General Aptitude

Q. No. 1 – 5 Carry One Mark Each

1. What is the adverb for the given word below?
Misogynous
(A) Misogynousness (B) Misogynity
(C) Misogynously (D) Misogynous

Answer: (C)

2. Choose the appropriate word–phrase out of the four options given below, to complete the following sentence
Dhoni, as well as the other team members of Indian team _______________ present on the occasion
(A) Were (B) Was (C) Has (D) Have

Answer: (B)

3. Ram and Ramesh appeared in an interview for two vacancies in the same department. The probability of Ram's selection is 1/6 and that of Ramesh is 1/8. What is the probability that only one of them will be selected?
(A) 47/48 (B) 1/4 (C) 13/48 (D) 35/48

Answer: (B)

Exp: $P(\text{Ram}) = 1/6; \quad p(\text{Ramesh}) = 1/8$

$$p(\text{only at}) = p(\text{Ram}) \times p(\text{not ramesh}) + p(\text{Ramesh}) \times p(n_0 \times R_{am}) = 1/6 + \frac{7}{8} + \frac{1}{8} \times \frac{5}{6}$$

$$\Rightarrow \frac{12}{40} = 1/4$$

4. Choose he word most similar in meaning to the given word:
Awkward
(A) Inept (B) Graceful (C) Suitable (D) Dreadful

Answer: (A)

5. An electric bus has onboard instruments that report the total electricity consumed since the start of the trip as well as the total distance covered. During a single day of operation, the bus travels on stretches M, N, O and P, in that order. The cumulative distances traveled and the corresponding electricity consumption are shown in the Table below

Stretch	Cumulative distance (km)	Electricity used (kWh)
M	20	12
N	45	25
O	75	45
P	100	57

The stretch where the electricity consumption per km is minimum is
(A) M (B) N (C) O (D) P

Answer: (B)

Exp:

Stretch	Comulative distance(km)	Electricity used (kWh)	Individual(km) Distance	Individual electricity(kWh)
M	20	12	20	12
N	45	25	25	13
O	75	45	30	20
P	100	57	25	12

For $M \Rightarrow {}^{12}\!/_{20} = 0.6$

$N \Rightarrow {}^{13}\!/_{25} = 0.555$

$O \Rightarrow {}^{20}\!/_{30} = 0.667$

$P \Rightarrow {}^{12}\!/_{25} = 0.48$

Q. No. 6 – 10 Carry Two Marks Each

6. Given below are two statements followed by two conclusions. Assuming these statements to be true, decide which one logically follows.

Statements:

I. All film stars are playback singers.

II. All film directors are film stars

Conclusions:

I. All film directors are playback singers.

II. Some film stars are film directors.

(A) Only conclusion I follows

(B) Only conclusion II follows

(C) Neither conclusion I nor II follows

(D) Both conclusions I and II follow

Answer: (D)

7. Lamenting the gradual sidelining of the arts ill school curricula, a group of prominent artists wrote to the Chief Minister last year, asking him to allocate rnore funds to support arts education in schools. However, no such increase has been announced in this year's Budget. The artists expressed their deep anguish at their request not being approved, but many of them remain optimistic about funding in the future

Which of the staternent(s) below is/are logically valid and can be inferred from the above statements?

(i) The artists expected funding for the arts to increase this year

(ii) The Chief Minister was receptive to the idea of increasing funding for the arts

(iii) The Chief Minister is a prominent artist

(iv) Schools are giving less importance to arts education nowadays

(A) (iii) and (iv) (B) (i) and (iv) (C) (i), (ii) and (iv) (D) (i) and (iii)

Answer: (B)

8. A tiger is 50 leaps of its own behind a deer. The tiger takes 5 leaps per minute to the deer's 4. If the tiger and the deer cover 8 metre and 5 metre per leap respectively. What distance in metres will be tiger have to run before it catches the deer?

Answer: 800

Exp: $\text{Tiger} - 1\text{ leap} \Rightarrow 8\text{ meter}$

$\text{Speed} = 5\text{leap/hr} = 40\text{m/min}$

$\text{Deer} \rightarrow 1\text{ leap} = 5\text{meter}$

$\text{speed} = 4\text{hr} = 20\text{m/min}$

Let at time 't' the tiger catches the deer.

$\therefore$ Distance travelled by deer + initial distance between them

$50 \times 8 \Rightarrow 400\text{m} =$ distance covered by tiger.

$\Rightarrow 40 \times t = 400 + 20t$

$\Rightarrow t = \dfrac{400}{200} = 20\text{ min}$

$\Rightarrow \text{total dis tance} \Rightarrow 400 + 20 \times t = 800\text{ ms}$

9. If $a^2 + b^2 + c^2 = 1$, then $ab + bc + ac$ lies in the interval

(A) [1, 2/3] (B) [–1/2, 1] (C) [–1, 1/2] (D) [2, –4]

Answer: (B)

10. In the following sentence certain parts are underlined and marked P, Q and R. One of the parts may contain certain error or may not be acceptable in standard written communication. Select the part containing an error. Choose D as your answer if there is no error.

The student corrected all the errors (P) that the instructor marked (Q) on the answer book (R)

(A) P (B) Q (C) R (D) No error

Answer: (B)

Exp: The is not required in 'Q'

Electronics and Communication Engineering

Q. No. 1 – 25 Carry One Mark Each

1. Let the signal $f(t)=0$ outside the interval T_1, T_2, where T_1 and T_2 are finite. Furthermore, $|f(t)|<\infty$. The region of convergence (RoC) of the signal's bilateral Laplace transform F(s) is

1. A parallel strip containing the $j\Omega$ axis
2. A parallel strip not containing the $j\Omega$ axis
3. The entire s–plane
4. A half plane containing the $j\Omega$ axis

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

Answer: (C)

Exp: For a finite duration time domain signal ROC is entire s-plane.

2. A unity negative feedback system has an open–loop transfer function $G(s)=\frac{K}{s(s+10)}$. The gain K for the system to have a damping ratio of 0.25 is ______________.

Answer: 400

Exp: $G(s)=\frac{k}{s^2+10s}$

$$\text{CLTF}=\frac{k}{s^2+10s+k}$$

$$\xi=0.25$$

$$k=\omega_n^2$$

$$\omega_n=\sqrt{k}$$

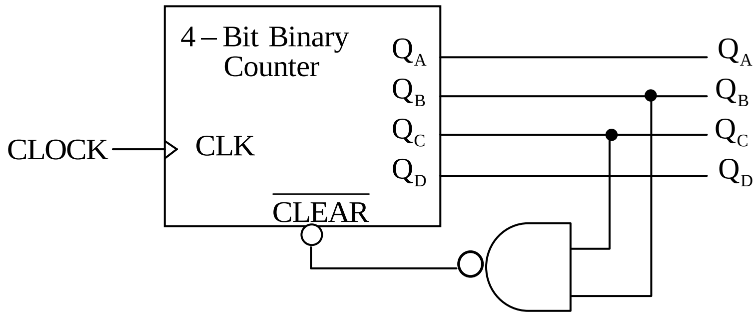
$$\xi=\frac{10}{2\sqrt{k}}=0.25$$

$$\sqrt{k}=\frac{10}{0.5}$$

$$k=(20)^2$$

$$\boxed{k=400}$$

3. A mod–n counter using a synchronous binary up–counter with synchronous clear input is shown in the figure. The value of n is ____________________



Answer: 6

Exp: To find the modulus of the counter, consider the status of the inputs (Q_B, Q_C) as 1.

So, $Q_AQ_BQ_CQ_D = 0110$

So, it is a MOD-6 counter

4. By performing cascading and/or summing/differencing operations using transfer function blocks $G_1(s)$ and $G_2(s)$, one **CANNOT** realize a transfer function of the form

(A) $G_1(s)G_2(s)$ (B) $\frac{G_1(s)}{G_2(s)}$

(C) $G_1(s)\left(\frac{1}{G_1(s)}+G_2(s)\right)$ (D) $G_1(s)\left(\frac{1}{G_1(s)}-G_2(s)\right)$

Answer: (B)

5. The electric field of a uniform plane electromagnetic wave is

$$\vec{E} = (\vec{a}_x + j4\vec{a}_y)\exp\left[j(2\pi\times10^7 t - 0.2z)\right]$$

The polarization of the wave is

(A) Right handed circular (B) Right handed elliptical
(C) Left handed circular (D) Left handed elliptical

Answer: (D)

Exp: $E = (a_x + 4ja_y)e^{j(2\pi\times10^7 t - 0.2z)}$

$\omega = 2\pi\times10^7$

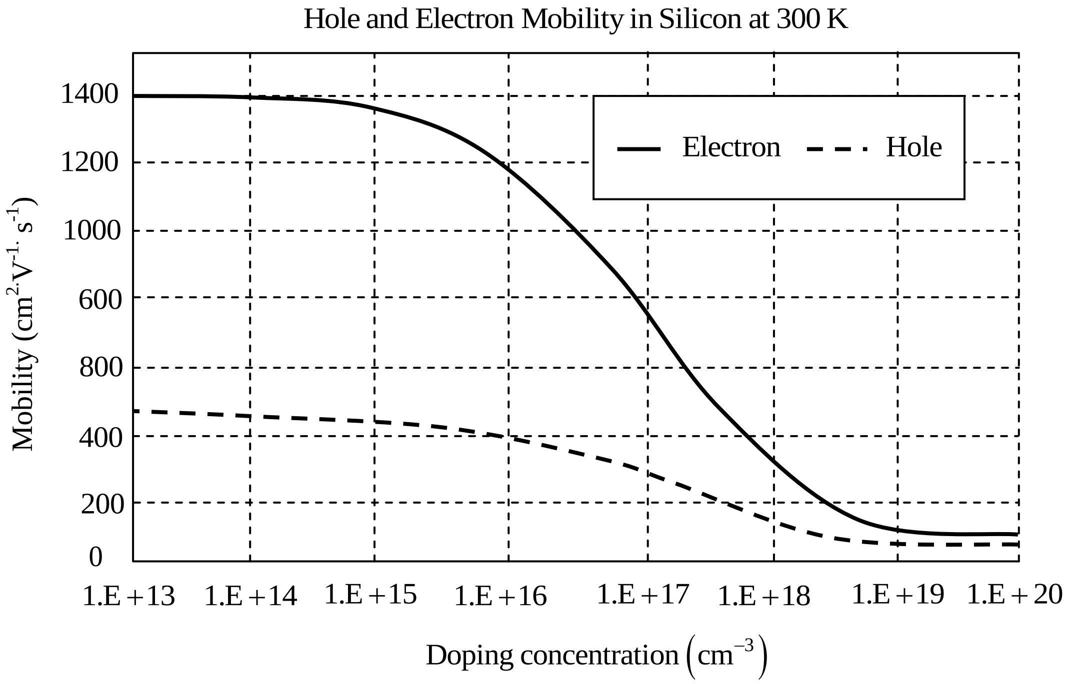
$\beta = 0.2$

$E_z = \cos\omega t$

$E_y = 4\cos(\omega + \pi/2) = -4\sin\omega t$

So, it left hand elliptical polrization

6. A piece of silicon is doped uniformly with phosphorous with a doping concentration of $10^{16}/\text{cm}^3$. The expected value of mobility versus doping concentration for silicon assuming full dopant ionization is shown below. The charge of an electron is 1.6×10^{-19} C. The conductivity $\left(\text{in S cm}^{-1}\right)$ of the silicon sample at 300 K is ________________



