$f_{c10} = \frac{c}{2a} = \frac{3\times10^8}{2(8\times10^{-2})} = 1.875\ \text{GHz}$$

Guide phase velocity, $V_p = \dfrac{c}{\sqrt{1-\left(\dfrac{f_{c10}}{f}\right)^2}}$

$$\frac{V_p}{c} = \frac{1}{\sqrt{1-\left(\dfrac{f_{c10}}{f}\right)^2}} = \frac{1}{\sqrt{1-\left(\dfrac{1.875}{3.4}\right)^2}} = 1.198$$

End of Solution

Q.10 The refractive indices of the core and cladding of an optical fibre are 1.50 and 1.48 respectively. The critical propagation angle, which is defined as the maximum angle that the light beam makes with the axis of optical fibre to achieve the total internal reflection is _____.

Ans. (9.366)

Given that

Refractive index of core $\eta_1 = 1.50$

Refractive index of clad $\eta_2 = 1.48$

Critical propagation angle (θ_p)

$$\theta_p = \sin^{-1}\left[\frac{\sqrt{\eta_1^2-\eta_2^2}}{\eta_1}\right] = \cos^{-1}\left[\frac{\eta_2}{\eta_1}\right]$$

$$\theta_p = \cos^{-1}\left[\frac{1.48}{1.50}\right] = 9.366°$$

End of Solution

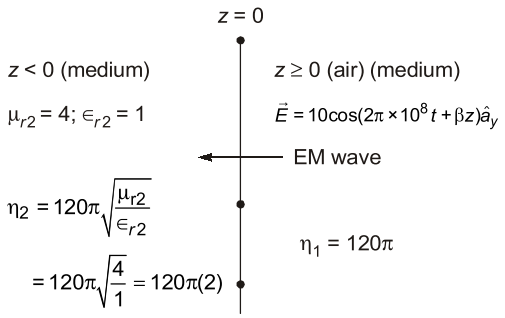
Q.11 Consider a rectangular coordinate system (x, y, z) with unit vector a_x, a_y and a_z. A plane wave travelling in the region $z \geq 0$ with electric field vector $E = 10\cos(2\pi \times 10^8 t + \beta_z)a_y$ is incident normally on the plane at $z = 0$, where β is the phase constant. The region $z \geq 0$ is in the tree space and the region $z < 0$ is filled with a lossless medium (permittiivity $\varepsilon = \varepsilon_0$, $\mu = 4\mu_0$). The value of the reflection coefficient is:
$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

(a) $\frac{3}{5}$ (b) $\frac{2}{5}$

(c) $\frac{1}{3}$ (d) $\frac{2}{3}$

Ans. (c)

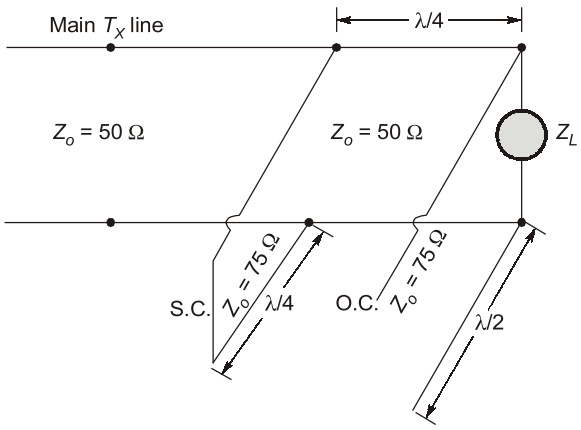
Given $\vec{E} = 10\cos(2\pi \times 10^8 t + \beta z)\hat{a}_y$ for $z \geq 0$ having free space. For $z < 0$ medium has $\epsilon_{r2} = 1$; $\mu_{r2} = 4$.



$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{120\pi(2) - 120\pi}{120\pi(2) + 120\pi} = \frac{1}{3}$$

End of Solution

Q.12 For matching main transmission line what is the value of Z_L.



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Ans. (50)

$$Z_{in}\frac{\lambda}{4} = \frac{Z_o^2}{Z_L} = \frac{(75)^2}{0} = \infty \quad \left[\text{for } \frac{\lambda}{4} T_X \text{ line}\right]$$

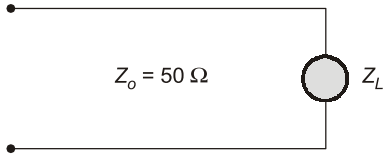
Given Z_L of $\frac{\lambda}{4}$ line is O(SC)

$$Z_{in}\frac{\lambda}{2} = Z_L = \infty \left[\text{for } \frac{\lambda}{4} T_X \text{ line}\right]$$

Given Z_L of $\frac{\lambda}{2}$ line is ∞(O.C)

The input impedance of $\frac{\lambda}{4}$ transmission line, as well as $\frac{\lambda}{2}$ transmission line is ∞, and they are in parallel with main transmission line, so they are not effective for main. Transmission line.

Final configuration of given line is



So for impedance matching purpose $Z_L = 50\ \Omega$ (because if $Z_L = Z_o$ then matching is done).

End of Solution

Q.13 Considering the vector field $F = a_z(4y - c_1z) + a_y(4x + 2z) + a_z(2y + z)$ in a rectangular coordinate system (x, y, z) with unit vector a_x, a_y and a_z, if the field F is irrotational the constant c_1 (in integer) is _____.

