1. Consider a system of linear equations:

$x-2y+3z=-1$

$x-3y+4z=1 \ \ and$

$-2x+4y-6z=k$

The value of k for which the system has infinitely many solution is ____________.

A. 4 B. 2

C. 8 D. 5

Answer ||| B

Solution |||

$x-2y+3z=-1$

$x-3y+4z=1 \ \ and$

$-2x+4y-6z=k$

$$[A:B]=\begin{bmatrix} 1 & -2 & 3:-1 \\ 1 & -3 & 4:1 \\ -2 & 4 & 6:K \end{bmatrix}$$

$R_2 \to R_2 - R_1, R_3 \to R_3 + 2R_1$

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

For infinite may solution

ρ(A : B) = ρ(A)

= r < number of variables

ρ(A : B) = 2

k - 2 = 0

k = 2

2. A function $f(x)=1-x^2+x^3$ is defined innte closed interval [−1, 1]. The value of x, in the open interval (−1, 1) for which the mean value theorem is satisfied, is

A. −1/2 B. −1/3

C. 1/3 D. 1/2

Answer ||| B

Solution ||| Since f(1) ≠ f{-1), Roll's mean value theorem does not apply.

By Lagrange mean value theorem

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

$-2x+3x^2=1$

$x=1,-\frac{1}{3}$

x lies in (-1, 1)

$\Rightarrow x=-\frac{1}{3}$

3. Suppose A and B are two independent events with probabilities P(A) ≠ 0 and P(B) ≠ 0. Let $\overline{A}$ and $\overline{B}$ be their complements. Which one of the following statements is FALSE?

A. $P(A\cup B)=P(A)P(B)$ B. $P(A/B)=P(A)$

C. $P(A\cup B)=P(A)+\mathrm{P(B)}$ D. $P(\overline{A}\cup\overline{B})=P(\overline{A})+\mathrm{P}(\overline{\mathrm{B}})$

Answer ||| C

Solution ||| P(A ∪ B) = P(A) + F(B) - P(A ∩ B)

Since P(A ∩ B) = P(A) p(B)

(not necessarily equal to zero).

So, P(A ∪ B) = P(A) + P(B) is false.

4. Let $z=x+iy$ be a complex variable. Consider that contour integration is performed along the unit circle in anticlockwise direction. Which one of the following statements is NOT TRUE?

A. The residue of $\frac{z}{z^2-1}$ at z = 1 is 1/2

B. $\oint_C Z^2 dz = 0$

C. $\frac{1}{2\pi i}\oint_C \frac{1}{z}dz = 1$

D. $\overline{z}$ (complex conjugate of z) is an analytical function

Answer ||| D

Solution ||| $f(z)=\overline{z}=x-iy$

$u=x \ \ v=-y$

$\Rightarrow u_x=1 \quad v_x=0$

$u_y=0 \quad v_y=-1$

$u_x \neq v_y$ i.e. C - R not satisfied

⇒ $\overline{z}$ is not analytic function.

5. The value of p such that the vector $\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$ is an eigenvector of the matrix $\begin{bmatrix} 4 & 1 & 2 \\ p & 2 & 1 \\ 14 & -4 & 10 \end{bmatrix}$ is _________.

A. 17 B. 28

C.21 D.18

Answer ||| A

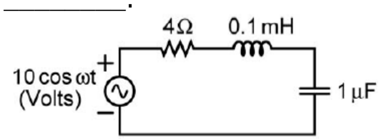
Solution ||| $AX=\lambda X$

$$\begin{bmatrix} 4 & 1 & 2 \\ p & 2 & 1 \\ 14 & -4 & 10 \end{bmatrix}\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}=\lambda\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$$

$$\begin{bmatrix} 12 \\ p+7 \\ 36 \end{bmatrix}=\lambda\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$$

$\frac{p+7}{12}=2 \Rightarrow p=17$

6. In the circuit shown, at resonance, the amplitude of the sinusoidal voltage (in Volts) across the capacitor is _________.



A. 45 B. 12

C.24 D.25

Answer ||| D

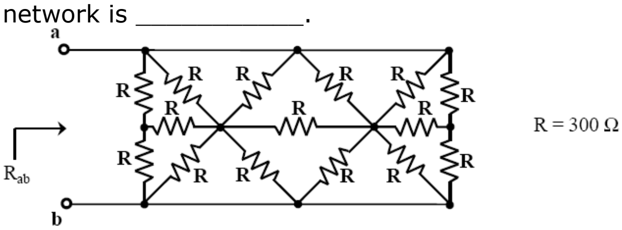
Solution ||| At resonance $I=\frac{10}{4}=2.5A$

$$\omega = \frac{1}{\sqrt{0.1\times10^{-3}\times10^{-6}}} = 10^5\, rad/\sec$$

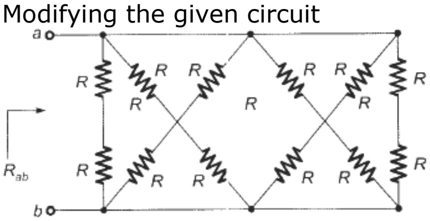
$$X_C = \frac{1}{\omega C} = \frac{1}{10^5\times1\times10^{-6}} = 10\Omega$$

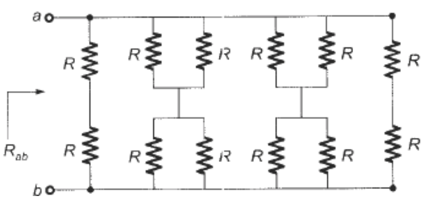
$$X_C = IX_C = 10\times2.5 = 25\,Volts$$

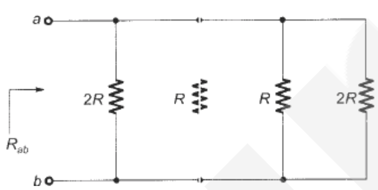
7. In the network shown in the figure, all resistor s are identical with R = 300 Ω. The resistance R_{ab} (in Ω) of the network is ____________.



A. 125 B. 231
C.100 D.200
Answer ||| C
Solution |||
Modifying the given circuit

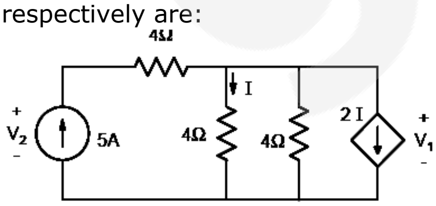




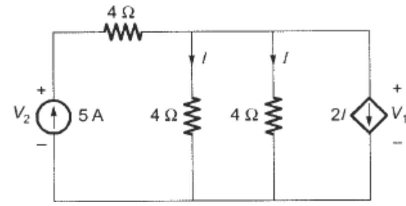


$$R_{ab} = \left(\frac{1}{2R}+\frac{1}{R}-\frac{1}{R}+\frac{1}{2R}\right)^{-1} = \frac{R}{3} = \frac{300}{3} = 100\Omega$$

8. In the given circuit, the values of V_1 and V_2 respectively are:



A. 5 V, 25 V B. 10 V, 30 V
C.15 V. 35 V D.0 V, 20 V
Answer ||| A
Solution |||



Current flowing through both the parallel 4 Ω will be I.
So, $V_2 = 4(I+I+2I)+4I$ by KVL
$I+I+2I=5$ by KVL

$$I = \frac{5}{4}A$$

$$V_2 = 4\times5+\frac{4\times5}{4} = 25V$$

$$V_1 = 4I = \frac{4\times5}{4} = 5V$$

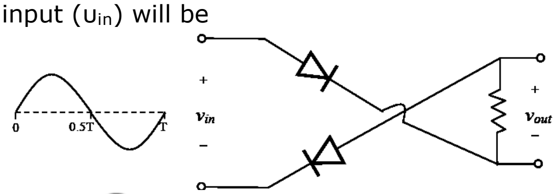
9. A region of negative differential resistance is observed in the current voltage characteristics of a silicon PN junction if
A. both the P-region and the N-region are heavily doped
B. the N-region is heavily doped compared to the P-region
C.the P-region is heavily doped compared to the N-region
D.an intrinsic silicon region is inserted between the P-region and the N-region
Answer ||| A
Solution ||| A region of negative differential resistance is observed in the current voltage characteristics of a silicon PN junction if both the P-region and the N-region are heavily doped.