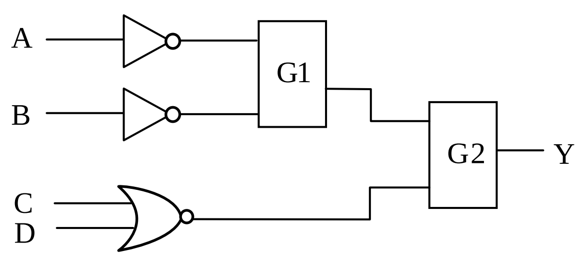
Answer: 1.92

Exp: As per the graph mobility of electrons at the concentration $10^{16}/\text{cm}^3$ is $1200\dfrac{\text{cm}^2}{\text{V}-\text{s}}$

So, $\mu_n = 1200\dfrac{\text{cm}^2}{\text{V}-\text{s}}$

$$\sigma_N = N_D q \mu_n$$
$$= 10^{16}\times1.6\times10^{-19}\times1200$$
$$= 1.92\ \text{S cm}^{-1}$$

7. In the figure shown, the output Y is required to be $Y = AB + \bar{C}\bar{D}$. The gates G1 and G2 must be, respectively,



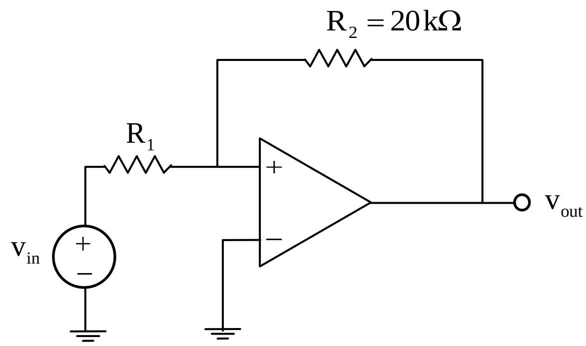
(A) NOR, OR (B) OR, NAND (C) NAND, OR (D) AND, NAND

Answer: (A)

Exp: Given expression is $Y = AB + \overline{C}\overline{D}$

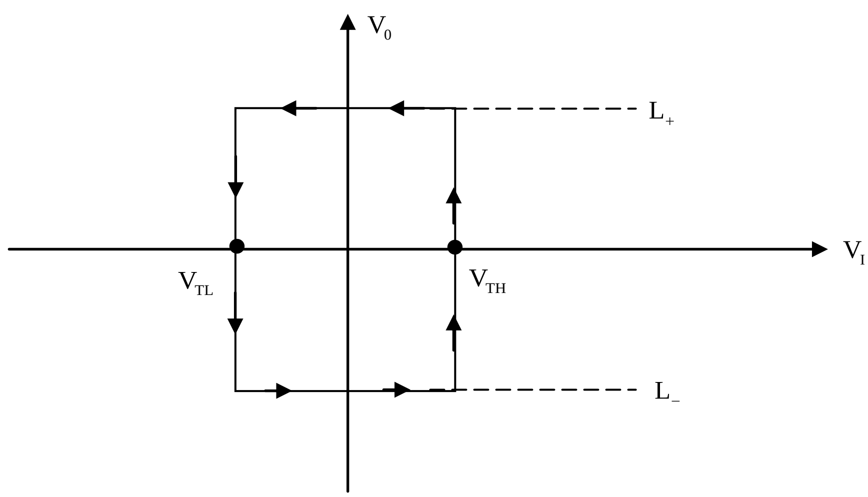
The first term can be obtained by considering G_1 as NOR gate, and second term $\left(\overline{C}\overline{D}\right)$ is obtained from another lower NOR-Gate. So, final expression can be implemented by considering G_2 as OR-Gate.

8. In the bistable circuit shown, the ideal opamp has saturation level of $\pm 5V$. The value of $R_1 (\text{in } k\Omega)$ that gives a hysteresis width of 500 mV is ______________.



Answer: **1**

Exp:



$$\text{Hysteresis} = V_{TH} - V_{TL}$$

$$= -L_-\left(\frac{R_1}{R_2}\right) + L_+\left(\frac{R_1}{R_2}\right)$$

$$500\text{mV} = -(-5)\left(\frac{R_1}{20k}\right) + 5\left(\frac{R_1}{20k}\right)$$

$$= \frac{R_1}{2k}$$

$\therefore R_1 = 500 \times 2 \times 10^3 \times 10^{-3}$

$= 1000\,\Omega = 1k\Omega$

9. Two causal discrete–time signal $x[n]$ and $y[n]$ are related as $y[n] = \sum_{m=0}^{n} x[m]$

It the z–transform of $y[n]$ is $\frac{2}{z(z-1)^2}$, the value of $x[2]$ is __________

Answer: 0

Exp: $y[n] = \sum_{m=0}^{n} x[m]$

According to accumulation property of z-transform

$$Y(z) = \frac{X(z)}{(1-z^{-1})} \Rightarrow \frac{2}{z(z-1)} = \frac{zX(z)}{(z-1)}$$

$$\therefore X(z) = \frac{2z^{-2}}{(z-1)} = \frac{2z^{-3}}{(1-z^{-1})}$$

$$\therefore x[n] = 2u[n-3] \text{ thus } x[2] = 0$$

10. The bilateral Laplace transform of a function $f(t) = \begin{cases} 1 \text{ if } a \le t \le b \\ 0 \text{ otherwise} \end{cases}$

(A) $\frac{a-b}{s}$ (B) $\frac{e^2(a-b)}{s}$ (C) $\frac{e^{-as} - e^{-bs}}{s}$ (D) $\frac{e^{s(a-b)}}{s}$

Answer: (C)

Exp: Given $f(t) = \begin{vmatrix} 1 & a \le t \le b \\ 0 & \text{otherwise} \end{vmatrix}$

$$L\{f(t)\} = \int_0^{\infty} e^{-st} f(t)\, dt$$

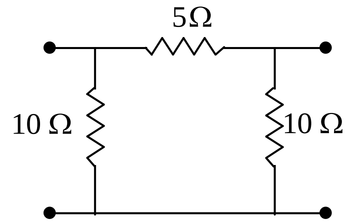
$$= \int_0^{a} e^{-st} f(t) + \int_a^{\infty} e^{-st} f(t)\, dt + \int_b^{\infty} e^{-st} f(t)\, dt$$

$$= 0 + \int_a^{b} e^{-st}\, dt + 0$$

$$= \frac{e^{-st}}{-s}\Big|_a^b = \frac{-1}{s}\left[e^{-bs} - e^{-as}\right]$$

$$= \frac{e^{-as} - e^{-bs}}{s}$$

11. The 2–port admittance matrix of the circuit shown is given by



(A) $\begin{bmatrix} 0.3 & 0.2 \\ 0.2 & 0.3 \end{bmatrix}$ (B) $\begin{bmatrix} 15 & 5 \\ 5 & 15 \end{bmatrix}$

(C) $\begin{bmatrix} 3.33 & 5 \\ 5 & 3.33 \end{bmatrix}$ (D) $\begin{bmatrix} 0.3 & 0.4 \\ 0.4 & 0.3 \end{bmatrix}$

Answer:

Exp: Correct answer not given in options

$$\begin{bmatrix} 0.3 & -0.2 \\ -0.2 & 0.3 \end{bmatrix}$$

12. The value of *x* for which all the eigen–values of the matrix given below are real is

$$\begin{bmatrix} 10 & 5+j & 4 \\ x & 20 & 2 \\ 4 & 2 & -10 \end{bmatrix}$$

(A) $5+j$ (B) $5-j$ (C) $1-5j$ (D) $1+5j$

Answer: (B)

Exp: Let $A = \begin{bmatrix} 10 & 5+J & 4 \\ x & 20 & 2 \\ 4 & 2 & -10 \end{bmatrix}$

Given that all eigen values of A are real.

$\Rightarrow$ A is Hermitian

$\Rightarrow A^{\theta} = A$ ie. $\left(\overline{A}\right)^T = A$

$$\begin{bmatrix} 10 & \overline{x} & 4 \\ 5-j & 20 & 2 \\ 4 & 2 & -10 \end{bmatrix} = \begin{bmatrix} 10 & 5+j & 4 \\ x & 20 & 2 \\ 4 & 2 & -10 \end{bmatrix} \Rightarrow x = 5-j$$

13. The signal $\cos\left(10\pi t + \frac{\pi}{4}\right)$ is ideally sampled at a sampling frequency of 15 Hz. The sampled signal is passed through a filter with impulse response $\left(\frac{\sin(\pi t)}{\pi t}\right)\cos\left(40\pi t - \frac{\pi}{2}\right)$. The filter output is

(A) $\frac{15}{2}\cos\left(40\pi t - \frac{\pi}{4}\right)$

(B) $\frac{15}{2}\left(\frac{\sin(\pi t)}{\pi t}\right)\cos\left(10\pi t + \frac{\pi}{4}\right)$

(C) $\frac{15}{2}\cos\left(10\pi t - \frac{\pi}{4}\right)$

(D) $\frac{15}{2}\left(\frac{\sin(\pi t)}{\pi t}\right)\cos\left(40\pi t - \frac{\pi}{2}\right)$

Answer: (A)

Exp: Given signal is $x(t) = \cos\left(10\pi t + \frac{\pi}{4}\right)$

Neglect the phase-shift $\frac{\pi}{4}$ and it can be inserted at the end result.

