GATE 2016 – A Brief Analysis
(Based on student test experiences in the stream of EC on 31st January, 2016 – (Afternoon Session)

Section wise analysis of the paper

Section Classification	1 Mark	2 Marks	Total No of Questions
Engineering Mathematics	5	4	9
Networks	1	3	4
Electronic Devices	3	3	6
Analog Circuits	3	4	7
Digital Circuits	3	3	6
Signals and Systems	3	4	7
Control Systems	2	3	5
Communication	3	4	7
Electromagnetics	2	2	4
Verbal Ability	2	3	5
Numerical Ability	3	2	5
	30	35	65

Type of Questions asked from each section

Digital Circuits	Questions came from Boolean expression simplification, microprocessor, logic gates, Sequential circuits.
Electronic Devices	Questions came from Solar cell, pn junction diode, MOS capacitor, BJT
Analog Circuits	OP-amp, zener diode, diode, 555 timers, BJT, MOSFET
Signals and Systems	Questions came from Z-transforms, Sampling, Laplace transform, Filters, DFT.
Networks	Questions came from Basics of networks, Two port networks, Steady state Analysis.
Control Systems	Questions came from Root locus, R-H criterion, Block diagram reduction, Time Domain analysis
Communications	Questions came from Digital communication, Information theory.
Electromagnetics	Questions came from Wave guides, Polarization, Maxwells equations

Questions from the paper

General Aptitude

1. If y=mx+c curve passes through (0,0) and (2,6) then m= _________.

Key: 3

Exp: y=mx+c passing through $(0,0) \Rightarrow 0 = 0 + c \Rightarrow c = 0$

y=mx+c passing through $(2,6) \Rightarrow 6 = 2m \Rightarrow m = 3$

2. It takes 10s, 15s for two trains moving in same direction, to completely pass a pole. Length of first train is 120 m and other is 150m. The magnitude of the difference between speeds is m/s.

(A) 2 (B) 10 (C) 12 (D) 22

Key: (A)

Exp: Speed $= \dfrac{\text{length}}{\text{time}} \Rightarrow \text{length} = \text{speed} \times \text{time}$

$120 = 10 \times s_1 \Rightarrow s_1 = 12$

$150 = 15 \times s_2 \Rightarrow s_2 = 10$

$|s_1 - s_2| = 2$

3. Four undergraduates are staying is a room. They agreed that older enjoys the more space. Manu is two months older than Sravan, who is one month younger than Trideep. Pavan is one month older than Sravan. Who will enjoy more space in room.

(A) Manu (B) Sravan (C) Trideep (D) Pavan

Key: (A)

4. The area bounded by 3x+2y=14 and 2x-3y=5 in the first quadrant is

(A) 14.95 (B) 15.25 (C) 15.70 (D) 20.35

Key: (B)

Exp $A = \left(\dfrac{14}{3}, 0\right)$

$B = (0, 7)$

$C = \left(\dfrac{5}{2}, 0\right)$

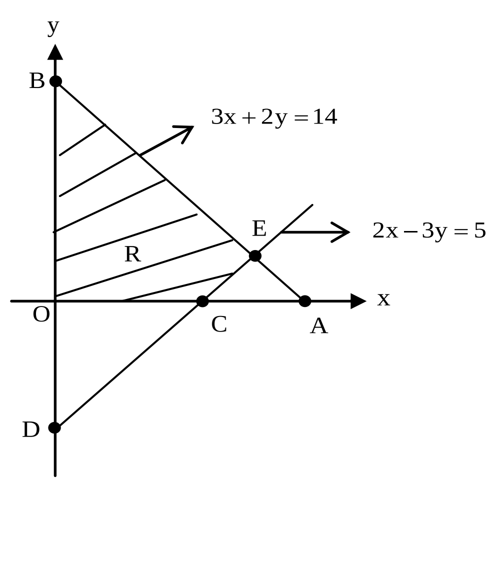
$D = \left(0, \dfrac{-5}{3}\right)$

$E = (4,1)$

Required area is area of

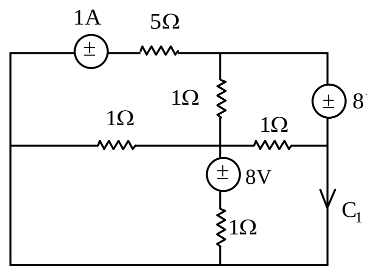
Δ OAB – area of Δ CEA

$= \dfrac{1}{2}\left(\dfrac{14}{3}\right)(7) = 15.25$ sq.units



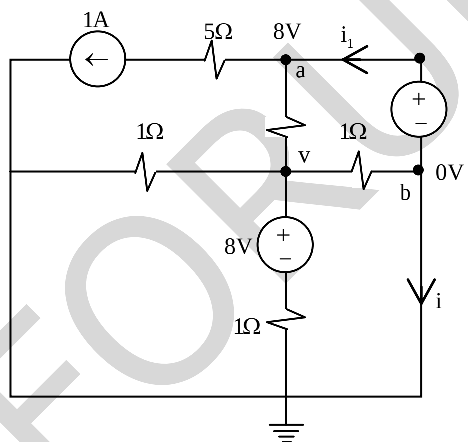
Technical

1. In below figure current 'i' is __________A.



Key: -1

Exp: Nodal equation at V



$$\frac{V-8}{1}+\frac{V}{1}+\frac{V-8}{1}+\frac{V}{1}=0$$

$$\Rightarrow 4V=16$$

$$\Rightarrow V=4V$$

By using KCL at node 'a'.