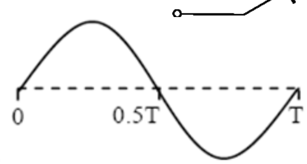
10. A silicon sample is uniformly doped with donor type impurities with a concentration of 1016 /cm³. The electron and hole mobilities in the sample are 1200 cm²/V-s and 400 cm² /V-s respectively.
Assume complete ionization of impurities. The charge of an electron is 1.6×10^{-19} C. The resistivity of the sample (in Ω-cm) is __________.
A. 0.345 B. 0.520
C.0.234 D.0.423
Answer ||| B
Solution |||

$$P = \frac{1}{\sigma_N} = \frac{1}{N_D q\mu_n}$$

$$= \frac{1}{10^{16}\times1.6\times10^{-19}\times1200} = 0.52\Omega - cm$$

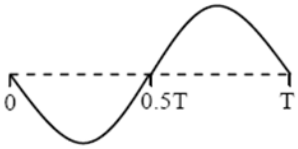
11. For the circuit with ideal diodes shown in the figure, the shape of the output (υ_{out}) for the given sine wave input (υ_{in}) will be



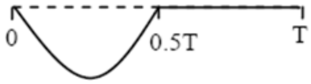


A.

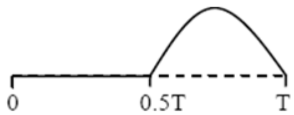
B.



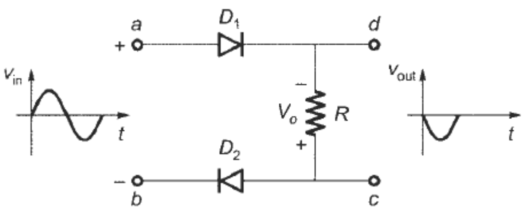
C.



D.

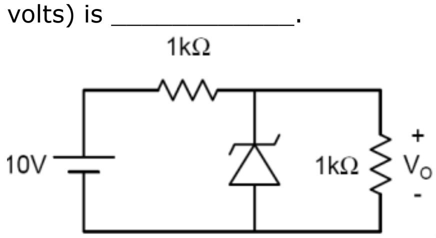


Answer ||| C
Solution ||| The circuit can be redrawn as

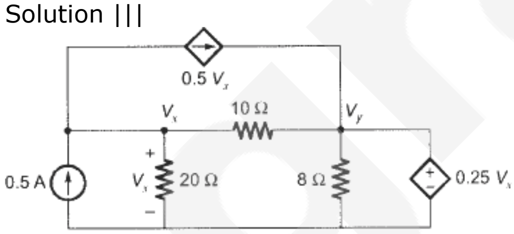


During positive pulse, both diodes are forward biased.
During negative pulse, both diodes are reverse biased.
So, V_o = 0V

12. In the circuit shown below, the Zener diode is ideal and the Zener voltage is 6V. The output voltage V_0 (in volts) is _____________.



A. 6 B. 8
C.4 D.2
Answer ||| B
Solution |||

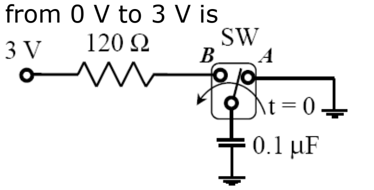


$$\frac{V_x}{20}+\frac{V_x-V_y}{10}+0.5V_x=5A\ ...(i)$$

$V_y = 0.25V_x$ . . . (ii)

$V_x = 8 Volts$

13. In the circuit shown, the switch SW is thrown from position A to position B at time t = 0. The energy (in μJ) taken from the 3V source to charge the 0.1 μF capacitor from 0 V to 3 V is



A. 0.3 B. 0.45
C.0.9 D.3
Answer ||| C
Solution |||

$v_c(0^-) = 0\,\text{V}$

$v_c(0^+) = 0\,\text{V}$

$v_c(\infty) = 0\,\text{V}$

Time constant

$\tau = RC = 120\times 0.1\times 10^{-6}$

$v_c(t) = 3+(0-3)e^{-t/\tau} = 3+(1-e^{-t/\tau})$

$$I_c(t)=\frac{Cdv_c(t)}{dt}=\frac{0.1\times10^{-6}\times3\times e^{-t/\tau}}{\tau}$$

$$=\frac{0.1\times10^{-6}\times3e^{-t/\tau}}{120\times0.1\times10^{-6}}=\frac{1}{40}e^{-t/\tau}$$

Energy $=\int_0^\infty VIdt$

$$=\int_0^\infty 3.\frac{1}{40}\times e^{-t/\tau}=-\frac{3}{40}\times\tau e^{-t/\tau}\Big|_0^\infty=\frac{3}{40}\times12\times0^{-6}=0.9\mu J$$

14. In an 8085 microprocessor, the shift registers which store the result of an addition and the overflow bit are, respectively
A. B and F B. A and F
C.H and F D.A and C
Answer ||| B
Solution ||| Shift register are accumulator and flag register (A & F).
Hence B. is the correct option.

15. A 16 Kb (=16,384 bit) memory array is designed as a square with an aspect ratio of one (number of rows is equal to the number of columns). The minimum number of address lines needed for the row decoder is ___________ .
A. 5 B. 7
C.8 D.9
Answer ||| B
Solution ||| Memory size = 16 kB = 214 bits
Number of address lines = Number of data lines
From
$2^n \bullet 2^n = 2^{14}$
From n = 7

16. Consider a four bit D to A converter. The analog value corresponding to digital signals of values 0000 and 0001 are 0 V and 0.0625 V respectively. The analog value (in Volts) corresponding to the digital signal 1111 is _________.
A. 0.8724 B. 0.8283
C.0.9375 D.0.9127
Answer ||| C
Solution ||| Step size = 0.0625 V
Decimal equivalent = 15
Analog output = 15 x 0.0625 = 0.9375 Volts

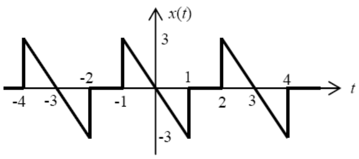
17. The result of the convolution x(−t) * δ (−t − t_0) is
A. $x(t+t_0)$ B. $x(t-t_0)$
C. $x(-t+t_0)$ D. $x(-t-t_0)$

Answer ||| D

Solution ||| $x(-t)*\delta(-t-t_0)=x(-t)*\delta(t+t_0)$

$=x(-t-t_0)$

18. The waveform of a periodic signal x(t) is shown in the figure.



A signal g(t) is defined by $g(t)=x\left(\frac{t-1}{2}\right)$. The average power of g(t) is ___________.