$\therefore$ If $x_1(t) = \cos 10\pi t \xrightarrow{L} X_1(f) = \frac{1}{2}\left[\delta(f-5)+\delta(f+5)\right]$

Given filter impulse response is,

$$h(t) = \left(\frac{\sin \pi t}{\pi t}\right) \cos\left(40\pi t - \frac{\pi}{2}\right)$$

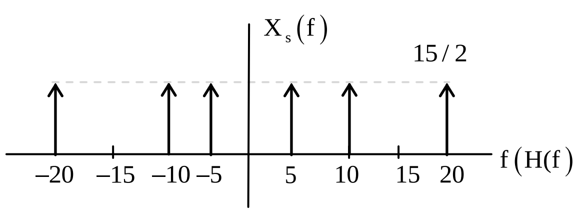
$$= (\sin c\, t) \sin(40\pi t)$$

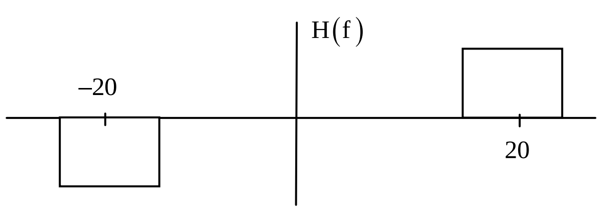
$$\therefore H(f) = \text{rect } f * \frac{1}{2j}\left[\delta(f-20) - \delta(f+20)\right]$$

$$= \frac{1}{2j}\left[\text{rect}(f-20) - \text{rect}(f+20)\right]$$

$X_1(f)$ repeats with a value $f_o = 15\text{Hz}$ and each impulse value is $\frac{15}{2}$

Thus the sampled signal spectrum and the spectrum of the filter are as follows:





$$\therefore X_s(f)\, H(f) = \frac{15}{4j}\left[\delta(f-20) - \delta(f+20)\right]$$

$$x_r(t) = \frac{15}{2} \sin(40\pi t) \rightarrow \text{recovered signal}$$

$$= \frac{15}{2} \cos\left(40\pi t - \frac{\pi}{2}\right)$$

Insert the neglected phase shift $\frac{\pi}{4}$

$$\therefore x_r(t) = \frac{15}{2}\cos\left(40\pi t - \frac{\pi}{2} + \frac{\pi}{4}\right) = \frac{15}{2}\cos\left(40\pi t - \frac{\pi}{4}\right)$$

14. A sinusoidal signal of amplitude *A* is quantized by a uniform quantizer Assume that the signal utilizes all the representation levels of the quantizer. If the signal to quantization noise ratio is 31.8 dB, the number of levels in the quantizer is ____________________

Answer: 32

Exp: Signal power $= A^2/2$

Quantization step size, $\Delta = \frac{2A}{L}$

Quantization noise power $= \frac{\Delta^2}{12}$

$$= \frac{4A^2}{12L^2} = \frac{A^2}{3L^2}$$

$\Rightarrow$ Signal to quantiation noise ratio $= \frac{3}{2}L^2$

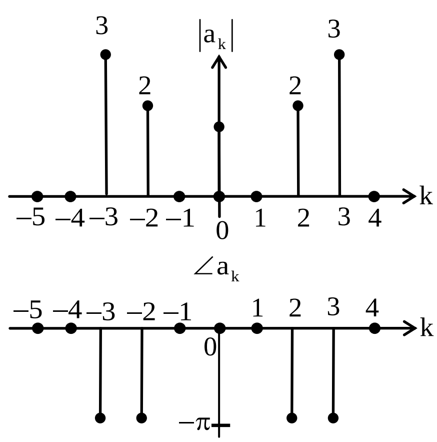
Given signal to quantization noise ratio $= 31.8\text{dB or } 1513.56$

$\Rightarrow \frac{3}{2}L^2 = 1513.56$

$\Rightarrow L = 31.76$

≈ 32

15. The magnitude and phase of the complex Fourier series coefficients a_k of a periodic signal x(t) are shown in the figure. Choose the correct statement form the four chices given. Notation: C is the set of complex numbers, R is the set of purely real numbers, and P is the set purely imaginary numbers.



(A) $x(t) \in R$

(B) $x(t) \in P$

(C) $x(t) \in (C - R)$

(D) The information given is not sufficient to draw any conclusion about x(t)

Answer: (A)

Exp: $\angle a_k = -\pi$ only changes the sign of the magnitude $|a_k|$. Since the magnitude spectrum $|a_k|$ is even the corresponding time-domain signal is real.

16. The general solution of the differential equation $\frac{dy}{dx} = \frac{1+\cos 2y}{1-\cos 2x}$ is

(A) $\tan y - \cot x = c$ (c is a constant) (B) $\tan x - \cot y = c$ (c is a constant)

(C) $\tan y + \cot x = c$ (c is a constant) (D) $\tan x + \cot y = c$ (c is a constant)

Answer: (C)

Exp: Given $\frac{dy}{dx} = \frac{1+\cos 2y}{1-\cos 2x}$

$$\Rightarrow \frac{dy}{1+\cos 2y} = \frac{dx}{1-\cos 2x} \quad \text{(Variable – Separable)}$$

$$\Rightarrow \frac{dy}{2\cos^2 y} = \frac{dx}{2\sin^2 x}$$

$$\Rightarrow \int \sec^2 y\,dy = \int \operatorname{cosec}^2 x\,dx$$

$$\Rightarrow \tan y = -\cot x + k$$

$$\Rightarrow \tan y + \cot x = k$$

17. An n–type silicon sample is uniformly illuminated with light which generates 10^{20} electron hole pairs per cm^3 per second. The minority carrier lifetime in the sample is $1\mu s$. Int eh steady state, the hole concentration in the sample is approximately 10^x, where x is an integer. The value of x is ________________

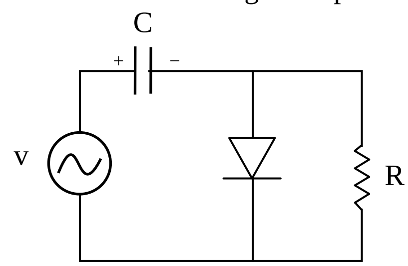
Answer: 14

Exp: The concentration of hole-electron pair in $1\mu sec = 10^{20} \times 10^{-6} = 10^{14}/cm^3$

So, the power of 10 is 14.

$x = 14$

18. If the circuit shown has to function as a clamping circuit, which one of the following conditions should be satisfied for sinusoidal signal of period T?



(A) RC<<T (B) RC = 0.35T (C) $RC \approx T$ (D) RC >> T

Answer: (D)

19. In a source free region in vacuum, if the electrostatic potential $\varphi = 2x^2 + y^2 + cz^2$, the value of constant c must be ________________________

Answer: -3

Exp: $\varphi = 2x^2 + y^2 + cz^2$

$E = -\nabla\varphi = -4xa_x - 2ya_y - 2cza_z$

$\nabla.E = 0$

$-4 - 2 - 2c = 0$

$c = -3$

20. In an 8085 microprocessor, which one of the following instructions changes the content of the accumulator?

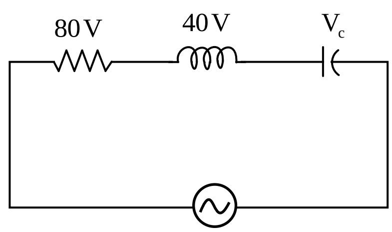
(A) MOV B, M (B) PCHL (C) RNZ (D) SBI BEH

Answer: (D)

Exp: Generally arithmetic or logical instructions update the data of accumulator and flags. So, in the given option only SBT BE H is arithmetic instruction.

SBI BE H $\rightarrow$ Add the content of accumulator with immediate data BE H and store the result in accumulator.

21. The voltage (V_C) across the capacitor (in Volts) in the network shown is ______________



Answer: 100

Exp: $V = \sqrt{V_R^2 + (V_c - V_L)^2}$

$(100)^2 = (80)^2 + (V_c - 40)^2$

$(V_c - 40)^2 = (180)(20)$

$(V_c - 40) = \pm\sqrt{2 \times 90 \times 20}$

$V_c - 40 = \pm 60$

$V_c = \pm 60 + 40$

$V_c = 60 + 40$

$V_c = 100V$

22. Let $f(z) = \dfrac{az+b}{cz+d}$. If $f(z_1) = f(z_2)$ for all $z_1 \neq z_2, a = 2, b = 4$ and $c = 5$, then d should be equal to ___________.

Answer: 10

Exp: $f(z)=\dfrac{az+b}{cz+d}$ if $f(z_1)=f(z_2)$, for $z_1 \neq z_2$

$a=2,\ b=4,\ c=5$

$f(z)=\dfrac{2z+4}{5z+d}$

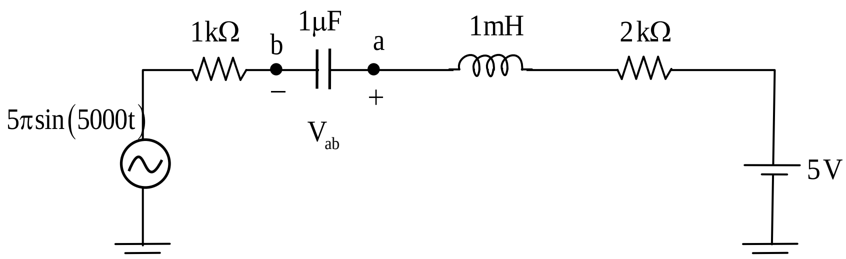
$f(z_1)=f(z_2) \Rightarrow \dfrac{2z_1+4}{5z_1+d}=\dfrac{2z_2+4}{5z_2+d}$