Ans. (0)

$$\nabla \times \bar{F} = 0$$

$$\begin{vmatrix} i & j & k \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 4y - c_1z & 4x + 2z & 2y + z \end{vmatrix} = 0$$

$$= i(2 - 2) - j(0 + c_1) + k(4 - 4) = 0$$

$$c_1 = 0$$

End of Solution

Q.14 Find the integrating factor of given linear differential equation.

$$\frac{dy}{dx}-\frac{x}{1-x^2}y=x\sqrt{y}$$

(a) $(1-x^2)^{\frac{-1}{2}}$

(b) $(1-x^2)^{\frac{-1}{4}}$

(c) $(1-x^2)^{\frac{-3}{2}}$

(d) $(1-x^2)^{\frac{-3}{4}}$

Ans. **(b)**

$$\frac{dy}{dx}+\frac{x}{1-x^2}y = x\sqrt{y}, \quad \text{I.F} = ?$$

Divided by $\sqrt{y}$

$$\frac{1}{\sqrt{y}}\frac{dy}{dx}+\frac{x}{1-x^2}\sqrt{y} = x$$

$$2\frac{du}{dx}+\frac{x}{1-x^2}u = x$$

Let $x\sqrt{y} = u$

$$\frac{1}{2\sqrt{y}}\frac{dy}{dx} = \frac{du}{dx}$$

$\Rightarrow$ $\frac{du}{dx}+\frac{x}{2(1-x^2)}u = \frac{x}{2}$ $\rightarrow$ lines diff. equ.

$$\text{I.F} = e^{\int\frac{x}{2(1-x^2)}dx} = e^{-\frac{1}{4}\log(1-x^2)} = e^{\log(1-x^2)^{\frac{-1}{4}}}$$

$$\text{I.F} = \frac{1}{(1-x^2)^{\frac{1}{4}}}$$

End of Solution

Q.15 Consider 2 × 2 non-singualr matrix with same eigen values

$$A=\begin{bmatrix} x & -3 \\ 3 & 4 \end{bmatrix}$$

where x is real and positive value of the matrix. Find the value of x.

Ans. **(10)**

$$A = \begin{bmatrix} x & -3 \\ 3 & 4 \end{bmatrix}$$

Characteristic equation

$$|A-\lambda I| = \begin{vmatrix} x-\lambda & -3 \\ 3 & 4-\lambda \end{vmatrix} = 0$$

$\Rightarrow \quad \lambda^2 - (4 + x)\lambda + (4x + 9) = 0$

Roots are repeating

$\Rightarrow \quad b^2 - 4ac = 0$

$(4 + x^2) - 4(4x + 9) = 0$

$16 + x^2 + 8x - 16x - 20 = 0$

$x = 10$

$\Rightarrow \quad x^2 - 8x + 20 = 0$

$$x = \frac{8 \pm \sqrt{64+80}}{2} = \frac{8 \pm 12}{2} = -2, 10$$

End of Solution

Q.16 The value of the integeral

$$\oint_c \frac{\sin x}{x^2\left(x^2+4\right)} dx$$

evaluated using contour integration at $|x - i| = 2$.

Ans. (*)

$$\oint_c \frac{\sin x}{x^2(x^2+4)} dx, \; c : |x - i| = 2$$

Poles are given by $x^2 = 0$ and $x^2 + 4 = 0$

$\Downarrow$

$\Rightarrow \quad x = 0$ is a pole of order '2'

$x = 2i$ are simple nodes

$x = 0$ lies inside 'c'

$x = 2i$ lies inside 'c'

$x = -2i$ lies outside 'c'

$$\text{Res}_0 = \frac{1}{(2-1)!} \lim_{x \to 0} \frac{d}{dz}\left[(x-0)^2 \frac{\sin x}{x^2(x^2+4)}\right]$$

$$= \lim_{x \to 0} \frac{(x^2+4)\cos x - \sin x(2x)}{(x^2+4)^2} = \frac{1}{4}$$

$$\text{Res}_{2i} = \frac{\phi(2i)}{\nu} \lim_{x \to 2i} (x - 2i) \frac{\sin x}{x^2(x-2i)(2+2i)} = \frac{\sin(2i)}{(-4)(4i)}$$

By CRT $\quad \oint_c f \cos \partial x = 2\pi i\left[\text{Res}_0 + \text{Res}_{2i}\right] = 2\pi i\left[\frac{1}{4} + \frac{\sin(2i)}{-16}\right]$

End of Solution

Q.17 If the vectors (1, –1, 2) (7, 3, x), (2, 3, 1) in R^3 are linearly dependent.

The value of x is _____.

Ans. **(8)**

$x_1(1, -1, 2)$
(7, 3, x) are linearly dependent when x = ?
(2, 3, 1)

$$\begin{vmatrix} 1 & -1 & 2 \\ 7 & 3 & x \\ 2 & 3 & 1 \end{vmatrix} = 0 \Rightarrow 1(3 - 3x) + 1(7 - 2x) + 2(15) = 0$$

$$\Rightarrow \quad -5x = -40$$
$$x = 8$$

End of Solution

Q.18 Consider $\bar{F} = -xi + yj$, then find the value of $\int_c \vec{F}\vec{dr}$

Ans. **(1/2)**

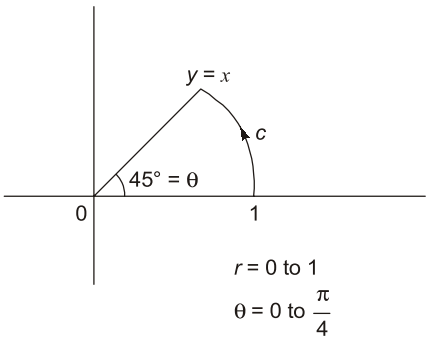
$$\bar{F} = -xi + yj, \int_c \vec{F}\,\vec{dr}$$

$$\Rightarrow \int -x dx + y\, dy$$

$$\Rightarrow \int (-\cos\theta(-\sin\theta) + \sin\theta\cos\theta) d\theta$$

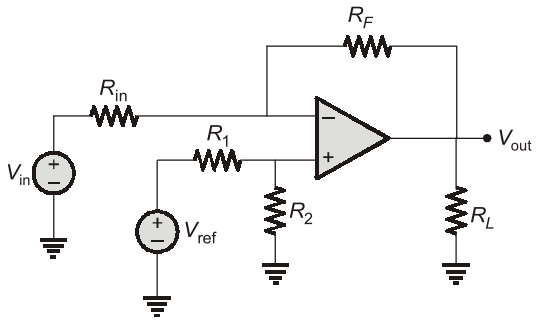
$$\int_{\theta=0}^{\pi/4} \sin 2\theta\, d\theta = -\frac{\cos 2\theta}{2}\Big]_0^{\pi/4}$$

$$= -\frac{1}{2}[0 - 1] = \frac{1}{2}$$



End of Solution

Q.19 Ideal op-amp amplifier, V_{ref}, is fixed.
V_{out} = 1 V for V_{in} = 0.1 V
V_{out} = 6 V for V_{in} = 1 V_1



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where V_{out} is measured across R_L connected at the output of the operational amplifier, the value of R_f/R_{in} = ?