A. 7 B. 2

C.6 D.8

Answer ||| B

Solution ||| $x\left(\frac{t-1}{2}\right)=-\frac{3}{2}(t-1) \quad -1<t<3$

And T = 8

Average power $\frac{1}{8}\int_1^3\left(-\frac{3}{2}(t-1)\right)^2 dt=2$

19. Negative feedback in a closed-loop control system DOES NOT

A. reduce the overall gain

B. reduce bandwidth

C.improve disturbance rejection

D.reduce sensitivity to parameter variation

Answer ||| B

Solution ||| Negative Feedback reduces gain but Bandwidth is (↑). So, Negative feedback in a closed-loop control system DOES NOT reduce bandwidth.

20. A unity negative feedback system has the open-loop transfer function $G(s)=\frac{K}{s(s+1)(s+3)}$. The value of the gain K (>0) at which the root locus crosses the imaginary axis is _____________.

A. 500 B. 400

C.200 D.300

Answer ||| B

Solution |||

$$T(s)=\frac{G(s)}{1+G(s)H(s)}=\frac{K}{s^2+10s+K}$$

Comparing with standard second order transfer function

$$T(s)=\frac{\omega_n^2}{s^2+2z\omega_n s+\omega_n^2}$$

We have

$\omega_n^2=K$

And $2\xi\omega_n=10$

$\because$ 25 (given)

$\therefore \omega_n=\frac{10}{2\times 0.25}=20$

And $K=\omega_n^2=(20)^2=400$

21. The polar plot of the transfer function $G(s)=\frac{10(s+1)}{s+10}$ for $0\le\omega<\infty$ will be in the

A. first quadrant B. second quadrant

C.third quadrant D.fourth quadrant

Answer ||| A

Solution ||| $G(s)=\frac{10(s+1)}{(s+10)}$

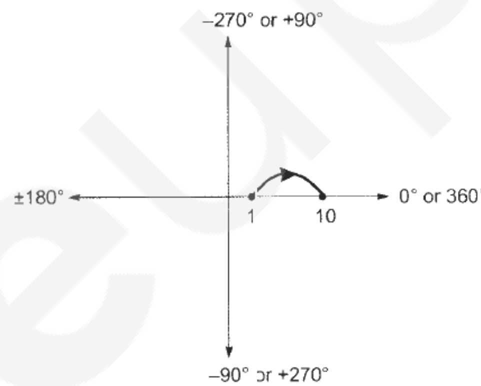
For

$\omega=0\Rightarrow M_1=1 \text{ and } \phi_1=0°$

$\omega=0\Rightarrow M_2=10$

$\text{And } \phi_2=-\tan^{-1}\infty+\tan^{-1}\infty=0°$

$\therefore$ Polar plot



As the zero is nearer to the imaginary axis hence the direction of polar plot is clockwise.

22. A sinusoidal signal of 2 kHz frequency is applied to a delta modulator. The sampling rate and step-size Δ of the delta modulator are 20, 000 sample per second and 0.1 V, respectively. To prevent slope overload, the maximum amplitude of the sinusoidal signal (in Volts) is

A. $\frac{1}{2\pi}$ B. $\frac{1}{\pi}$

C. $\frac{2}{\pi}$ D.π

Answer ||| A

Solution ||| Slope signal = Slope of delta modulator

$A_m(2\pi f_m)=\Delta f_s$

$A_m(2\pi 2\times 10^3)=20,000\times 0.1$

$A_m=\frac{1}{2\pi}$

23. Consider the signal

$s(t)=m(t)\cos(2\pi f_c t)+\hat{m}(t)\sin(2\pi f_c t)$

Where $\hat{m}(t)$ denotes the Hilbert transform of m(t) and the bandwidth of m(t) is very small compared to f_c. The signal s(t) is a

A. high-pass signal

B. low-pass signal

C.band-pass signal

D.double sideband suppressed carrier signal

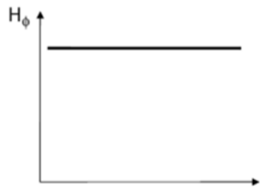
Answer ||| C

Solution ||| Given s(f) is an SSB modulated signal.

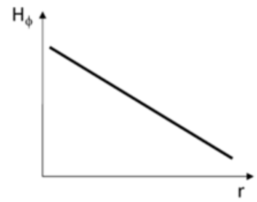
Alternate Solution:

It is the canonical representation of a bandpass signal.

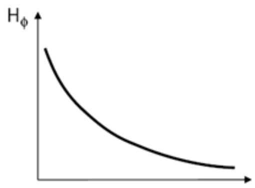
24. Consider a straight, infinitely long, current carrying conductor lying on the z-axis. Which one of the following plots (111 linear scale) qualitatively represents the dependence of H_ϕ oil r, where H_ϕ is the magnitude of the azimuthal component of magnetic field outside the conductor and r is the radial distance from the conductor?



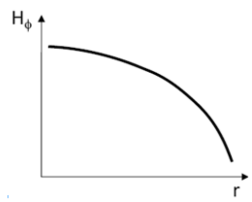
A.



B.



C.



D.

Answer ||| C

Solution ||| $H\phi = \frac{I}{2\pi r}\hat{a}_\phi$

$\Rightarrow H_\phi \propto \frac{1}{r}$

Option on C.is satisfied.

25. The electric field component of a plane wave traveling in a lossless dielectric medium is given by $\vec{E}(z,t) = \hat{a}_y 2\cos\left(10^8 t - \frac{z}{\sqrt{2}}\right)$ V/m. The wavelength (in m) foe the wave is ____________.

A. 8.89 B. 7.28

C.4.87 D.6.23

Answer ||| A

Solution |||

$$\vec{E}(z,t) = \hat{a}_y 2\cos\left(10^8 t - \frac{z}{\sqrt{2}}\right) V/m$$

General form of

$$\vec{E}(z,t) = \hat{a}_y E_0 \cos(\omega t - \beta z) V/m$$

Comparing both, we get

$$\beta = \frac{1}{\sqrt{2}}$$

Since, $\beta = \frac{2\pi}{\lambda}$

$$\Rightarrow \lambda = \frac{2\pi}{\beta} = \frac{2\pi}{\frac{1}{\sqrt{2}}} = 2\sqrt{2}\pi m$$

$$\Rightarrow \lambda = 8.88m$$

26. The solution of the differential equation $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + y = 0$ with y(0 = y′(0) = 1 is

A. $(2-t)e^t$ B. $(1+2t)e^{-t}$

C. $(2+t)e^{-t}$ D. $(1-2t)e^t$

Answer ||| B

Solution |||

$r^2 + 2r + 1 = 0$

roots are equal $r_1 = r_2 = -1$

So, $y = c_1e^{-t} + c_2t\, e^{-t}$

$y(0) = C_1 = 1$

$y' = -C_1e^{-t} - C_2t\, e^{-t} + C_2e^{-t}$

$y'(0) = -C_1 + C_2 = 1$

$C_2 = 2$

So solution is $y = e^{-t} + 2te^{-t}$

$y = (1 + 2t)\, e^{-t}$.