$\Rightarrow 10z_1z_2+20z_2+2dz_1+4d=10z_1z_2+20z_1+2dz_2+4d$

$\Rightarrow 20(z_2-z_1)=2d(z_2-z_1)$

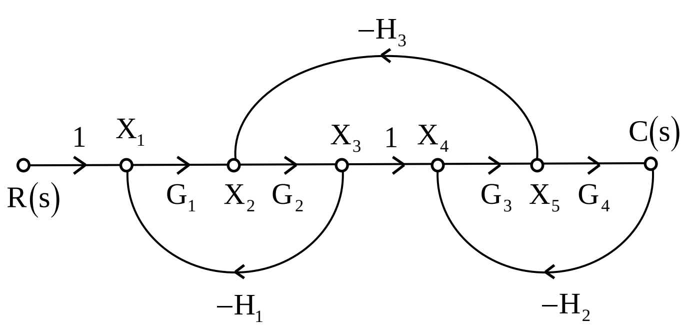
$\Rightarrow d=10$

23. In the circuit shown the average value of the voltage V_{ab} (in Volts) in steady state condition is ______________.



Answer: 5

24. For the signal flow graph shown in the figure, the value of $\dfrac{C(s)}{R(s)}$ is



(A) $\dfrac{G_1G_2G_3G_4}{1-G_1G_2H_1-G_3G_4H_2-G_2G_3H_3+G_1G_2G_3G_4H_1H_2}$

(B) $\dfrac{G_1G_2G_3G_4}{1+G_1G_2H_1+G_3G_4H_2+G_2G_3H_3+G_1G_2G_3G_4H_1H_2}$

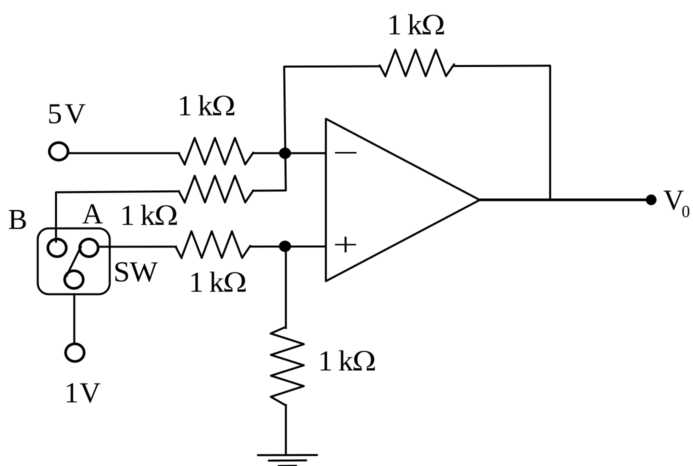
(C) $\dfrac{1}{1+G_1G_2H_1+G_3G_4H_2+G_2G_3H_3+G_1G_2G_3G_4H_1H_2}$

(D) $\dfrac{1}{1-G_1G_2H_1-G_3G_4H_2-G_2G_3H_3+G_1G_2G_3G_4H_1H_2}$

Answer: (B)

Exp: Using mason gain formula we get it directly.

25. In the circuit shown, $V_0 = V_{0A}$ for switch SW in position A and $V_0 = V_{0B}$ for SW in position B. Assume that the opamp is ideal. The value of $\dfrac{V_{0B}}{V_{0A}}$ is ____________________



Answer: 1.5

Exp: $V_{OB} = -5\left(\dfrac{1\Omega}{1k\Omega}\right) - 1\left(\dfrac{1k\Omega}{1k\Omega}\right)$

$= -6V$

$V_{OA} = -5\left(\dfrac{1k\Omega}{1k\Omega}\right) + \dfrac{1}{2}\left(1+\dfrac{1k\Omega}{1k\Omega}\right) = -4V \quad \left(\because V_+ = \dfrac{1}{2}V\right)$

$\therefore \dfrac{V_{OB}}{V_{OA}} = 1.5$

Q. No. 26 – 55 carry Two Marks Each

26. Let $X \in \{0,1\}$ and $Y \in \{0,1\}$ be two independent binary random variables. If P (X = 0) = p and P(Y = 0) = q, then $P(X+Y \geq 1)$ is equal to

(A) $pq + (1-p)(1-q)$ (B) pq

(C) $p(1-q)$ (D) $1-pq$

Answer: (D)

Exp: $P\{x=0\}=P \Rightarrow P\{x=1\}=1-p$

$P\{y=0\}=q \Rightarrow P\{y=1\}=1-q$

Let $Z=X+Y$

X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	2

From above table,

$P\{X+Y+Z\} \Rightarrow P<Z\geq B$

$P\{Z\geq 1\}=P\{X=0 \text{ and } Y=1\}+P\{X=1 \text{ and } Y=0\}+P\{X=1 \text{ and } Y=1\}$

$=1-P\{X=0 \text{ and } Y=0\}$

$=1-pq$

27. An LC tank circuit consists of an ideal capacitor C connected in parallel with a coil of inductance L having an internal resistance R. The resonant frequency of the tank circuit is

(A) $\frac{1}{2\pi\sqrt{LC}}$

(B) $\frac{1}{2\pi\sqrt{LC}}\sqrt{1-R^2\frac{C}{L}}$

(C) $\frac{1}{2\pi\sqrt{LC}}\sqrt{1-\frac{L}{R^2C}}$

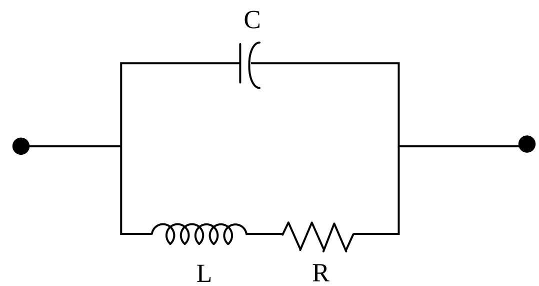
(D) $\frac{1}{2\pi\sqrt{LC}}\left(1-R^2\frac{C}{L}\right)$

Answer: (B)

Exp: $Y=Y_c+Y_{LR}$

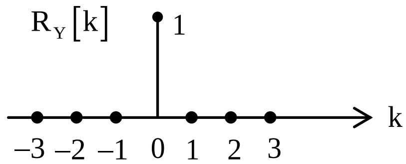
$Y=j\omega C+\frac{1}{(j\omega L+R)}=j\omega C+\frac{(R-j\omega L)}{(R^2+\omega^2L^2)}$

Placing Imaginary part to zero we get option (B).

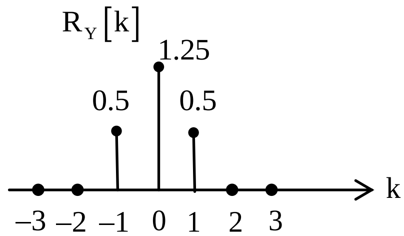


28. $\{X_n\}_{n=-\infty}^{n=\infty}$ is an independent and identically distributed (i,i,d,) random process with X_n equally likely to be $+1$ or -1. $\{Y_n\}_{n=-\infty}^{n=\infty}$ is another random process obtained as $Y_n=X_n+0.5X_{n-1}$. The autocorrelation function of $\{Y_n\}_{n=-\infty}^{n=\infty}$ denoted by $R_Y[k]$ is

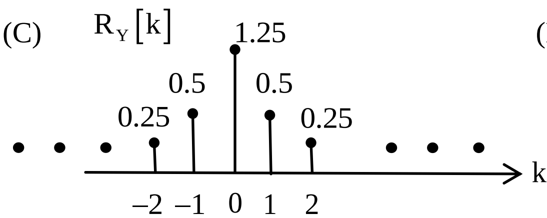
(A)



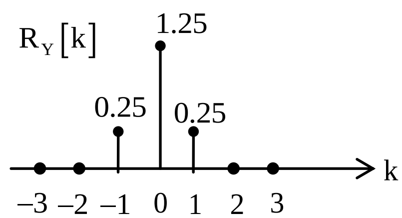
(B)



(C)



(D)



Answer: (B)

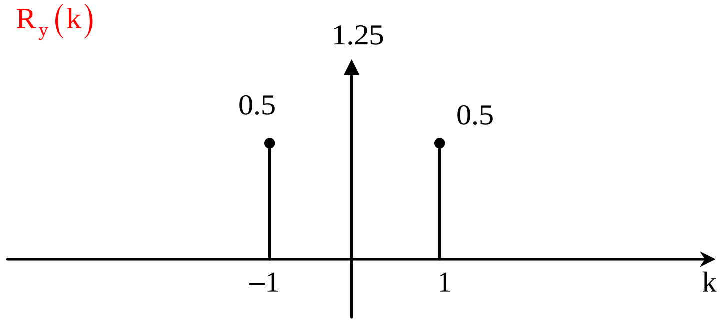
Exp:
$$R_Y(k) = R_y(n, n+k)$$
$$= E\left[Y(n).Y(n+k)\right]$$
$$Y(n) = x(n) + 0.5x(n-1)$$
$$R_y(k) = E\left[\left(x[n]+0.5x[n-1]\right)\left(x(n+k)+0.5x(n+k-1)\right)\right]$$
$$= E\left[x(n).x(n+k) + x(n)0.5x(n+k-1) + 0.5x(n-1).x(n+k)\right.$$
$$\left. + 0.25x(n-1)x(n+k-1)\right)$$
$$= E\left[x[n].x(n+k) + 0.5E\left[x(n)x(n+k-1)\right]\right.$$
$$+ 0.5E\left[\left(x(n-1)x(n+k)\right)\right]$$
$$\left. +0.25E\left[x(n-1)x(n+k-1)\right]\right]$$
$$= R_X(k) + 0.5R_x(k-1) + 0.5R_x(k+1) + 0.25R_x(k)$$
$$R_y(k) = 1.25R_x(k) + 0.5R_x(k-1) + 0.5R_x(k+1)$$
$$R_x(k) = E\left[x(n).x(n+k)\right]$$
if $k = 0$,
$$R_x(0) = E\left[x^2(n)\right]$$
$$= 1^2.\frac{1}{2} + (-1)^2 \times \frac{1}{2}$$
$$= 1$$
if $k \neq 0$,
$$R_x(k) = E\left[x(n)\right].E\left[x(n+k)\right]$$
$$= 0$$

$$\left\{\begin{array}{l}\because E[x(n)]=0 \\ E[x(n+k)]=0\end{array}\right\}$$

$$\Rightarrow \quad R_y(0)=1.25R_x(0)+0.5R_x(-1)+0.5R_x(1)$$
$$=1.25$$
$$R_y(1)=1.25R_x(1)+0.5R_x(0)+0.5R_x(2)$$
$$=0.5$$
$$R_y(-1)=1.25R_x(-1)+0.5R_x(-2)+0.5R_x(0)$$
$$=0.5$$