(a) 2.860 (b) 3.285

(c) 3.825 (d) 5.555

Ans. (d)

$$V^- = V^+ = 0$$

$$\frac{V_{out}R_{in} + V_{in}R_F}{R_{in} + R_F} = \frac{V_{ref}R_2}{R_1 + R_2}$$

$$\frac{1\times R_{in} + 0.1\times R_F}{R_{in} + R_F} = \frac{V_{ref}R_2}{R_1 + R_2} \quad ...(i)$$

$$\frac{6R_{in} + 1\times R_F}{R_{in} + R_F} = \frac{V_{ref}R_2}{R_1 + R_2} \quad ...(ii)$$

Equate equation (i) and (ii),

$$1 \times R_{in} + 0.1 \times R_F = 6 \times R_{in} + 1 \times R_F$$

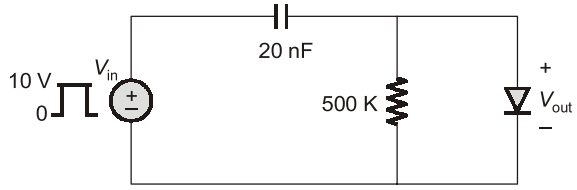
$$-5\ R_{in} = 0.9\ R_F$$

$$\therefore \quad \frac{R_F}{R_{in}} = \frac{-5}{0.9} = -5.55$$

(According to the given data magnitude is taken)

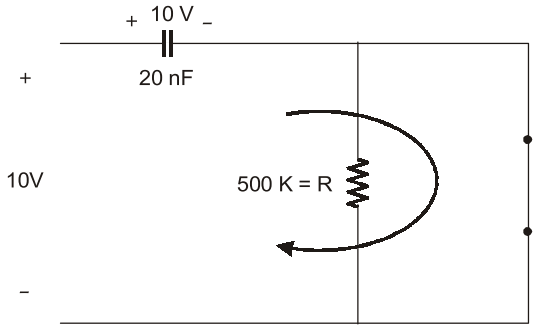
End of Solution

Q.20 An asymetrical periodic pulse train V_{in} of 10 V amplitude with on T_{on} = 1 ms and off time T_{off} = 1 µs in applied to the figure shown below. Find V_{out}. (Assume diode is ideal)



Ans. (10)

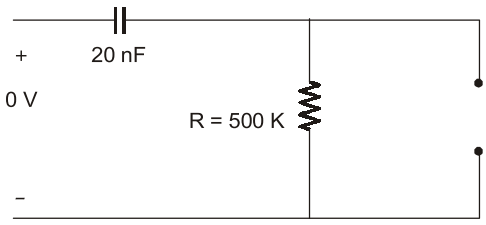
V_{in} = 10 V: Diode is ON



∴ Capacitor charges upto 10 V,

$\therefore$ $V_C = 10$ V

$V_{in} = 0$; Diode is OFF



Discharging time constant = $R \times C$

= 10 m sec

$\tau_{Discharges} >> \tau_{OFF}$

Capacitor discharges negligibilly

$\therefore$ $V_C = 10$ V

In steady state, $V_C = 10$ V

$V_{out} = V_{in} - V_c = V_{in} - 10V$

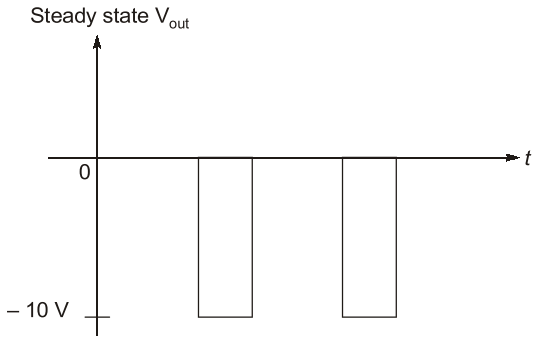
When $V_{in} = 10\,V$

$\Rightarrow$ $V_{out} = 10 - 10 = 0$ V

$V_{in} = 10$ V

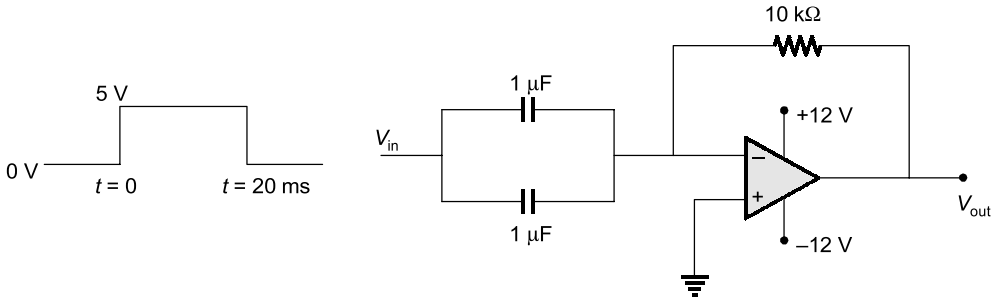
$\Rightarrow$ $V_{out} = 0 - 10 = -10$ V

$V_{out(max)} - V_{out(min)} = 0 - (-10) = 10$ V



End of Solution

Q.21 A circuit with an ideal OPAMP is shown in figure, a pulse V_{in} of 20 ms direction is applied to the input. The capacitance as initially uncharged.
The output voltage V_{out} of this circuit at $t = 0^+$ (in integer) is _____ V.