27. A vector $\vec{P}$ is given by $\vec{P} = x^3y\vec{a}_x - x^2y^2\vec{a}_y - x^2yz\vec{a}_z$.

Which one of the following statements is TRUE?

A. $\vec{P}$ is solenoidal, but not irrotational

B. $\vec{P}$ is irrotational, but not solenoidal

C. $\vec{P}$ is neither solenoidal nor irrotational

D. $\vec{P}$ is both solenoidal and irrotational

Answer ||| A

Solution |||

$\vec{P} = x^3y\vec{a}_x - x^2y^2\vec{a}_y - x^2yz\vec{a}_z$

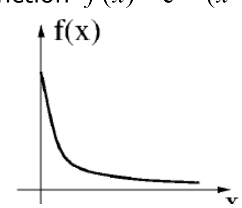
For solenoidal $\nabla.\vec{P} = 0$

$\Rightarrow \nabla.\vec{P} = \frac{\partial P_x}{\partial_x} + \frac{\partial P_x}{\partial_x} + \frac{\partial P_z}{\partial_z}$

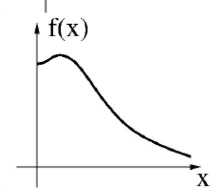
$= 3x^2y - 2x^2y - x^2y$

$\Rightarrow \vec{P}$ is solenoidal

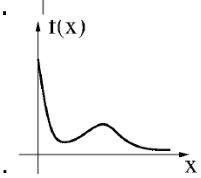
28. Which one of the following graphs describes the function $f(x) = e^{-(x)}(x^2 + x + 1)$?



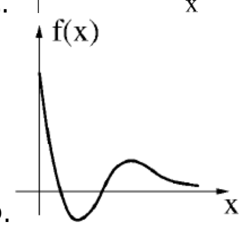
A.



B.



C.



D.

Answer ||| B

Solution ||| $f(x) = e^{-x}(x^2 + x + 1)$

$f'(x) = e^{-x}(2x+1) - e^{x}(x - x^2)$

$= e^{-x}(x - x^2) = -e^{x}(x)(1-x)$

Putting f′(x) = 0, we get
x = 0, or x = 1

$f''(x) = e^{-x}(1-2x) - e^{-x}(x - x^2)$

$= e^{-x}(1 - 3x + x^2)$

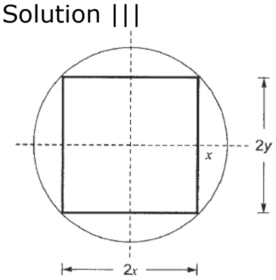
At x = 0, f"(x) = 1 (so we have a minimum)

At x = 1, $f''(x) = -\frac{1}{e}$

(so we have a maximum), curve B. shows a single local minimum = 0 and a single local maximum at x = 1.

29. The maximum area (in square units) of a rectangle whose vertices lie on the ellipse $x^2 + 4y^2 = 1$ is ________.

A. 1 B. 5
C.6 D.8
Answer ||| A
Solution |||



$x^2 + 4y^2 = 1$

Area of rectangle

$= 2x.2y = 4xy$

Let f = (Area)^2=16x^{2}y^2

$4x^2(1-x^2) \quad (\because 1 - x^2 = 4y^2)$

$f'(x) = 0$

We get $x = \frac{1}{\sqrt{2}}$

$y = \frac{1}{\sqrt{8}}$

$Area = 4xy = 4 \times \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{8}} = 1$

30. The damping ratio of a series RLC circuit can be expressed as

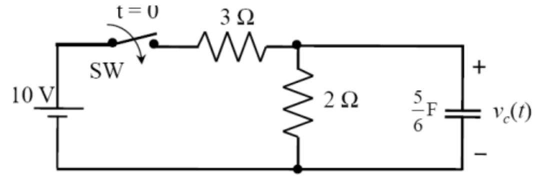
A. $\frac{R^2C}{2L}$ B. $\frac{2L}{R^2C}$

C. $\frac{R}{2}\sqrt{\frac{C}{L}}$ D. $\frac{2}{R}\sqrt{\frac{L}{C}}$

Answer ||| C

Solution ||| Damping ratio $= \frac{R}{2}\sqrt{\frac{C}{L}}$

31. In the circuit shown, switch SW is closed at t = 0. Assuming zero initial conditions, the value of $v_c(t)$ (in Volts) at t = 1 sec is _____________.

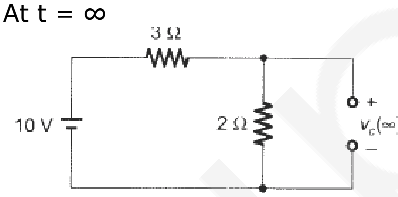


A. 2.528 B. 4.234
C.3.343 D.4.343
Answer ||| A

Solution ||| $v_c(0^-) = 0\,\text{V}$

$v_c(0^+) = 0\,\text{V}$

At t = ∞



$v_c(\infty) = \frac{2}{2+3} \times 10$

= 4V [By voltage divider]

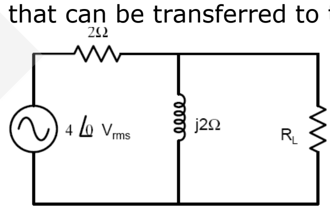
$v_c(t) = 4[I - e^{-t/\tau}]$

$\tau = R_{eq}C = \frac{3\times 2}{3+2} \times \frac{5}{6}$

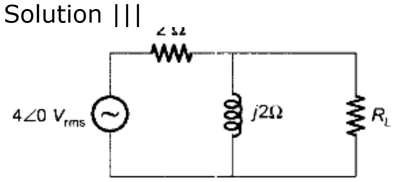
= 1 sec

$v_c(1) = 4[1 - e^{-1/1}] = 2.528$ volts

32. In the given circuit, the maximum power (in Watts) that can be transferred to the load R_L is _________.



A. 3.283 B. 1.649
C.2.832 D.3.123
Answer ||| B
Solution |||

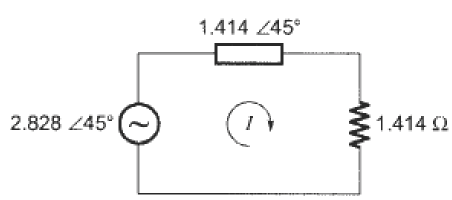


For maximum power transfer

$R_L = |R_{Th}| = |2 \,||\, j2|$

$= \left|\frac{2 \times j2}{2 + j2}\right| = 1.414\Omega$

$V_{Th} = \frac{4\angle 0^\circ}{2 + j2} = 2 + j2 = 2.828\angle 45^\circ$



$I = \frac{2.828\angle 45^\circ}{1.414\angle 45^\circ + 1.414} = 1.08\angle 22.5^\circ$

Power = $I^2R = (1.08)^2 \times \sqrt{2} = 1.649W$

33. The built-in potential of an abrupt p-n junction is 0.75 V. If its junction capacitance (Q) at a reverse bias (V_R) of 1.25 V is 5 pF, the value of C_J (in pF) when V_R = 7.25 V is_________.
A. 3.4 B. 2.5
C.4.7 D.3.5
Answer ||| B
Solution |||

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

$$\frac{C_{2j}}{C_{1j}} = \sqrt{\frac{V_{bi}+V_{R_1}}{B_{bi}+V_{R_2}}}$$

$$C_{2j} = C_{1j}\sqrt{\frac{2}{8}} = \frac{C_{1j}}{2} = 2.5pF$$

So, answer is 2.5.