$R_y(k)$ for k other than 0, 1 and $-1 = 0$

$\Rightarrow \quad R_y(k)$



29. In a MOS capacitor with an oxide layer thickness of 10 nm, the maximum depletion layer thickness is 100 nm. The permittivities of the semiconductor and the oxide layer are ε_s and ε_{ox} respectively. Assuming $\varepsilon_s/\varepsilon_{ox}=3$, the ratio of the maximum capacitance to the minimum capacitance of this MOS capacitor is ______________________

Answer: 4.33

Exp: $$\frac{C_{max}}{C_{min}}=\frac{\frac{\epsilon_{ox}}{t_{ox}}}{\frac{\frac{\epsilon_{ox}}{t_{ox}}\times\frac{\epsilon_s}{X_{d\max}}}{\frac{\epsilon_{ox}}{t_{ox}}+\frac{\epsilon_s}{X_{d\max}}}}=\left[1+\frac{X_{d\max}}{t_{ox}}\times\frac{\epsilon_{ox}}{\epsilon_s}\right]=\left[1+\frac{100}{10}\times\frac{1}{3}\right]=4.33$$

30. Let the random variable *X* represent the number of times a fair coin needs to be tossed till two consecutive heads appear for the first time. The expectation of *X* is ______________________

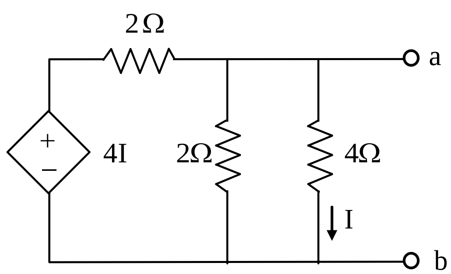
Answer: 1.5

Exp: Let x be a random variable which denotes number of tosses to get two heads.

$$P(x=2) = HH = \frac{1}{2}\times\frac{1}{2}$$
$$P(x=3) = THH = \frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$$
$$P(x=4) = TTHH = \frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$$
....

$$E(x) = 2\left(\frac{1}{2}\times\frac{1}{2}\right) + 3\times\left(\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\right) + 4\left(\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\right) + \ldots\ldots\ldots$$
$$= 2\times\frac{1}{2^2} + 3\times\frac{1}{2^3} + 4\times\frac{1}{2^4} + \ldots\ldots\ldots\ldots$$
$$= \frac{1}{2}\left[2.\frac{1}{2} + 3.\frac{1}{2^2} + 4\frac{1}{2^3} + \ldots\ldots\ldots\ldots\right]$$
$$= \frac{1}{2}\left[\left(1 + 2.\frac{1}{2} + 3\frac{1}{2^2} + \ldots\ldots\right) - 1\right]$$
$$= \frac{1}{2}\left[\left(1 - \frac{1}{2}\right)^{-2} - 1\right] = \frac{1}{2}[4-1] = \frac{3}{2}$$

31. In the circuit shown, the Norton equivalent resistance $(\text{in}\,\Omega)$ across terminals a–b is ______________.



Answer: 1.333

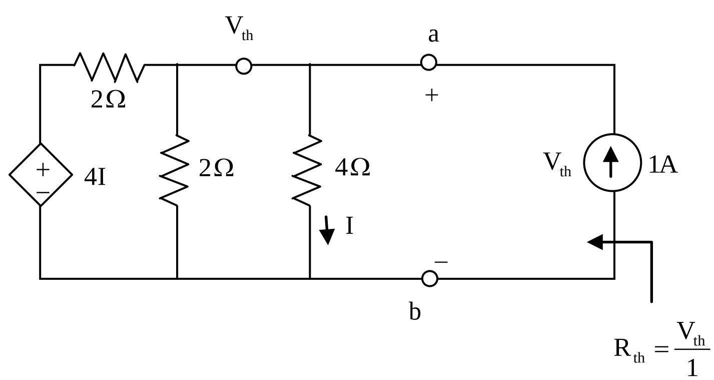
Exp: Nodal @ 'a'

$$\frac{V_{th} - 4I}{2} + \frac{V_{th}}{2} + \frac{V_{th}}{4} - 1 = 0$$

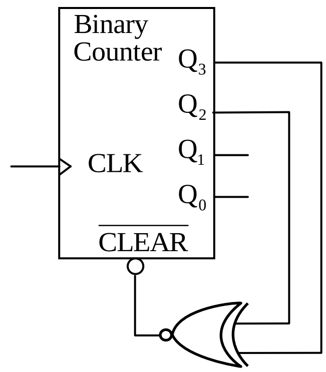
Also $V_{th} = 4I$

$$\Rightarrow V_{th} = \frac{4}{3}$$

$$R_{th} = \frac{4}{3} = 1\frac{1}{3} = 1.333$$



32. The figure shows a binary counter with synchronous clear input. With the decoding logic shown, the counter works as a



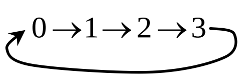
(A) mod–2 counter (B) mod–4 counter (C) mod–5 counter (D) mod–6 counter

Answer: (B)

Exp:

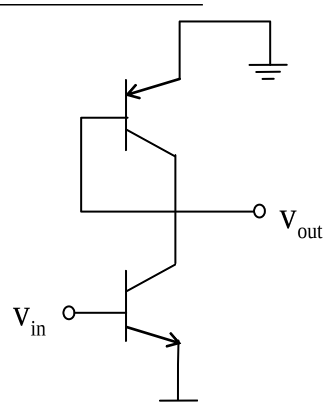
Q_3	Q_2	Q_1	Q_0
0	0	0	0
0	0	0	1
0	0	1	0
0	0	1	1
0	1	0	0

Once the output of Ex-NOR gate is 0 then counter will be RESET. So, Ex-NOR-gate will produce logic 0 for $Q_3 = 0$, $Q_2 = 1$. So, the counter will show the sequence like:



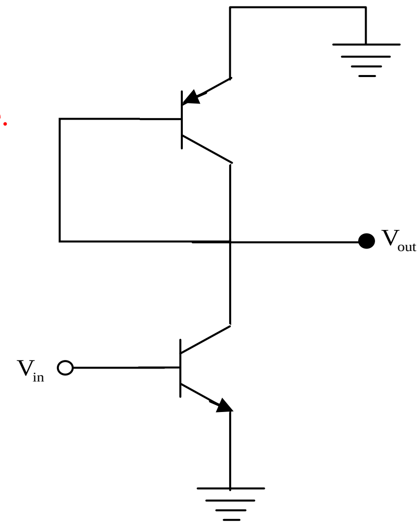
So, it is MOD-4 counter.

33. In the ac equivalent circuit shown, the two BJTs are bbiased in active region and have identical parameters with $\beta >> 1$. The open circuit small signal voltage gain is approximately ____________________



Answer: -1

Exp:



When Base and collector is shorted, it act as a diode.

So $V_0 = -0.7V$.

Gain , $\frac{V_0}{V_{in}} = -\frac{0.7V}{0.7V} = -1$

34. The state variable representation of a system is given as

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix} x; \quad x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix} x$$

The response y(t) is

(A) $\sin(t)$ (B) $1 - e^t$ (C) $1 - \cos(t)$ (D) 0

Answer: (D)

Exp: $\dot{X} = AX$

$$X(s) = (sI - A)^{-1} X(0)$$

$$X(s) = \begin{bmatrix} s & -1 \\ 0 & s+1 \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$X(s) = \begin{bmatrix} 1/s \\ 0 \end{bmatrix}$$

$$x(t) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$y(t) = [0 \ \ 1]\begin{bmatrix} 1 \\ 0 \end{bmatrix} = 0$$

35. Consider the differential equation $\frac{dx}{dt} = 10 - 0.2x$ with initial condition $x(0) = 1$. The response $x(t)$ for $t > 0$ is

(A) $2 - e^{-0.2t}$ (B) $2 - e^{0.2t}$ (C) $50 - 49e^{-0.2t}$ (D) $50 - 49e^{0.2t}$

Answer: (C)

Exp: Given D.E $\frac{dx}{dt} = 10 - 0.2x \qquad x(0) = 1$

$$\Rightarrow \frac{dx}{dt} + (0.2)x = 10$$

Auxiliary equation is $m + 0.2 = 0$

$$m = -0.2$$

Complementary solution $x_c = C\,e^{(-0.2)t}$

$$x_p = \frac{1}{D + (0.2)} 10\,e^{0t} = \frac{10\,e^{0t}}{0.2}$$

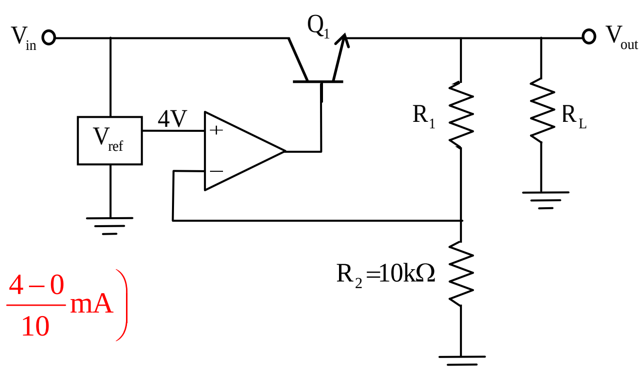
$$= 50\,e^{0t} = 50$$

$$x = x_c + x_p = C\,e^{(-0.2)t} + 50$$

Given $x(0) = 1 \Rightarrow C + 50 = 1 \Rightarrow C = -49$

$$x = 50 - 49\,e^{(-0.2)t}$$

36. For the voltage regulator circuit shown, the input voltage (V_{in}) is $20V \pm 20\%$ and the regulated output volage (V_{out}) is 10V. Assume the opamp to be ideal. For a load R_L drawing 200 mA, the maximum power dissipation in Q_1 (in Watts) is ______________.