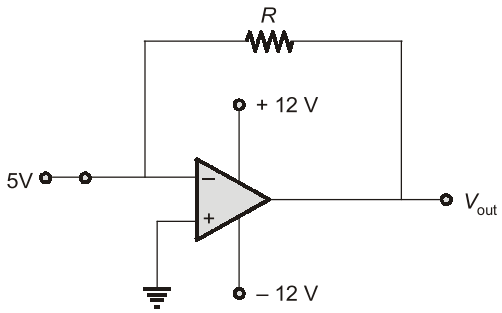


Ans. (–12)

At, $t = 0^+$: Capacitor is short circuit

$\therefore$ $V^- = V_{in} = 5V$

$V^+ = 0$ V

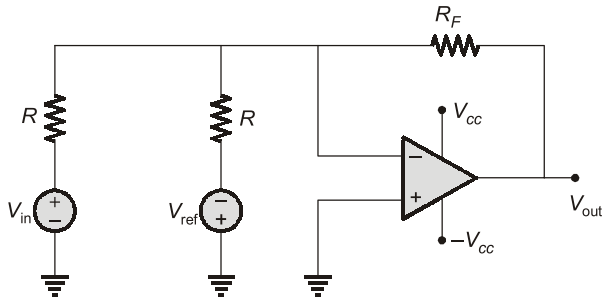


If $V^- > V^+$

$V_{out} = -V_{sat} = -12$ V

End of Solution

Q.22 Consider the circuit with an idael OPAMP shown in figure.
Assuming $|V_{in}| << |V_{cc}|$ and $|V_{REF}| << |V_{cc}|$. The condition at which V_{out} equal to zero is



(a) $V_{in} = V_{REF}$ (b) $V_{in} = 2V_{REF}$

(c) $V_{in} = 0.5\ V_{REF}$ (d) $V_{in} = 2 + V_{REF}$

Ans. (a)

For ideal op-amp, $V^- = V^+ = 0$

KCL at node V^- :

$$\frac{V_{in}-0}{R}+\frac{(-V_{ref}-0)}{R}+\frac{V_{out}-0}{R_F}=0$$

$$\frac{V_{out}}{R_F}=\frac{1}{R}(V_{ref}-V_{in})$$

$$V_{out}=\frac{R_F}{R}(V_{ref}-V_{in})$$

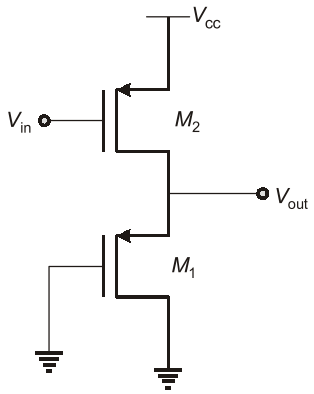
We want, $V_{out} = 0$

$\Rightarrow$ $V_{ref} - V_{in} = 0$

$\Rightarrow$ $V_{in} = V_{ref}$

End of Solution

Q.23 The MOSFET circuit is as shown below, with g_{m1} and g_{m2} be respective transconductors and r_{01} and r_{02} are be the output resistance of M_1 and M_2 respectively. The voltage gain of the circuit is ____.



(a) $gm_1\left[\frac{1}{gm_2} \| r_{01} \| r_{02}\right]$

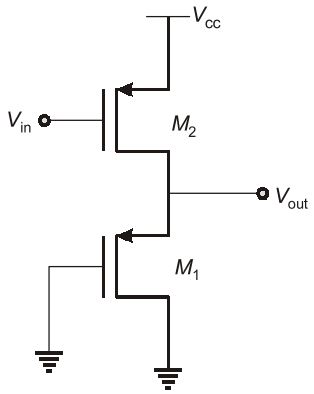
(b) $gm_1\left[\frac{1}{gm_2} \| r_{01}\right]$

(c) $gm_2\left[\frac{1}{gm_1} \| r_{01} \| r_{02}\right]$

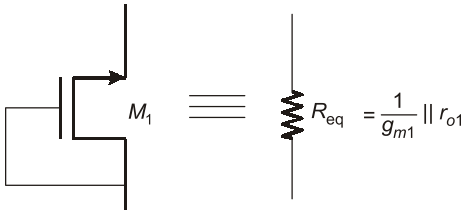
(d) $gm_1[r_{01} \| r_{02}]$

Ans. **(c)**

MOSFET M_2 acts as common source amplifier.



Drain to gate connected MOSFET M_1 acts as load.



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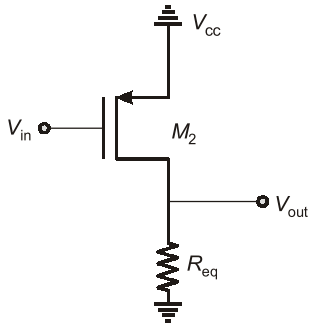
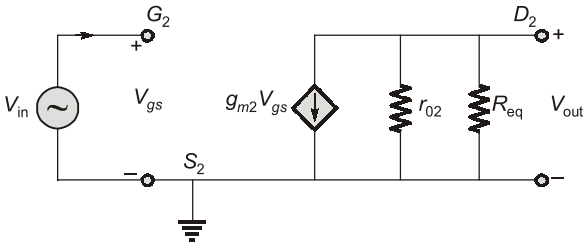
For given circuit, AC equivalent is as shown.



Replace M_2 with small signal model



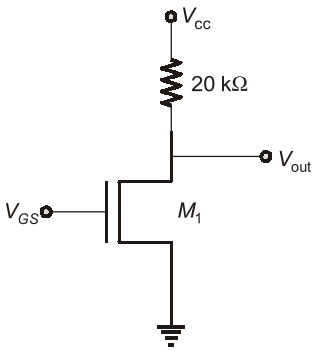
$$\frac{V_{out}}{V_{in}} = \frac{-g_{m2}V_{gs}\left(r_{o2} \parallel R_{eq}\right)}{V_{gs}}$$

$$|A_V| = g_{m2}\left(r_{o2} \parallel \frac{1}{g_{m1}} \parallel r_{o1}\right)$$

Hence, option (c) is correct.

End of Solution

Q.24 Consider the MOSFET given below:



Parameters of MOSFET are

$$\mu_n C_{ox} = 100\ \mu\ \text{A/V}$$

$$\frac{W}{L} = 10$$

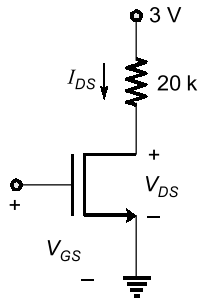
MOSFET M_1 is at the edge of saturation for V_{GS} = 1 V. The threshold value of M_1 is _____.