34. A MOSFET in saturation has a drain current of 1 mA for V_{DS} = 0.5 V. If the channel length modulation coefficient is 0.05 V^{-1}, the output resistance (in kΩ) of the MOSFET is ________.
A. 25 B. 18
C.20 D.30
Answer ||| C
Solution ||| Under channel length modulation

$$I_D = I_{Dsat}(1+\lambda V_{DS})$$

$$\frac{dI_D}{dV_{DS}} = \frac{1}{r_0} = \lambda I_{Dsat}$$

$$r_0 = \frac{1}{\lambda I_{Dsat}} = \frac{1}{0.05\times 10^{-3}} = 20k\Omega$$

35. For a silicon diode with long P and N regions, the accepter and donor impurity concentrations are 1 x 101 cm^{-3} and 1 × 10^{15} cm^{-3}, respectively. The lifetimes of electrons in P region and holes in N region are both 100 μs. The electron and hole diffusion coefficients are 49 cm^2/s and 36 cm^2/s, respectively. Assume kT/q = 26 mV, the intrinsic earner concentration is 1× 10^{10} cm^{-3}, and q = 1.6 × 10^{-19} C. When a forward voltage of 208 mV is applied across the diode, the hole current density (in nA/cm^2) injected from P region to N region is _______.
A. 356.17 B. 156.23
C.286.17 D.432.12
Answer ||| C
Solution ||| The hole current density injected from P region to N region is given by

$$\frac{qn_i^2 D_p}{N_D L_p}\left[\exp\left(\frac{V_{FB}}{V_T}\right)-1\right]$$

Where,
Q = charge on electron
n_i = Intrinsic carrier concentration in silicon
N_D = Donor doping
D_P = Hole diffusion coefficient
L_p = Mean diffusion length of hole
V_{FB} = Forward voltage applied across diode
V_T = kT/q = 26 mV

$$L_p = \sqrt{\tau_p D_p} = \sqrt{100\times 10^{-6}\times 36}$$
$$= 0.06cm$$

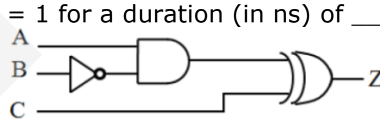
Using the above values, we get hole current density injected from P region to N region is = 286.17 nA/cm^2

36. The Boolean expression $F(X,Y,Z) = \overline{X}Y\overline{Z} + X\overline{Y}\overline{Z} + XY\overline{Z} + XYZ$ converted into the canonical product of sum (POS) form is
A. $(X+Y+Z)(X+Y+\overline{Z})(X+\overline{Y}+\overline{Z})(\overline{X}+Y+\overline{Z})$
B. $(X+\overline{Y}+Z)(\overline{X}+Y+\overline{Z})(\overline{X}+\overline{Y}+Z)(\overline{X}+\overline{Y}+\overline{Z})$
C. $(X+Y+Z)(\overline{X}+Y+\overline{Z})(X+\overline{Y}+Z)(\overline{X}+\overline{Y}+\overline{Z})$
D. $(X+\overline{Y}+\overline{Z})(\overline{X}+Y+Z)(\overline{X}+\overline{Y}+Z)(X+Y+Z)$
Answer ||| A
Solution ||| $F(X,Y,Z) = \overline{X}Y\overline{Z} + X\overline{Y}\overline{Z} + XY\overline{Z} + XYZ$

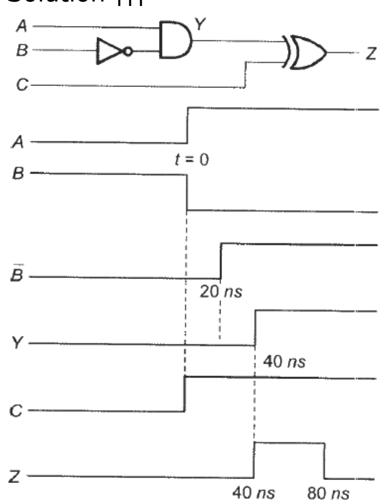
X \ YZ	00	01	11	10
0	0	0	0	1
1	1	1	0	1

$$F = (X+Y+Z)(X+Y+\overline{Z})(X+\overline{Y}+\overline{Z})(\overline{X}+Y+\overline{Z})$$

37. All the logic gates shown in the figure have a propagation delay of 20 ns. Let A = C = 0 and B = 1 until time t = 0. At t = 0, all the inputs flip (i.e., A = C = 1 and B = 0) and remain in that state. For t > 0, output Z = 1 for a duration (in ns) of __________.



A. 20 B. 40
C.35 D.25
Answer ||| B
Solution |||



Zis '1' for 40 n-sec.

38. A 3-input majority gate is defined by the logic function M(a, b,c) = ab + be + ca . Which one of the following gates is represented by the function $M(\overline{M(a,b,c)}, M(a,b,\overline{c}), c)$?
A. 3-input NAND gate B. 3-input XOR gate
C.3-input NOR gate D.3-input XNOR gate

Answer ||| B

Solution ||| $M(a,b,c) = ab + bc + ca$

$\overline{M(a,b,c)} = \overline{ab + bc + ca}$

$= \overline{ab}.\overline{bc}.\overline{ca}$

$= (\bar{a} + \bar{b})(\bar{b} + \bar{c})(\bar{c} + \bar{a})$

$M(a,b,\bar{c}) = ab + b\bar{c} + \bar{c}a$

$M(\overline{M(a,b,c)}, M(a,b,\bar{c})c) =$

$\begin{bmatrix} (\overline{ab}.\overline{bc}.\overline{ca})(ab + b\bar{c} + \bar{c}a) \\ +(ab + b\bar{c} + \bar{c}a)(c) + (\overline{ab}.\overline{bc}.\overline{ca})c \end{bmatrix}$

$\begin{bmatrix} (\bar{a} + \bar{b})(\bar{b} + \bar{c})(\bar{c} + \bar{a})(ab + b\bar{c} + \bar{c}a) \\ + abc + (\bar{a} + \bar{b})(\bar{b} + \bar{c}) + (\bar{c} + \bar{a})c \end{bmatrix}$

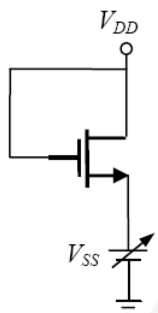
$= (\bar{a} + \bar{b})(\bar{b} + \bar{c})(\bar{c} + \bar{a})[ab + b\bar{c} + \bar{c}a + c] + abc$

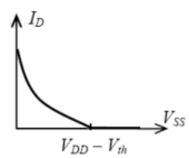
$= (\bar{a}\bar{b} + \bar{b}\bar{c} + \bar{c}\bar{a})[a + b + c] + abc$

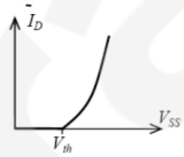
$F = \bar{a}\bar{b}\bar{c} + b\bar{c}\bar{a} + c\bar{a}\bar{b} + abc$

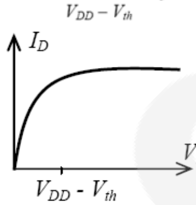
$F = A \oplus B \oplus C$

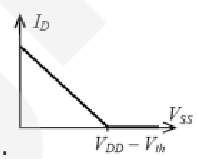
39. For the NMOSFET in the circuit shown, the threshold voltage is V_{th}, where $V_{th} > 0$. The source voltage V_{SS} is varied from 0 to V_{DD}. Neglecting the channel length modulation, the drain current I_D as a function of V_{SS} is represented by



A. 