Answer: 2.8056

Exp: $P_{Q_1(max)} = V_{CE(max)} \times I_{cmax} \qquad \ldots(i)$

$V_{CE(max)} = (24 - 10)V = 14V$

$I_{cmax} = (200 + 0.4)mA$

$I_E = I_c = 200mA + 0.4mA$

$= 200.4mA \qquad \left(\because I_{R2} = I_{R_1} = \frac{4-0}{10} mA\right)$

Put values in Equation (1), we get

$P_{Q_1(max)} = 14 \times 200.4 \times 10^{-3}$ Watt

$= 2.8056$ Watt

37. Input x(t) and output y(t) of an LTI system are related by the differential equation $y''(t) - y'(t) - 6y(t) = x(t)$. If the system is neither causal nor stable, the impulse response h(t) of the system is

(A) $\frac{1}{5}e^{3t}u(-t) + \frac{1}{5}e^{-2t}u(-t)$ (B) $-\frac{1}{5}e^{3t}u(-t) + \frac{1}{5}e^{-2t}u(-t)$

(C) $\frac{1}{5}e^{3t}u(-t)-\frac{1}{5}e^{-2t}u(t)$ (D) $-\frac{1}{5}e^{3t}u(-t)-\frac{1}{5}e^{-2t}u(t)$

Answer: (B)

Exp: The given differential equation is,

$$y''(t)-y'(t)-6y(t)=x(t)$$

On applying Laplace transform on both sides,

$$s^2\,y(s)-sy(0)-y(0)-\left[s\,y(s)-y(0)\right]-6y(s)=x(s)$$

To calculate the transfer function all initial conditions are taken as '0'.

$$\therefore\left(s^2-s-6\right)y(s)=x(s)$$

$$H(s)=\frac{1}{\left(s^2-s-6\right)}=\frac{1}{(s-3)(s+2)}=\frac{1}{5}\left[\frac{1}{s-3}-\frac{1}{s+2}\right]$$

It is given that h(t) is non-casual and un-stable.

To satisfy both the conditions ROC should be left of the left most pole.

Using the following standard pair

$$\frac{1}{s+a}\longleftrightarrow -e^{-at}u(-t)\,;\;\sigma<-a$$

$$\frac{1}{s-a}\longleftrightarrow -e^{at}u(-t)\,;\;\sigma<a$$

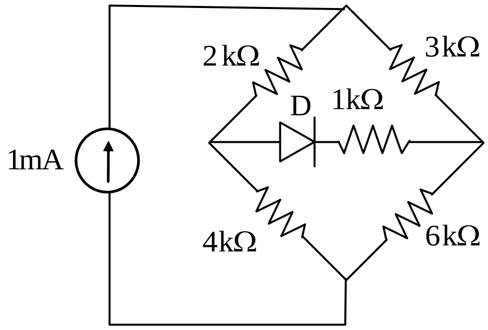
$$H(s)=\frac{1}{5}\left[\frac{1}{s-3}-\frac{1}{s+2}\right]$$

$$=\frac{1}{5}\left[-e^{3t}u(-t)+e^{-2t}u(-t)\right]$$

$$=\frac{-1}{5}e^{-3t}u(-t)+\frac{1}{5}e^{-2t}u(-t)$$

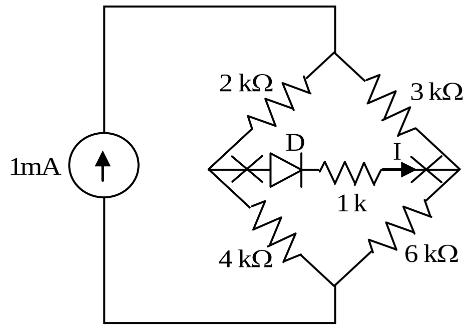
So option (B) is correct.

38. The diode in the circuit given below has $V_{ON} = 0.7V$ but is ideal otherwise. The current (in mA) in the $4k\Omega$ resistor is __________.



Answer: 0.6

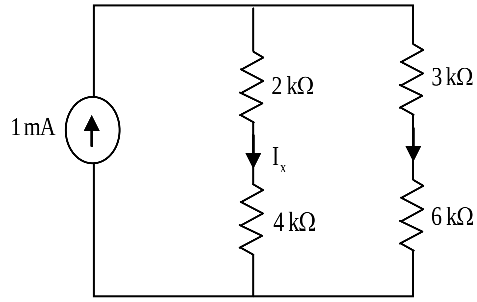
Exp:



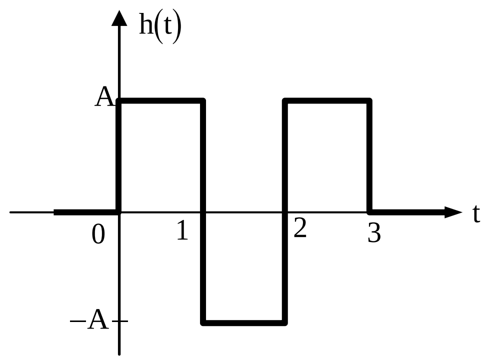
Bridge is Balanced., I = 0.

So,

$$I_x = \frac{1mA \times 9k}{9k + 6k} = 0.6\,mA$$



39. A zero mean white Gaussian noise having power spectral density $\frac{N_0}{2}$ is passed through an LTI filter whose impulse response h(t) is shown in the figure. The variance of the filtered noise at t = 4 is



(A) $\frac{3}{2}A^2N_0$ (B) $\frac{3}{4}A^2N_0$ (C) A^2N_0 (D) $\frac{1}{2}A^2N_0$

Answer: (A)

Exp: Let N(t) be the noise at the output of filter.

Variance of $N(t) = E(N^2(t)) - E(N(+1))^2$

Since the input noise is zero mean,
Output noise mean is also zero.

$$E(N(t)) = E(W(t)).\left(\int_{-\infty}^{\infty} h(t)dt\right)$$

$$E(W(t)) = 0$$

W(t) is white noise

$$\Rightarrow \text{var}(N(t)) = E(N^2(t)) = R_N(0)$$

Since $R_N(\tau) = h(\tau) * h(-\tau) * R_\omega(\tau)$

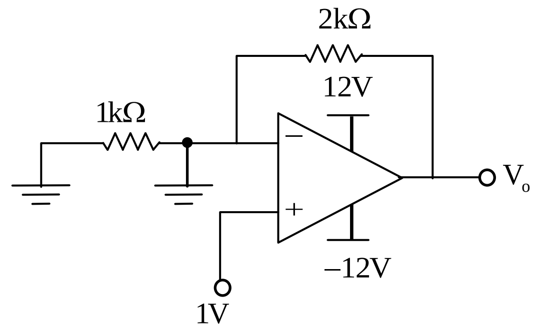
Since $R_N(\tau) = \frac{N_o}{2}.\delta(\tau)$

$$R_N(\tau) = [h(\tau) * h(-\tau)].\frac{N_o}{2}$$

$$R_N(\tau) = \frac{N_o}{2}\int_{-\infty}^{\infty} h(k).h(\tau+k)dk$$

$$R_N(0) = \frac{N_o}{2}\int_{-\infty}^{\infty} h^2(k)dk = \frac{N_o}{2}(3A^2) = \frac{3}{2}.A^2.N_o$$

40. Assuming that the opamp in the circuit shown below is ideal, the output voltage V_0 (in volts) is ___________________

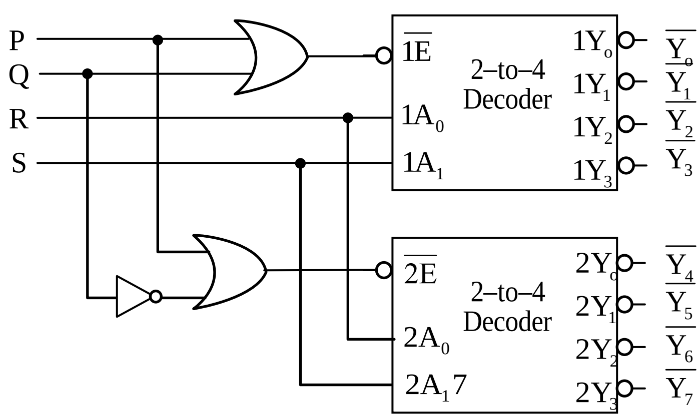


Answer: 12

Exp: $V_+ > V_-$

So $V_o = V_{sat} = 12\,\text{Volts}$

41. A 1–to–8 demultiplexer with data input D_{in}, address inputs S_0, S_1, S_2 (with S_0 as the LSB) and $\overline{Y}_0$ to $\overline{Y}_7$ as the eight demultiplexed output, is to be designed using two 2–to–4 decoders (with enable input $\overline{E}$ and address input A_0 and A_1) as shown in the figure D_{in}, S_0, S_1 and S_2 are to be connected to P, Q, R and S, but not necessarily in this order. The respective input connections to P, Q, R and S terminals should be



(A) S_2, D_{in}, S_0, S_1 (B) S_1, D_{in}, S_0, S_2 (C) D_{in}, S_0, S_1, S_2 (D) D_{in}, S_2, S_0, S_1

Answer: (D)

Exp: We need to implement 1 : 8 DEMUX

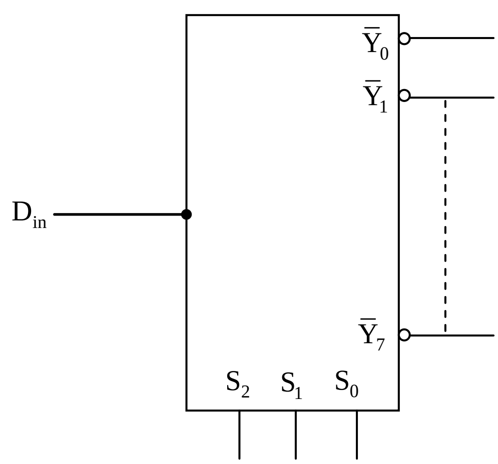
Select lines of DEMUX should be mapped to address lines of decoder. So, LSB of DEMUX should be connected to LSB of address lines of decoder.

$R \rightarrow S_0$

$S \rightarrow S_1$

Input to both the decoder should be same so $P \rightarrow D_{in}$

NOT gate along with OR gate in case to select one decoder at a time so $Q \rightarrow S_a$.