Ans. (0.5)

$$I_{DS} = \frac{\mu_n C_{ox}}{2} \times \frac{W}{L}(V_{GS} - V_T)^2$$

Given, $V_{GS} = 1$ V

$$I_{DS} = \frac{1}{2}(1 - V_T)^2 \quad \text{...(i)}$$



$$V_{DS} = 3 - 20 \times I_{DS}$$

$$V_{DS} = 3 - \frac{20}{2}(1 - V_T)^2$$

$$V_{DS} = 3 - 10(1 - V_T)^2$$

MOSFET operates in saturation if

$$V_{DS} \geq V_{GS} - V_T$$

So, we take, $V_{DS} = V_{GS} - V_T$

$$V_{GS} - V_T = 3 - 10(1 - V_T)^2$$

$$1 - V_T = 3 - 10(1 - V_T)^2$$

Let, $1 - V_T = x$

$$3 - 10x^2 = x$$

$$10x^2 + x - 3x = 0$$

We get, $x = -\frac{1 \pm \sqrt{1 + 120}}{20}$

$$x = -\frac{1 \pm 11}{20}$$

$\therefore$ $x = 0.5$ and -0.6

$x = 0.5$

$\Rightarrow$ $1 - V_T = 0.5$

$\Rightarrow$ $V_T = 0.5$ V

$x = -0.6$

$\Rightarrow$ $1 - V_T = -0.6$

$\Rightarrow$ $V_T = 1.6$ V

But $V_{GS} > V_T$

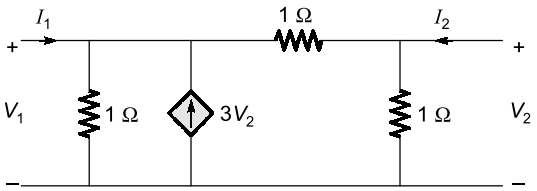
or $V_T < V_{GS}$

i.e., $V_T < 1$

$\therefore$ $V_T = 0.5$ V

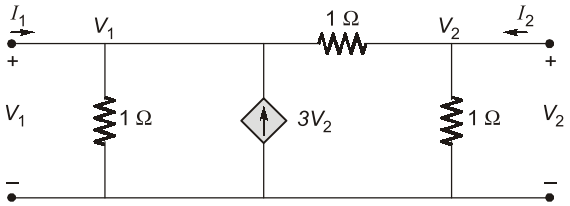
End of Solution

Q.25 The admittance parameter are



(a) $Y_{11} = 2,\ Y_{12} = -4,\ Y_{21} = -4,\ Y_{22} = 2$
(b) $Y_{11} = 1,\ Y_{12} = -2,\ Y_{21} = -1,\ Y_{22} = 3$
(c) $Y_{11} = 2,\ Y_{12} = -4,\ Y_{21} = -4,\ Y_{22} = 3$
(d) $Y_{11} = 2,\ Y_{12} = -4,\ Y_{21} = -1,\ Y_{22} = 2$

Ans. **(d)**



Write KCL at V_1

$$I_1 = \frac{V_1}{1} + \frac{V_1 - V_2}{1} - 3V_2$$

$$I_1 = 2V_1 - 4V_2 \quad \ldots (i)$$

Write KCL at V_2

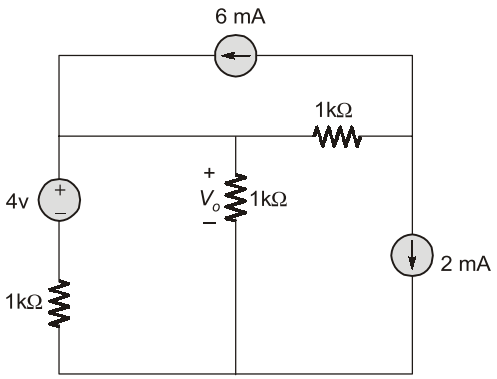
$$I_2 = \frac{V_2}{1} + \frac{V_2 - V_1}{1}$$

$$I_2 = -V_1 - 4V_2 \quad \ldots (ii)$$

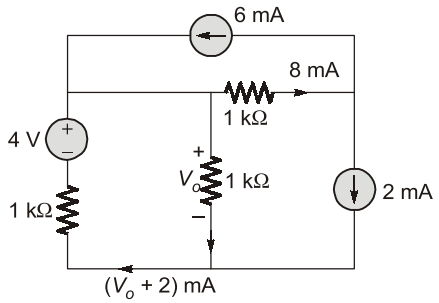
$$[y] = \begin{bmatrix} 2 & -4 \\ -1 & 2 \end{bmatrix} \mho$$

End of Solution

Q.26 Find the value of V_D.



Ans. (1)



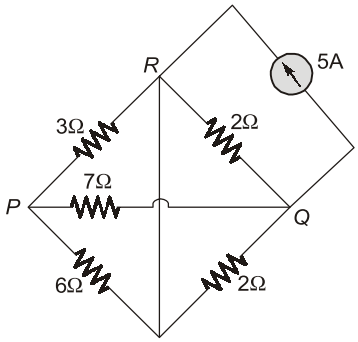
Write KVL equation first loop,

$$V_o - 4 + 1(V_o + 2) = 0$$

$$V_o = 1 \text{ V}$$

End of Solution

Q.27 Find the current I_{PQ} in the circuit shown below.

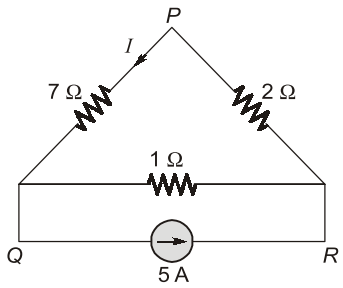


Ans. (0.5)

Redraw the circuit,

$$3\Omega \parallel 6\Omega = 2\Omega$$

$$2\Omega \parallel 2\Omega = 1\Omega$$



$$I_{eq} = 5 \times \frac{1}{10} = 0.5A$$

End of Solution

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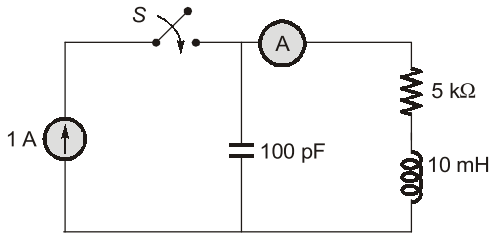
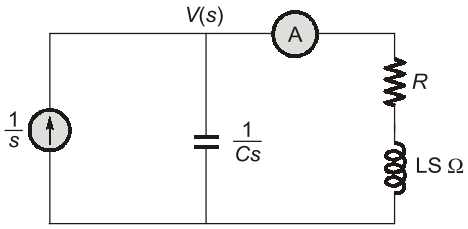
Q.28 The circuit contain current source driving a load having an inductor and a resistor in series with a shunt capacitor across the load. The ammeter is assumed to have zero resistance. The switch is closed at $t = 0$, initially when the switch is open, the capacitor is discharged and ammeter reads '0' A. After the switch is closed, the ammeter reading keeps fluctuating for some time till it settles to a final steady state value.
The maximum ammeter reading that one will observe after the switch is closed is _____ A.