B. 

C. 

D. 

Answer ||| A

Solution ||| $V_{GS} = V_{DS}$

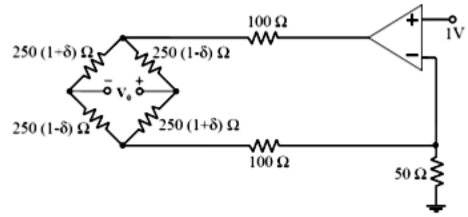
Hence MOS transistor is in saturation.

In saturation,

$I_D = k(V_{GS} - V)_r^2 = k(V_{DD} - V_{SS} - V_T)^2$

As V_{ss} increases I_D decreases (Not linearly because square factor) Hence option A. is correct.

40. In the circuit shown, assume that the opamp is ideal. The bridge output voltage V_0 (in mV) for δ = 0.05 is ___________.



A. 350 B. 250

C.450 D.125

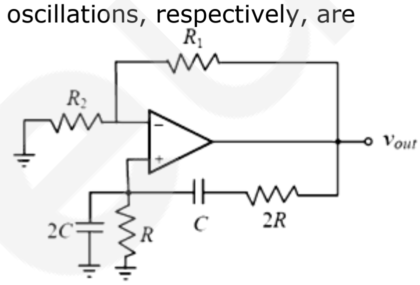
Answer ||| B

Solution ||| $I_{50\Omega} = \frac{1}{50} A = I_{100\Omega}$

$V_0 = \frac{1}{100}[250(1+\delta) - 250(1-\delta)]$

$= \frac{1}{100} \times 250 = 0.25V = 250mV$

41. The circuit shown in the figure has an ideal opamp. The oscillation frequency and the condition to sustain the oscillations, respectively, are



A. $\frac{1}{CR}$ and $R_1 = R_2$

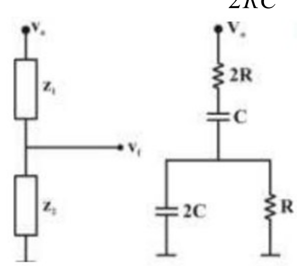
B. $\frac{1}{CR}$ and $R_1 = 4R_2$

C. $\frac{1}{2CR}$ and $R_1 = R_2$

D. $\frac{1}{2CR}$ and $R_1 = 4R_2$

Answer ||| D

Solution ||| $\omega_0 = \frac{1}{2RC}$ & ($R_1 = 5R_2$)



Frequency of Wein bridge is $\omega_0 = \frac{1}{RC}$ but here Time constant is doubled so frequency becomes halved ⇒ $\omega_0 = \frac{1}{2RC}$

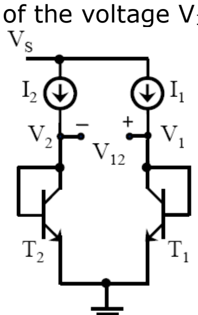
z_1 = 2R + $\frac{1}{j\omega C} = 2(R - jR)$

$$z2=\frac{R\times\frac{1}{2j\omega C}}{R+\frac{1}{2j\omega C}}=\frac{\frac{R}{2}\times\frac{1}{j}\times 2R}{R+jR}$$

$$\beta=\frac{z_2}{z_1+z_2}=\frac{1}{5}$$

Now, A = 5 1 + $\frac{R_1}{R_2}=5$ ($R_1 = 4R_2$)

42. In the circuit shown, I_1 = 80 mA and I_2 = 4 mA. Transistors T_1 and T_2 are identical. Assume that the thermal voltage V_T is 26 mV at 27°C. At 50°C, the value of the voltage $V_{12} = V_1 - V_2$ (in mV) is ________.



A. 87.14 B. 83.15
C.84.12 D.81.13
Answer ||| B

Solution ||| $I_2=I_s e^{\frac{V_{BE_2}}{\eta V_T}}$

$V_{BE_2}=V_2$

$I_1=I_s e^{\frac{V_{BE_1}}{\eta V_T}}$

$V_{BE_1}=V_1$

$\frac{I_1}{I_2}=e^{\frac{v_1-v_2}{\eta V_T}}$

Since V_T at 27° is 26 mV then V_T at 50° is 27.99 mV. Thus

$V_1-V_2=83.15mV$

43. Two sequences [a, b, c] and [A, B, C] are related as

$$\begin{bmatrix}A\\B\\C\end{bmatrix}=\begin{bmatrix}1&1&1\\1&W_3^{-1}&W_3^{-2}\\1&W_3^{-2}&W_3^{-4}\end{bmatrix}\begin{bmatrix}a\\b\\c\end{bmatrix}$$ where $W_3=e^{j\frac{2\pi}{3}}$

If another sequence [p, q, r] is derived as,

$$\begin{bmatrix}p\\q\\r\end{bmatrix}=\begin{bmatrix}1&1&1\\1&W_3^{1}&W_3^{2}\\1&W_3^{2}&W_3^{4}\end{bmatrix}\begin{bmatrix}1&0&0\\0&W_3^{2}&0\\0&0&W_3^{4}\end{bmatrix}\begin{bmatrix}A/3\\B/3\\C/3\end{bmatrix}$$

then the relationship between the sequences [p, q, r] and [a, b, c] is

A. [p, q, r] = [b, a, c] B. [p, q, r] = [b, c, a]
C.[p, q, r] = [c, a, b] D.[p, q, r] = [c, b, a]
Answer ||| C

Solution ||| $\begin{bmatrix}A\\B\\C\end{bmatrix}=\begin{bmatrix}a+b+c\\a+bW_3^{-1}+cW_3^{-2}\\a+bW_3^{-2}+cW_3^{-1}\end{bmatrix}$

$$\begin{bmatrix}p\\q\\r\end{bmatrix}=\begin{bmatrix}1&W_3^2&W_3^1\\1&W_3^1W_3^2&W_3^2W_3^1\\1&W_3^2W_3^2&W_3^1W_3^1\end{bmatrix}\begin{bmatrix}\frac{a+b+c}{3}\\\frac{a+bW_3^{-1}+cW_3^{-2}}{3}\\\frac{a+bW_3^{-2}+cW_3^{-1}}{3}\end{bmatrix}$$

Where $W_3^1=e^{j\frac{2\pi}{3}}$

$W_3^2=e^{j\frac{4\pi}{3}}$

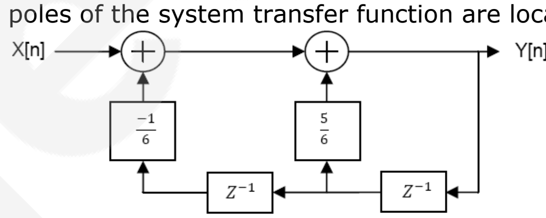
$W_3^{-1}=e^{-j\frac{2\pi}{3}}$

$W_3^{-2}=e^{-j\frac{4\pi}{3}}$

$W_3^{-4}=W_3^{-1}=e^{-j\frac{2\pi}{3}}$

$=\begin{bmatrix}c\\a\\b\end{bmatrix}$

44. For the discrete-time system shown in the figure, the poles of the system transfer function are located at



A. 2, 3 B. $\frac{1}{2},3$

C. $\frac{1}{2},\frac{1}{3}$ D. $2,\frac{1}{3}$

Answer ||| C

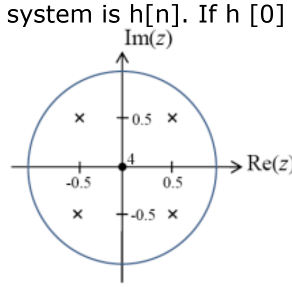
Solution ||| The difference equation of the system

$$x(n)-\frac{1}{6}y(n-2)+\frac{5}{6}y(n-1)=y(n)$$

$$H(z)=\frac{Y(z)}{X(z)}=\frac{1}{1+\frac{1}{6}z^{-2}-\frac{5}{6}z^{-1}}$$

Poles are at $z=\frac{1}{2},\frac{1}{3}$

45. The pole-zero diagram of a causal and stable discrete-time system is shown in the figure. The zero at the origin has multiplicity 4. The impulse response of the system is h[n]. If h [0] = 1, we can conclude