$P \to D_{in}$
$Q \to S_2$
$R \to S_0$
$S \to S_1$

42. The value of the integral $\int_{-\infty}^{\infty} 12\cos(2\pi t)\dfrac{\sin(4\pi t)}{4\pi t}\,dt$ is ________________

Answer: 3

Exp: $\int_{-\infty}^{\infty} 12\cos 2\pi t \dfrac{\sin 4\pi t}{4\pi t}dt$

$$\frac{12}{4\pi}\int_0^{\infty}\frac{2\cos 2\pi t \sin 4\pi t}{t}\,dt$$

$$\frac{3}{\pi}\left[\int_0^{\infty}\frac{\sin 6\pi t\,dt}{t}+\int_0^{\infty}\frac{\sin 2\pi t\,dt}{t}\right]\left(\because \sin A-\cos B=\sin(A+B)+\sin(A-B)\right)$$

$$=\frac{3}{\pi}\left[\int_0^{\infty}e^{\theta t}\,\frac{6\sin 6\pi t}{t}dt+\int_0^{\infty}e^{\theta t}\,\frac{\sin 2\pi t}{t}dt\right]$$

$$=\frac{3}{\pi}\left[L\left\{\frac{\sin 6\pi t}{t}\right\}+L\left\{\frac{\sin 2\pi t}{t}\right\}\right]\text{ with } s=0$$

$$=\frac{3}{\pi}\left[\int_s^{\infty}\frac{6\pi}{s^2+36\pi^2}ds+\int_s^{\infty}\frac{2\pi}{s^2+4\pi^2}ds\right]\text{ with } s=0$$

$$=\frac{3}{\pi}\left[6\pi.\frac{1}{6\pi}\tan^{-1}\left(\frac{s}{6\pi}\right)+2\pi.\frac{1}{2\pi}\tan^{-1}\left(\frac{s}{2\pi}\right)\Bigg|_s^{\infty}\right]\text{ with } s=0$$

$$=\frac{3}{\pi}\left[\tan^{-1}\infty-\tan^{-1}\left(\frac{s}{6\pi}\right)+\tan^{-1}(\infty)-\tan^{-1}\left(\frac{s}{2\pi}\right)\right]$$

$$\Rightarrow\frac{3}{\pi}\left[\frac{\pi}{2}-\tan^{-1}0+\frac{\pi}{2}-\tan^{-1}0\right]$$

$$\Rightarrow\frac{3}{\pi}\left[\frac{\pi}{2}-0+\frac{\pi}{2}-0\right]=\frac{3}{\pi}\times\pi=3$$

43. A function of Boolean variables X, Y and Z is expressed in terms of the min–terms as $F(X,Y,Z)=\Sigma(1,2,5,6,7)$

Which one of the product of sums given below is equal to the function $F(X,Y,Z)$?

(A) $(\bar{X}+\bar{Y}+\bar{Z}).(\bar{X}+Y+Z).(X+\bar{Y}+\bar{Z})$

(B) $(X+Y+Z).(X+\bar{Y}+\bar{Z}).(\bar{X}+Y+Z)$

(C) $(\bar{X}+\bar{Y}+Z).(\bar{X}+Y+\bar{Z}).(X+\bar{Y}+Z).(X+Y+\bar{Z}).(X+Y+Z)$

(D) $\left(X+Y+\overline{Z}\right).\left(\overline{X}+Y+Z\right).\left(\overline{X}+Y+\overline{Z}\right).\left(\overline{X}+\overline{Y}+Z\right).\left(\overline{X}+\overline{Y}+\overline{Z}\right)$

Answer: (B)

Exp: Given minterm is : $F(X,Y,Z)=\Sigma(1,2,5,6,7)$

So, maxterm is : $F(X,Y,Z)=\pi M(0,3,4)$

$POS=\left(X+Y+Z\right)\left(X+\overline{Y}+\overline{Z}\right)\left(\overline{X}+Y+Z\right)$

44. The transfer function of a mass–spring damper system is given by

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

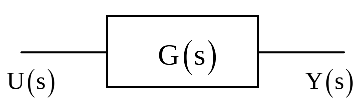
The frequency response data for the system are given in the following table.

ω in rad/s	$\lvert G(j\omega)\rvert$ in dB	$\arg\left(G(j\omega)\right)$ in deg
0.01	–18.5	–0.2
0.1	–18.5	–1.3
0.2	–18.4	–2.6
1	–16	–16.9
2	–11.4	–89.4
3	–21.5	–151
5	–32.8	–167
10	–45.3	–174.5

The unit step response of the system approaches a steady state value of ________________

Answer: 0.12

Exp:



Y(s) = G(s) U(s)

$$Y(s)=\frac{1}{\left(Ms^2+Bs+K\right)}.\frac{1}{s}$$

$$y(\infty)=\lim_{s\to 0} sY(s)=\lim_{s\to 0}\frac{1}{\left(Ms^2+Bs+K\right)}$$

$$y(\infty)=\frac{1}{K}$$

Now, @ $\omega=0.01\,\text{rad/s},\ \lvert G(j\omega)\rvert_{dB}=-18.5$

$$20\log\lvert G(j\omega)\rvert=-18.5$$

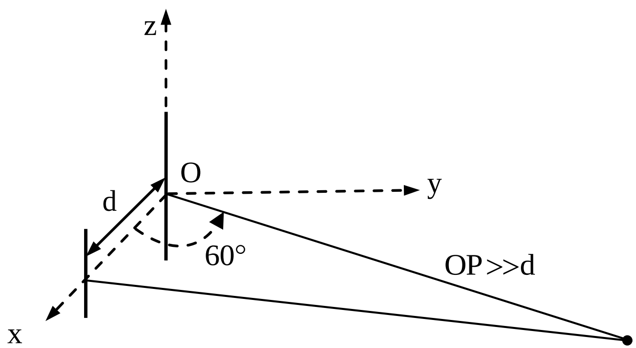
$$20\log\left|\frac{1}{k}\right| = -18.5$$

$$\log\left(\frac{1}{k}\right) = \frac{-18.5}{20}$$

$$y(\infty) = \frac{1}{k} = 10^{\frac{-18.5}{20}} = 0.1188$$

$$y(\infty) \approx 0.12$$

45. Two half–wave dipole antennas placed as shown in the figure are excited with sinusoidally varying currents of frequency 3 MHz and phase shift of $\pi/2$ between them (the element at the origin leads in phase). If the maximum radiated E–field at the point P in the x–y plane occurs at an azimuthal angle of $60^{o.}$ the distance d (in meters) between the antennas is ________________.



Answer: 50

Exp: $\psi = \delta + \beta d\cos\theta$

For maximum field, $\psi = 0$ | $\lambda = \frac{3\times10^8}{3\times10^6} = 100\,m$

$$\delta + \beta d\cos\theta = 0$$

$$-\frac{\pi}{2} + \frac{2\pi}{\lambda} d\cos 60 = 0$$

$$\frac{\pi}{2} = \frac{2\pi}{100}(d)\frac{1}{2}$$

$$d = 50m$$

46. An air–filled rectangular waveguide of internal dimensions a $cm \times b cm (a > b)$ has a cutoff frequency of 6 GHz for the dominant TE_{10} mode. For the same waveguide, if the cutoff frequency of the TM_{11} mode is 15 GHz, the cutoff frequency of the TE_{01} mode in GHz is ______________.

Answer: 13.7

Exp:

$\underline{TE_{10}}$

$f_c = 6GHz$

$f_c = \frac{1}{2\sqrt{\mu \in}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$

$a = \frac{1}{40}$

$\underline{TM_{11}}$

$15\times10^9 = \frac{3\times10^8}{2}\sqrt{\frac{1}{a^2}+\frac{1}{b^2}}$

$= \frac{1}{b} = 91.65$

$\underline{TE_{01}}$

$f_c = \frac{3\times10^8}{2}.\frac{1}{b}$

$f_c = 13.7\,GHz$

47. Consider two real sequences with time–origin marked by the bold value

$x_1[n] = \{1,2,3,0\}, x_2[n] = \{1,3,2,1\}$

Let $X_1(k)$ and $X_2(k)$ be 4–point DFTs of $x_1[n]$ and $x_2[n]$, respectively

Another sequence $x_3[n]$ is derived by taking 4–point inverse DFT of $x_3(k) = x_1(k)x_2(k)$.

The value of $x_3[2]$ is __________

Answer: 11

Exp: $x_1[n] = \{1,2,3,0\},\ x_2[n] = \{1,3,2,1\}$

$X_3(k) = X_1(k)\ X_2(k)$

Based on the properties of DFT,

$x_1[n] \otimes x_2[n] = X_1(k)\ X_2(k) = x_3[n]$

Circular convolution between two 4-point signals is as follows:

$$\begin{bmatrix}1&0&3&2\\2&1&0&3\\3&2&1&0\\0&3&2&1\end{bmatrix}\begin{bmatrix}1\\3\\2\\1\end{bmatrix} = \begin{bmatrix}9\\8\\11\\14\end{bmatrix}$$

$\therefore x_3[2] = 11$

48. Let $x(t) = a s(t) + s(-t)$ with $s(t) = \beta e^{-4t}u(t)$, where $u(t)$ is unit step function. If the bilateral Lapalce transform of x(t) is

$X(s) = \frac{16}{s^2-16} \quad -4 < Re\{s\} < 4$

Then the value of β is __________.

Answer: -2

Exp: $x(t) = \alpha s(t) + s(-t)$ & $s(t) = \beta e^{-4t} u(t)$

$$x(t) = \alpha\beta e^{-4t} u(t) + \beta e^{4t} u(-t)$$

$$\alpha\beta e^{-4t} u(t) \xrightarrow{L} \frac{\alpha\beta}{s+4}$$

$$\beta e^{4t} u(-t) \xrightarrow{L} \frac{\beta}{s-4}$$

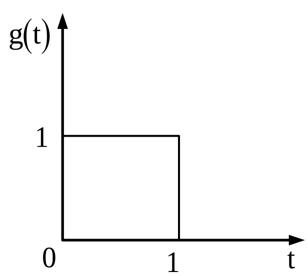
$$\therefore X(s) = \frac{\alpha B}{s+4} - \frac{\beta}{s-4}$$

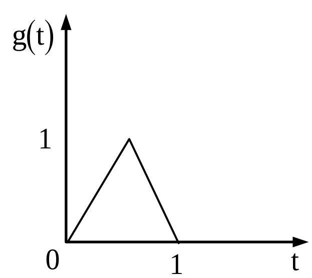
$$\beta\left[\frac{\alpha(s-4)-(s+4)}{s^2-16}\right] = \frac{16}{s^2-16} \quad ; -4 < \sigma < +4$$

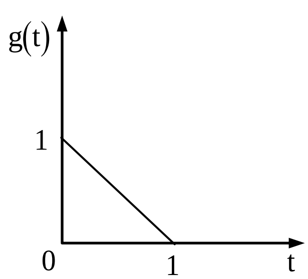
On solving the numerator

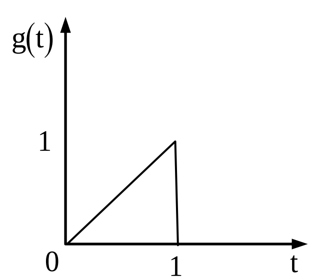
$\beta = -2$

49. Consider a binary, digital communication system which used pulses $g(t)$ and $-g(t)$ for transmitting bits over an AWGN channel. If the receiver uses a matched filter, which one of the following pulses will give the minimum probability of bit error?