Ans. (1.44)

Apply Laplace transform,



$$\frac{1}{s} = \frac{V(s)}{1/Cs} + \frac{V(s)}{R+Ls}$$

$$\frac{1}{s} = V(s)\left[Cs + \frac{1}{R+Ls}\right]$$

$$V(s) = \frac{(1/s)}{Cs + \frac{1}{R+Ls}}$$

$$V(s) = \frac{(1/s)(R+LS)}{LCs^2 + RCs + 1}$$

$$I(s) = \frac{(1/s)(R+Ls)}{LCs^2 + RCs + 1} \cdot \frac{1}{(R+Ls)}$$

$$I(s) = \frac{1/LC}{s\left(s^2 + \frac{R}{L}s + \frac{1}{LC}\right)}$$

$L = 10$ mH; $C = 100$ pF; $R = 5 \times 10^3\ \Omega$

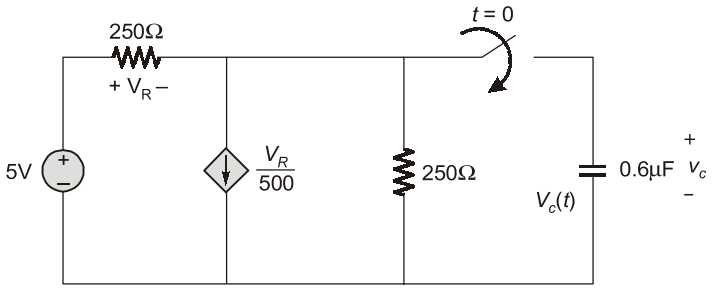
$$\xi = \frac{R}{2}\sqrt{\frac{C}{L}} = \frac{5\times10^3}{2}\sqrt{\frac{100\times10^{-12}}{10\times10^{-3}}} = 0.25$$

$$\text{Max. over shoot} = e^{-\pi\xi/\sqrt{1-\xi^2}} = 0.44$$

Maximum value = Steady state + Max. overshoot
= 1 + 0.44
= 1.44 A

End of Solution

Q.29 The circuit shown in figure which is closed at $t = 0$ while the capacitor initially charged to –5 V. The time after which the voltage across capacitor become zero.

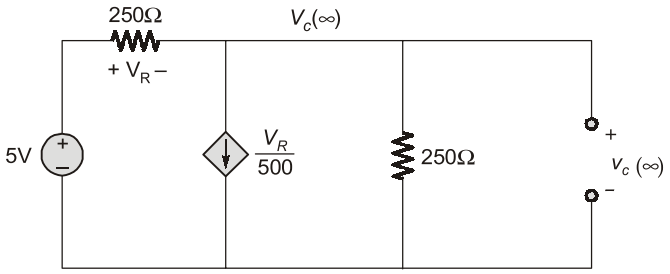


Ans. (0.1386)

$$V_c(0^-) = -5\text{V}$$

$$V_c(0^+) = -5\text{V}$$

$t \to \infty$, capacitor acts as a O.C.

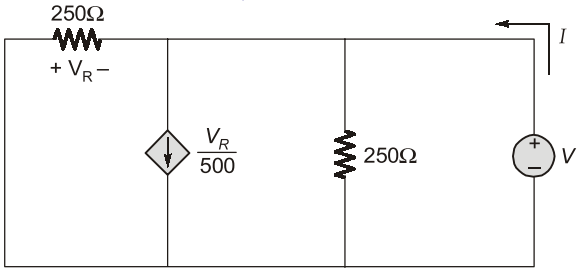


Write KCL at node

$$\frac{V_c(\infty)-5}{250}+\frac{V_R}{500}+\frac{V_c(\infty)}{250}=0$$

$$V_c(\infty)=\frac{5}{3}\ \text{Volts}$$

Time constant (τ) = $R_{eq}C$.



$$I=\frac{V}{250}+\frac{V_R}{500}+\frac{V}{250}$$

$$V_R = -V$$

$$I = \frac{V}{250} - \frac{V}{500} + \frac{V}{250}$$

$$\frac{V}{I} = \frac{500}{3}\Omega ; \; R_{eq} = \frac{500}{3}\Omega$$

$$\tau = \frac{500}{3} \times 0.6\mu = 0.1 \times 10^{-3}$$

$$v_c(t) = v_c(\infty) + (v_c(0) - v_c(\infty))e^{-t/\tau}$$

$$v_c(t) = \frac{5}{3} + \left(-5 - \frac{5}{3}\right)e^{-t/0.1\times10^{-3}}$$

$$0 = \frac{5}{3} - \frac{20}{3}e^{-10000t}$$

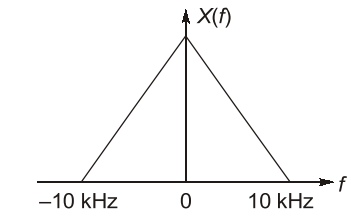
$$t = 0.1386 \text{ m sec}$$

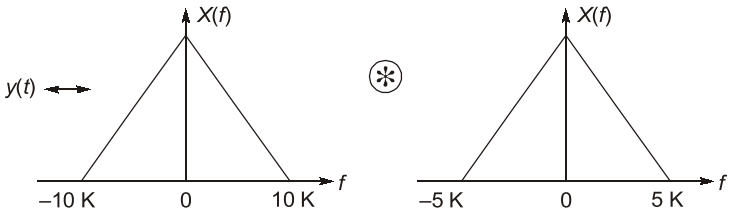
End of Solution

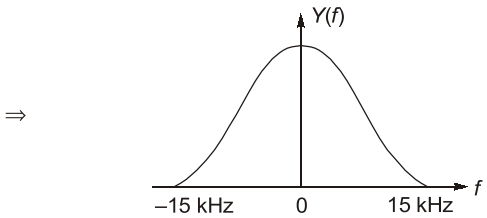
Q.30 Consider real value base band signal $x(t)$, band limited to 10 kHz. The Nyquist rate for signal $y(t) = x(t) \cdot \left(1 + \frac{t}{2}\right)$ is