A. h [n] is real for all n
B. h[n] is purely imaginary for all n

C. h [n] is real for only even n
D. h [n] is purely imaginary for only odd n
Answer ||| A

Solution ||| $H(z)=\dfrac{z^4}{\left[\left(z-\frac{1}{2}\right)^2+\frac{1}{4}\right]\left[\left(z+\frac{1}{2}\right)^2+\frac{1}{4}\right]}$

Poles = $=\frac{1}{2}\pm j\frac{1}{2},-\frac{1}{2}\pm j\frac{1}{2}$

$$=\frac{z^4}{\left(z^2-z+\frac{1}{2}\right)\left(z^2+z+\frac{1}{2}\right)}=\frac{z^4}{z^4+z^2+\frac{1}{4}-z^2}$$

$$H(z)=\frac{z^4}{z^4+\frac{1}{4}}$$

$$=Z^4+\frac{1}{4}\Big)\quad Z^4\quad \Big(1-\frac{1}{4}z^{-4}$$

$$\frac{Z^4+\frac{1}{4}}{-\frac{1}{4}}$$

46. The open-loop transfer function of a plant in a unity feedback configuration is given as $G(s)=\dfrac{K(s+4)}{(s+8)(s^2-9)}$.
The value of the gain K(> 0) for which −1 + j2 lies on the root locus is ___________.
A. 25.54 B. _26.34
C. 28.43 D. 84.23
Answer ||| A
Solution |||

If G(s) = $\dfrac{K(s+2)}{(s+8)(s^2-9)}$, H(s) = 1

Make $|G(s)H(s)|=1$ ⇒ K = 25.54

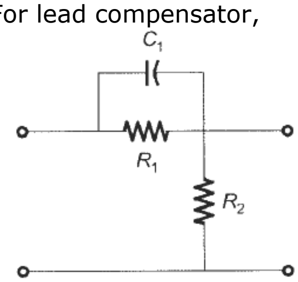
Or can be solved by use of characteristic equation

47. A lead compensator network includes a parallel combination of R and C in the feed-forward path. If the transfer function of the compensator is

$G_c(s)=\dfrac{s+2}{s+4}$, the value of RC is __________.
A. 0.5 B. 0.7
C. 1.5 D. 0.8
Answer ||| A

Solution ||| $G_C(s)=\dfrac{s+2}{s+4}$ ....(i)

For lead compensator,



Transfer function $=\dfrac{1+s\tau}{1+\alpha s\tau}$ ...(ii)

Where,
τ = Lead time constant = R_1C

And $\alpha=\dfrac{R_2}{R_1+R_2}$

Comparing equation (i) and (ii), we get

$\tau=\frac{1}{2}$ and $\alpha\tau=\frac{1}{4}$

Or $\alpha=\frac{1}{2}$

RC time constant = 0.5

48. A plant transfer function is given as $G(s)=\left(K_p+\dfrac{K_I}{s}\right)\dfrac{1}{s(s+2)}$. When the plant operates in a unity feedback configuration, the condition for the stability of the closed loop system is

A. $K_P>\frac{K_I}{2}>0$
B. $2K_I>K_P>0$
C. $2K_I<K_P$
D. $2K_I>K_P$
Answer ||| A

Solution ||| $G(s)=\left(K_p+\dfrac{K_i}{s}\right)\left(\dfrac{1}{s(s+2)}\right)$

The closed loop transfer function for unity feedback

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

$$=\frac{K_ps+K_i}{s^3+2s^2+K_ps+K_i}$$

Using Routh's tabular form:

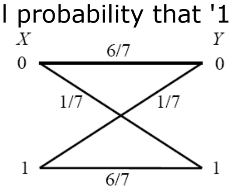
$$\begin{array}{c|cc} S^3 & 1 & K_p \\ S^2 & 2 & K_I \\ S^1 & \frac{2K_p-K_i}{2} & 0 \\ S^0 & K_p & \end{array}$$

For system to be stable:
$K_p>0$

And $\dfrac{2K_p-K_I}{2}>0$ Or $2K_p-K_I>0$

Or $K_p>\dfrac{K_I}{2}>0$

49. The input X to the Binary Symmetric Channel (BSC) shown in the figure is '1' with probability 0.8. The cross-over probability is 1/7. If the received bit Y= 0, the conditional probability that '1' was transmitted is _______.



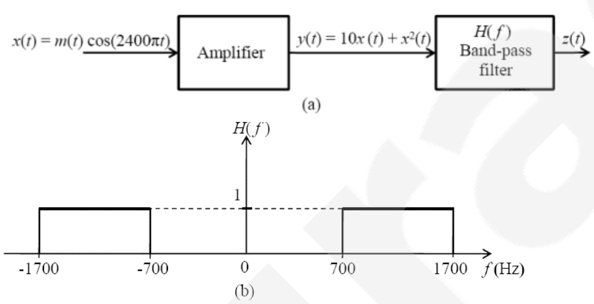
A. 0.5 B. 0.4
C. 0.7 D. 0.3
Answer ||| B
Solution ||| $P(x=1/Y=0)$

$$=\frac{P(Y=0/x=1)P(x=1)}{P(Y=0/X=1)P(X=1)+P(Y=0/X=0)P(X=0)}$$

$$=\frac{\left(\frac{1}{7}\right)(0.8)}{\left(\frac{1}{7}\right)(0.8)+\left(\frac{6}{7}\right)(0.2)}=0.4$$

50. The transmitted signal in a GSM system is of 200 kHz bandwidth and 8 users share a common bandwidth using TDMA. If at a given time 12 users are talking in a cell, the total bandwidth of the signal received by the base station of the cell will be at least (in kHz) ________ .
A. 300 kHz B. 400 kHz
C.450 kHz D.500 kHz
Answer ||| B
Solution ||| In the question it is given that GSM requires 200 kHz for 8 users and uses TDMA scheme to accommodate them. Thus for the next users we will required an extra of 200 kHz bandwidth. Thus 400 kHz bandwidth is to be used.

51. In the system shown in Figure (a), m(t) is a low-pass signal with bandwidth W Hz. The frequency response of the band-pass filter H(f) is shown in Figure (b). If it is desired that the output signal z(t) = 10x(t). The maximum value of W (in Hz) should be strictly less than __________.