(A)


(B)


(C)


(D)


Answer: (A)

Exp: Optimum receiver for AWGN channel is given by matched filter.

In case of matched filter receiver,

Probability of error $= Q\left(\sqrt{\frac{2E}{N_u}}\right)$

$\Rightarrow$ Probability of error is minimum for which E is maximum.

Now looking at options

Energy in option $(A) = 1^2 = 1$

Energy in option (C) and (D) is same = 1/3

Energy in option (B) $= 2\left[\int_0^{1/2} (2t)^2 \, dt\right]$

$= 2\left[\int_0^{1/2} 4t^2 dt\right]$

$= 2.4\left(\frac{t^3}{3}\right)\Bigg|_0^{1/2}$

$= 1/3$

Thus option (A) is correct answer.

50. The electric field of a plane wave propagating in a lossless non–magnetic medium is given by the following expression

$$E(z,t) = a_x 5\cos\left(2\pi\times10^9 t + \beta z\right) + a_y 3\cos\left(2\pi\times10^9 t + \beta z - \frac{\pi}{2}\right)$$

The type of the polarization is

(A) Right Hand Circular.
(B) Left Hand Elliptical
(C) Right Hand Elliptical
(D) Linear

Answer: (B)

Exp: $E_x = 5\cos(\omega t + \beta z)$

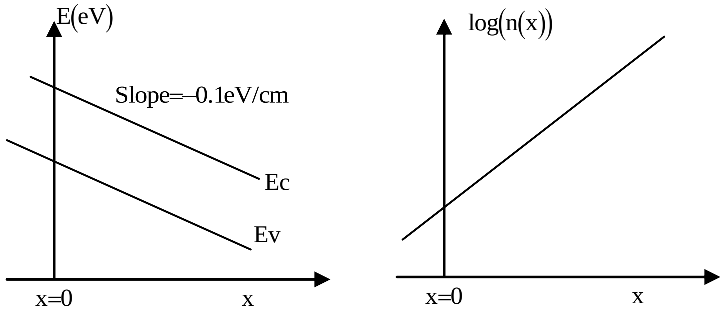
$E_y = 3\cos\left(\omega t + \beta z - \frac{\pi}{2}\right)$

$\phi = -\frac{\pi}{2}$

But the wave is propagating along negative z-direction

So, Left hand elliptical (LED).

51. The energy band diagram and electron density profile n(x) in a semiconductor are shown in the figure. Assume that $n(x) = 10^{15} e^{\left(\frac{q\alpha x}{kT}\right)} cm^{-3}$, with $\alpha = 0.1V/cm$ and x expressed in cm. Gvien $\frac{kT}{q} = 0.026V$, $D_n = 36 cm^2 s^{-1}$, and $\frac{D}{\mu} = \frac{kT}{q}$. The electron current density $\left(\text{in } A/cm^2\right)$ at x = 0 is



(A) -4.4×10^{-2} (B) -2.2×10^{-2} (C) 0 (D) 2.2×10^{-2}

Answer: (C)

Exp: $J_n(diff) = qD_n \frac{dn(x)}{dx}$

Given $n(x) = 10^{15} e^{\frac{q\alpha x}{kT}}$

$$\left.\frac{dn(x)}{dx}\right|_{x=0} = 3.846\times10^{15} \Big| cm^4$$

$$J_n(diff) = 2.2\times10^{-2} \ A/cm^2$$

$$J_{n(drift)}\Big|_{x=0} = n(0).q\mu_n E_x$$

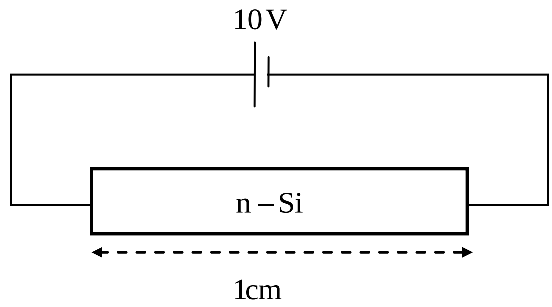
$$= 10^{15}\times1.6\times10^{-19}\times1384.5\times E_x$$

$$E_x = \frac{-kT}{q}.\frac{1}{n(x)}.\frac{dn(x)}{dx} = -\alpha = -0.1V/cm$$

$$J_n(drift) = -2.2\times10^{-12} \ A/cm^2$$

$$J = J_n(drift) + J_n(drift) = 0 \ A/cm^2$$

52. A dc voltage of 10V is applied across an n–type silicon bar having a rectangular cross–section and a length of 1cm as shown in figure. The donor doping concentration N_D and the mobility of electrons μ_n are $10^{16}\,cm^{-3}$ and $1000\,cm^2V^{-1}s^{-1}$, respectively. The average time $(\text{in } \mu s)$ taken by the electrons to move from one end of the bar to other end is _______________.



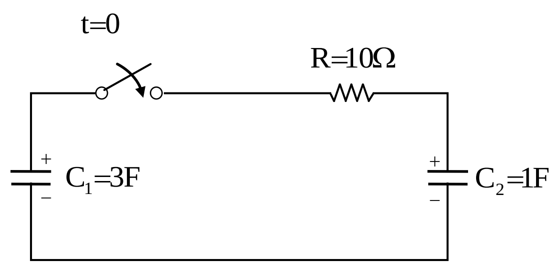
Answer: 100

Exp: $\varepsilon = \frac{V}{d} = \frac{10}{1} = 10\ V/m$

$v_d = \mu\varepsilon = 1000 \times 10 = 10^4\ cm/s$

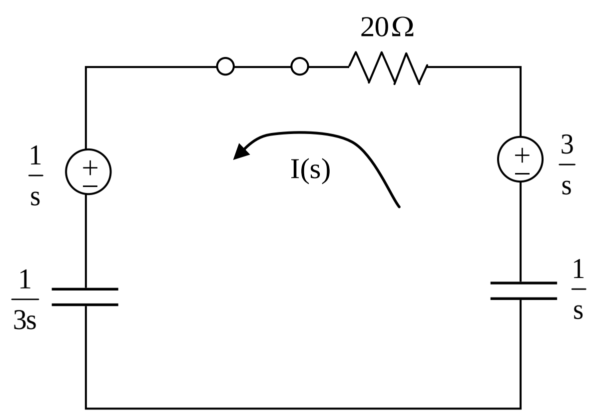
$v_d = \frac{L}{T} \Rightarrow T = \frac{L}{V_d} = \frac{1 \times 100}{10^4 \times 10^2} = 100\ \mu s$

53. In the circuit shown, the initial voltages across the capacitors C_1 and C_2 are 1V and 3V, respectively. The switch is closed at time t = 0. The total energy dissipated (in Joules) in the resistor R until steady state is reached is _________________________



Answer: 1.5

Exp: $I(s) = \frac{\left(\frac{3}{s} - \frac{1}{s}\right)}{\left(10 + \frac{1}{3s} + \frac{3}{3s}\right)}$



$I(s) = \frac{2}{\left(10s + \frac{4}{3}\right)} = \frac{2}{10\left(s + \frac{4}{30}\right)}$

$$i(t) = \frac{1}{5}e^{-\frac{4}{30}t};\ t \geq 0$$

$$E_R = \int_0^{\infty} i^2(t)10dt$$

$$= \left(\frac{10}{25}\right)\int_0^{\infty} e^{\frac{-4}{15}t}dt$$

$$= \frac{10}{25}.\frac{e^{-\frac{4}{15}t}}{\frac{-4}{15}}\Bigg]_0^{\infty}$$

$$= 0 - \frac{10}{25} \times \frac{15}{-4}$$

$$= 1.5\ J$$

54. The output of a standard second–order system for a unit step input is given as $y(t) = 1 - \frac{2}{\sqrt{3}}e^{-t}\cos\left(\sqrt{3}t - \frac{\pi}{6}\right)$. The transfer function of the system is

(A) $\frac{2}{(s+2)(s+\sqrt{3})}$ (B) $\frac{1}{s^2+2s+1}$ (C) $\frac{3}{s^2+2s+3}$ (D) $\frac{4}{s^2+2s+4}$

Answer: (D)

Exp: Here $\xi\omega_n = 1$

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

$$\xi = \frac{1}{2}$$

$$\omega_n = 2$$

55. If C denotes the counterclockwise unit circle, the value of the contour integral $\frac{1}{2\pi j}\oint_C \text{Re}\{z\}dz$ is ____________.

Answer: 0.5

Exp: $\frac{1}{2\pi J}\oint_e \text{Re}(z)dz$ where C is $|z| = 1$

Put $z = e^{j\theta} \Rightarrow d\theta = je^{j\theta}\, d\theta$

$$\frac{1}{2\pi j}\int_0^{2\pi} \mathrm{Re}\left(e^{j\theta}\right) je^{j\theta}\, d\theta$$

$$= \frac{1}{2\pi j}\int_0^{2\pi} \cos\theta \, . \, j\left(\cos\theta + j\sin\theta\right) d\theta$$

$$= \frac{j}{2\pi j}\left[\int_0^{2\pi} \cos^2\theta\, d\theta - \int_0^{2\pi} \cos\theta \sin\theta\, d\theta\right]$$

$$= \frac{j}{2\pi j}\left[\pi - 0\right] = \frac{1}{2}$$