(a) 30 kHz
(b) 15 kHz
(c) 20 kHz
(d) 60 kHz

Ans. (a)







$$NR = 2 \times f_{max} = 2 \times 15 = 30 \text{ kHz}$$

End of Solution

Q.31 Two continuous random variables x and y are defined as $y = 2x + 3$, then

(a) Var(y) = 2 Var(x)
(b) Var(x) = 4 Var(x)
(c) Var(y) = 5 Var(x)
(d) Var(y) = 25 Var(x)

Ans. (b)

$$\text{Var}[y] = E\left[(y-\bar{y})^2\right]$$

$$E[y] = \bar{y} = 2E[x] + 3$$

$$\bar{y} = 2\bar{x} + 3$$

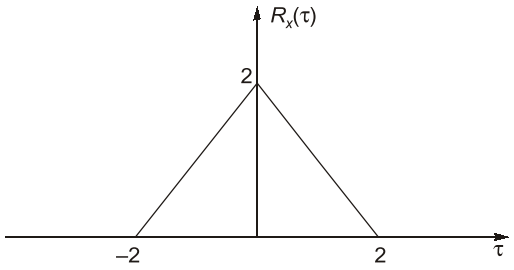
$$\text{Var}[y] = E\left[(y-\bar{y})^2\right] = E\left[(2x+3-2\bar{x}-3)^2\right] = E\left[(2x-2\bar{x})^2\right]$$

$$= E\left[4(x-\bar{x})^2\right] = 4\left[E(x-\bar{x})^2\right]$$

$$\text{Var}[y] = 4 \times \text{var}(x)$$

End of Solution

Q.32 Wide sense stationary process $R_x(\tau)$ is given below:



Find the average power (in Watts)?

Ans. (2)

$$\text{Average power} = R_x(0) = \text{Msq}[x(t)] = E[x^2(t)]$$
$$= 2 \text{ Watts}$$

End of Solution

Q.33 Consider a super hetrodyne receiver signal 600 kHz. If a local oscillator feeds 1000 kHz. Then image frequency is ____ kHz.

Ans. (1400)

Given: $f_s = 600$ kHz, $f_l = 1000$ kHz, $f_{si} = ?$

Default: $f_l > f_s$

$$IF = f_L - f_s = 1000 - 600 = 400 \text{ kHz}$$
$$F_{si} = f_s + 2I_f = 600 + 800 = 1400 \text{ kHz}$$

End of Solution

Q.34 A sinusoidal signal have RMS value of 4V and frequency of 1 kHz is fed to phase modulator with phase deviation constant of 2 rad/Volt. If $c(t) = 2\cos(2\pi \times 10^6 t))$ then $f_{(\text{instantanuous})\max}$ of phase modulated signal _____.

Ans. **(1011313.7)**

$$V_{peak} = \sqrt{2}\, V_{rms} = 4\sqrt{2}\ \text{V}$$

$$m(t) = 4\sqrt{2}\sin 2\pi \times 10^3 t$$

$$f_i = f_c + \frac{k_p}{2\pi}\frac{d}{dt}m(t)$$

$$(f_i)_{max} = f_c + \frac{k_p}{2\pi}\left[\frac{d}{dt}m(t)\right]_{max} \quad \ldots (i)$$

$$\frac{d}{dt}m(t) = 2\pi \times 10^3 \times 4\sqrt{2}\cos 2\pi \times 10^3 t$$

$$\left[\frac{d}{dt}m(t)\right]_{max} = 2\pi \times 10^3 \times 4\sqrt{2}$$

Putting in equation (i), $(f_i)_{max} = 1000 \times 10^3 + \left[\frac{2}{2\pi} \times \left(2\pi \times 10^3 \times 4\sqrt{2}\right)\right]$

$$= 1000 \times 10^3 + 8\sqrt{2} \times 10^3$$

$$= 1011313.7\ \text{Hz}$$

End of Solution

Q.35 A carrier is amplitude modulated with 50% of modulation. Find % of power saved if carrier and one of the sideband is removed?

Ans. **(94.4)**

$$\mu = 0.5$$

$$\%\ \text{of power saved} = \frac{4+\mu^2}{4+2\mu^2} = 94.4\%$$

End of Solution

Q.36 4 kHz sinusoidal signal with peak voltage of 4V is given to delta modulator the signal is sampled at the rate of 32 kHz. What is the value of minimum 'Δ' required to avoid slop overload error?

Ans. **(3.14)**

To avoid SOE, $\frac{\Delta}{T_3} \geq 2\pi f_m A_m$

$$\Delta \times 32\ \text{kHz} \geq 2\pi(4\text{kHz})(4\text{V})$$

$$\Delta \geq \frac{32\pi}{32} \geq \pi\ \text{volts}$$

$$\Delta_{min} = 3.14\ \text{V}$$

End of Solution

Q.37 The content of the registers are R_1 = 25H, R_2 = 30H and R_3 = 40H the following machine instriction are executed.

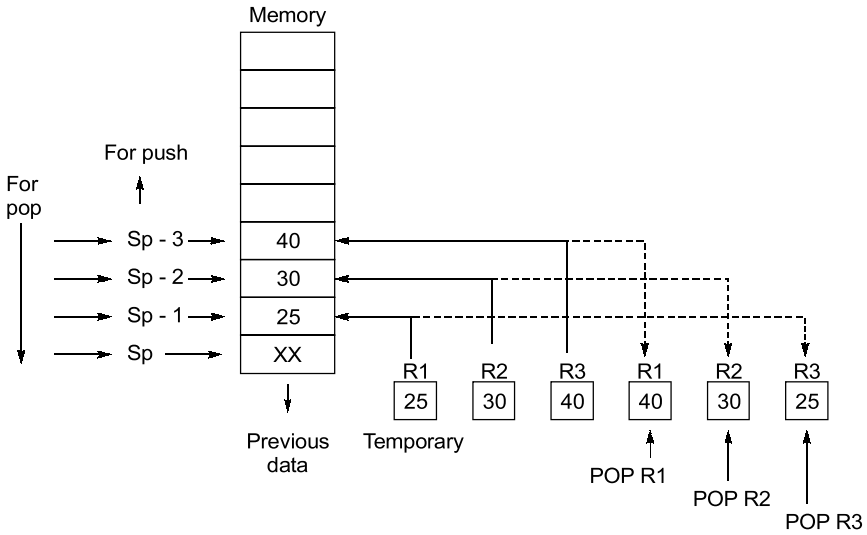
PUSH {R_1}
PUSH {R_2}
PUSH{R_3}
POP{R_1}
POP{R_2}
POP{R_3}