(a)
(b)

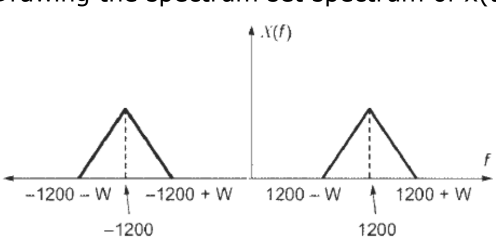
A. 450 B. 400
C. 350 D. 500
Answer ||| C
Solution ||| $x(t)=m(t)\cos 2400\pi t$

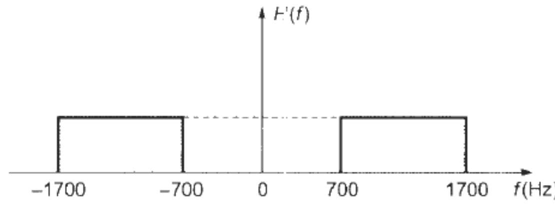
Thus $y(t)=10x(t)+x^2(t)$

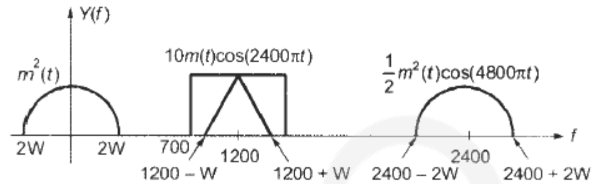
$$\therefore\ y(t)=10m(t)\cos(2400\pi t)+m^2(t)\cos^2(2400\pi t)$$

$$=10m(t)\cos(2400\pi t)+\frac{1}{2}m^2(t)\frac{1}{2}\cos(4800\pi t)$$

Drawing the spectrum set spectrum of x(t) be







For z(t) = 10x(t), maximum value of W must be less than 350 Hz.

52. A source emits bit 0 with probability 1/3 and bit 1 with probability 2/3. The emitted bits are communicate to the receiver decides for either 0 or 1 based on the received value R. It is given that the conditional density function of R are as

$$f_{R|0}(r)=\begin{cases}\frac{1}{4}, & -3\le x\le 1,\\ 0, & \text{otherwise,}\end{cases}$$ and

$$f_{R|1}(r)=\begin{cases}\frac{1}{6}, & -1\le x\le 5,\\ 0, & \text{otherwise,}\end{cases}$$

The minimum decision error probability is
A. 0 B. 1/12
C. 1/9 D. 1/6
Answer ||| D
Solution |||
Given the conditional density function of R as

$$f_{R|0}(r)=\begin{cases}\frac{1}{4}, & -3\le x\le 1,\\ 0, & \text{otherwise,}\end{cases}$$

$$f_{R|1}(r)=\begin{cases}\frac{1}{6}, & -1\le x\le 5,\\ 0, & \text{otherwise,}\end{cases}$$

Decision error probability that receiver decides 0 for a transmitted bit 1 is
$f_{R/1}$ (r = 0) = 1/6
Again, the decision error probability that receiver decides 1 for a transmitted bit 0 is
$f_{R/0}$ (r = 1) = 1/4
Hence, the minimum decision error probability is $f_{R/1}$ (r = 0) = 1/6

53. The longitudinal component of the magnetic field inside an air-filled rectangular waveguide made of a perfect electric conductor is given by the following expression

$$H_z(x,y,z,t)=0.1\cos(25\pi x)\cos(30.3\pi y)$$
$$\cos(12\pi\times 10^9 t-\beta z)$$

The cross-sectional dimensions of the waveguide are given as a = 0.08 m and b = 0.033 m. The mode of propagation inside the waveguide is

A. TM_{12} C. TE_{21}
B. TM_{21} D. TE_{12}

Answer ||| B

Solution |||

$$H_z(x,y,x,t) = 0.1\cos(25\pi x)\cos(30.3\pi y)$$
$$\cos(12\pi\times10^9 t - \beta z)A/m$$

Axial component is H ⇒ the propagating Mode is TE_{mn}, m, n can be found by

$$\frac{m\pi}{a}x = 25\pi x$$
$$\Rightarrow \frac{m}{0.08} = 25$$
$$\Rightarrow m = 2$$
$$\frac{n\pi}{b}y = 30.3\pi y$$
$$\Rightarrow \frac{n}{0.033} = 30.3$$
$$\Rightarrow n = 1$$

∴ The mode of propagation is TE_{21}.

54. The electric field intensity of a plane wave traveling in free space is given by the following expression

$$E(x,t) = a_y 24\pi\cos(\omega t - k_0 x)\ (V/m)$$

In this field, consider a square area 10 cm x 10 cm on a plane x + y = 1. The total time-averaged power (in mW) passing through the square area is ___________.

A. 43.29 B. 53.29
C.56.39 D.43.28

Answer ||| B

Solution |||

$$\vec{E}(x,t) = \hat{a}_y 24\pi\cos(\omega t - K_0 x)V/m$$

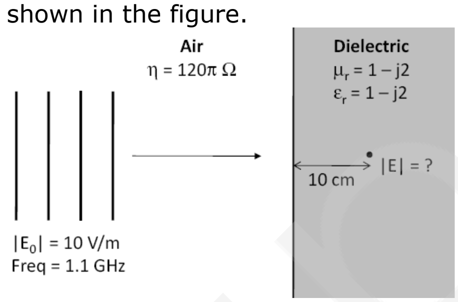
Power density

$$\vec{P} = \frac{1}{2}\frac{|E|^2}{\eta} = \frac{1}{2}\frac{(24\pi)^2}{120\pi}\hat{a}_x$$

Time average power

$$P_{avg} = \vec{P}.ds$$
$$= \left[\frac{1}{2}\frac{(24\pi)^2}{120\pi}\hat{a}_x\right].\left[\frac{\hat{a}_x + \hat{a}_y}{\sqrt{2}}\times10^{-2}\right]$$
$$P_{avg} = \frac{24\pi}{\sqrt{2}} = 53.29mW$$

55. Consider a uniform plane wave with amplitude (E_0) of 10 V/m and 1.1 GHz frequency travelling in air, and incident normally on a dielectric medium with complex relative permittivity (ε_r) and permeability (μ_r) as shown in the figure.



The magnitude of the transmitted electric field component (in V/m) after it has travelled a distance of 10 cm inside the dielectric region is _________.

A. 0.2 B. 0.3
C.0.1 D.0.4

Answer ||| C

Solution ||| Given,

$$\varepsilon_r = 1 - j2, \mu_r = 1 - j2, f = 1.1GHz$$
$$|E_0| = 10V/m$$

Attenuation constant of the medium is given by

$$\alpha = \beta_0\sqrt{\frac{\varepsilon'\mu_r'}{2}\sqrt{\left[1+(\varepsilon'')^2\right]\left[1+(\mu'')^2\right]} - \left[1-\varepsilon''\mu_r''\right]}$$

Where

$$\beta_0 = \frac{2\pi}{\lambda_0} = \frac{2\pi}{\frac{3\times10^8}{1.1\times10^9}} = \frac{22\pi}{3}$$
$$\Rightarrow \alpha = \frac{22\pi}{3}\sqrt{\frac{1}{2}\sqrt{[1+4][1+4]} - [1-4]}$$
$$\alpha = \frac{44\pi}{3}Nep/m = 46Nep/m$$
$$\alpha = 0.46Nep/cm$$

At a distance of 10 cm |E| is given by

$$|E| = 10e^{-\alpha\times10} = 0.1V/m$$

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