After the execution the content at register R_1, R_2, R_3 are:

(A) R_1 = 40H, R_2 = 25H, R_3 = 30H
(B) R_1 = 30H, R_2 = 40H, R_3 = 25H
(c) R_1 = 25H, R_2 = 30H, R_3 = 40H
(d) R_1 = 40H, R_2 = 30H, R_3 = 25H

Ans. **(d)**

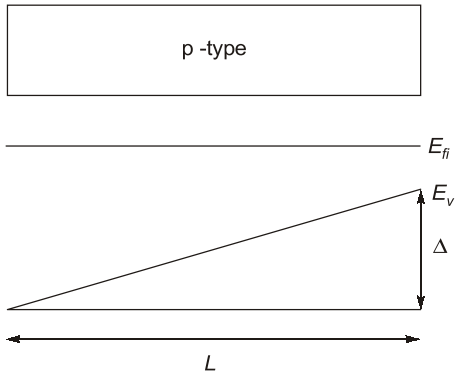
For push Sp in decremented and for opo Sp in incremented.



∴ [R1] = 40
[R2] = 30
[R3] = 25

End of Solution

Q.38 The p-type semiconducter bar is as shown below, with the energy band diagram.



Valence band E_V is inclined because of non-uniform doping. The value of electric field developed is
(Assume q is the charge of electron.)

(a) $\frac{2\Delta}{qL}$ (b) $\frac{3\Delta}{2qL}$

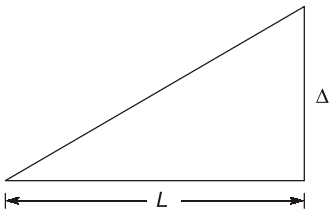
(c) $\frac{3\Delta}{qL}$ (d) $\frac{\Delta}{qL}$

Ans. **(d)**

$$E = \frac{1}{q}\frac{dE_v}{dx}$$

$$= \frac{1}{q}\frac{\Delta}{L}$$

$$= \frac{\Delta}{qL}$$



End of Solution

Q.39 Consider the following informations about $x(t)$:

(i) $x(t)$ = Real and even

(ii) $\text{Avg}_{x(t)} = 2$

(iii) $x(t) \rightleftharpoons a_K = \begin{cases} K, & 1 \le K \le 3 \\ 0, & K > 3 \end{cases}$

(iv) $T_0 = 6$

Power of $x(t)$ = ?

Ans. **(32)**

1. $kx(t)$ is real and even so a_k is also real and even $a_k = a_{-k}$
2. Average of $x(t)$ is 2 i.e., $a_0 = 2$.
3. $x(t) \rightarrow a_k = k \quad 1 \le k \le 3 \quad a_1 = 1 \quad a_{-1} = 1$
   $0 \quad k > 3 \quad a_2 = 2 \quad a_{-2} = 2$
   $a_3 = 3 \quad a_{-3} = 3$
4. $T_0 = 6$

Parsval's Power Theorem

$$\frac{1}{T}\int_0^T \left|x(t)^2\,dt\right| = \sum_{n=-\infty}^{+\infty} |a_k|^2$$

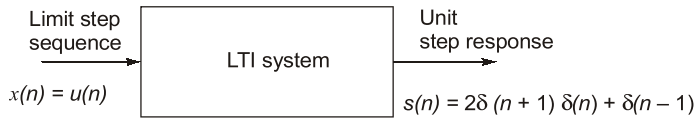
$$P_{x(t)} = \sum_{n=-\infty}^{+\infty} |a_k|^2 = |a_{-3}|^2 + |a_{-2}|^2 + |a_{-1}|^2 + |a_0|^2 + |a_1|^2 + |a_2|^2 + |a_3|^2$$

$$= 2|a_1|^2 + 2|a_2|^2 + 2|a_3|^2 + |a_0|^2$$
$$= 2 \times 1^2 + 2 \times (2)^2 + 2(3)^2 + (2)^2$$
$$= 2 + 8 + 18 + 4$$
$$P_{x(t)} = 32$$

End of Solution

Q.40 For the input $u(n)$, the output $y(n) = 2\delta(n+1) + \delta(n) + \delta(n-1)$. When the input $\left(\frac{1}{2}\right)^n u(n)$ is applied then value of $y(0)$ is _____.

Ans. (0)



The impulse respone $h(n) = s(n) - s(n-1)$

$$h(n) = 2\delta(n+1) + \delta(n) + \delta(n-1) - 2\delta(n) - \delta(n-1) - \delta(n-1-1)$$
$$= 2\delta(n+1) + \delta(n) + \delta(n-1) - 2\delta(n) - \delta(n-1) - \delta(n-2)$$
$$h(n) = 2\delta(n+1) - \delta(n) - \delta(n-2)$$

For input $x_1(n) = (1/2)^n u(n)$ then output $y_1(n) = x_1(n) * h(n)$

$$y_1(n) = \left(\frac{1}{2}\right)^n u(n) * [2\delta(n+1) - \delta(n) - \delta(n-2)]$$

$$y_1(n) = \left(\frac{1}{2}\right)^n u(n) \times 2\delta(n+1) - \left(\frac{1}{2}\right)^n u(n) \times \delta(n) - \left(\frac{1}{2}\right)^n u(n) \times \delta(n-2)$$

$$y_1(n) = 2\left(\frac{1}{2}\right)^{n+1} u(n+1) - \left(\frac{1}{2}\right)^n u(n) - \left(\frac{1}{2}\right)^{n-2} u(n-2)$$

$$y_1(n)|_{n=0} = 2\left(\frac{1}{2}\right)^1 u(1) - \left(\frac{1}{2}\right)^0 u(0) - \left(\frac{1}{2}\right)^{-2} u(-2)$$
$$= 1 - 1$$
$$y_1(0) = 0$$

End of Solution

■■■■