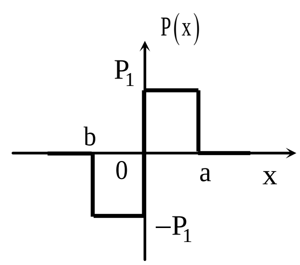
$$1+\frac{8-4}{1}-i_1=0 \Rightarrow i_1=5A$$

KCL at b

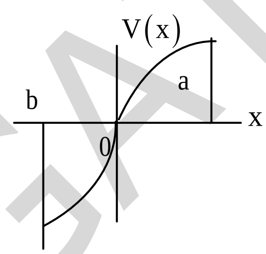
$$-\frac{4}{1}+i_1+i=0 \Rightarrow -4+5+i=0$$

$$\Rightarrow i=-1A$$

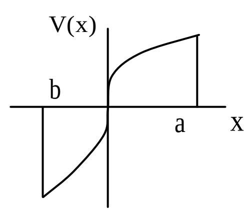
2. The charge density profile shown in figure. The resultant potential distribution is best described by



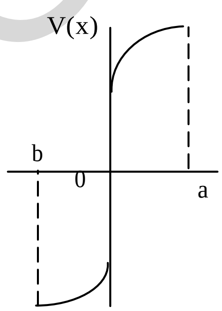
(A)



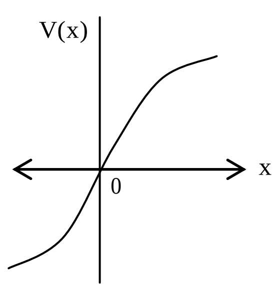
(B)



(C)



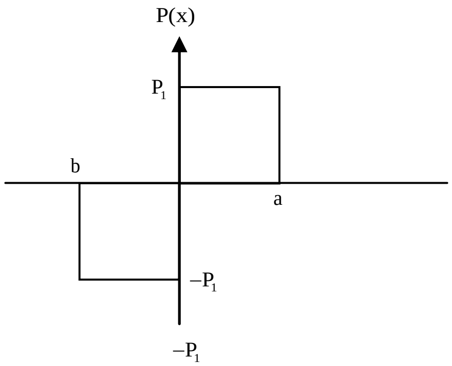
(D)

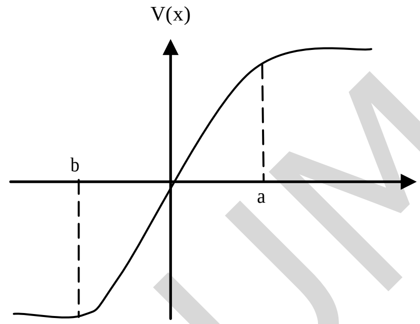


Key: (D)

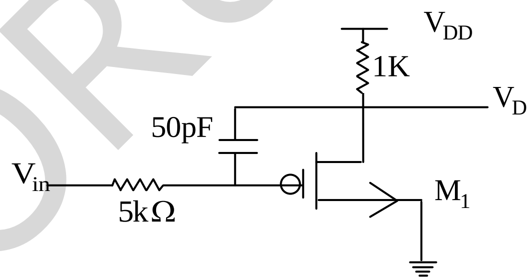
Exp: Electrical $\varepsilon_0 = -\frac{q}{\varepsilon} N_d x_{no} = -\frac{q}{\varepsilon} N_d x_{po}$

Potential $\psi(x) = |\varepsilon_0| \left(x - \frac{x^2}{2w_0} \right)$





3. In the below circuit M_1 is in saturation has transconductance g_m = 0.01 seimens, Ignoring internal parasitic capacitance and assuming the channel length modulation λ to be zero the small signal input pole frequency (kHz) is ______.



Key: 57.9

Exp: $C_{in} = 50PF(1 + g_m R) = 550PF$

$g_m = 0.015$

$R = 1k\Omega$

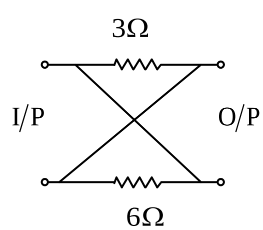
$R = 1k\Omega$

$1 + g_m R = 11$

$R_{in} = 5k\Omega$

$f_{in} = \frac{1}{2\pi R_{in} C_{in}} = 57.9\,\text{kHz}$

4. The Z – parameter matrix $\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$ for two port network shows

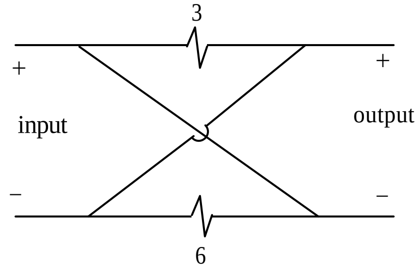


(A) $\begin{bmatrix} 2 & -2 \\ -2 & 2 \end{bmatrix}$ (B) $\begin{bmatrix} -2 & 2 \\ 2 & -2 \end{bmatrix}$ (C) $\begin{bmatrix} 1 & -2 \\ -2 & 1 \end{bmatrix}$ (D) $\begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix}$

Key: (A)

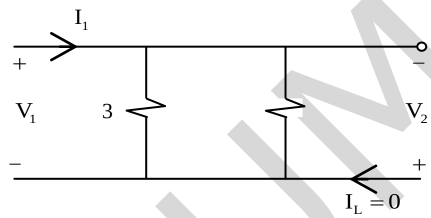
Exp: Since the given network is symmetric and reciprocal $Z_{11} = Z_{22}$

$Z_{12} = Z_{21}$



$$\Rightarrow Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0} = \frac{3\times 6}{3+6} = 2$$

$$\Rightarrow Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}$$



We know $V_2 = -V_1 \Rightarrow Z_{21} = -2$

So $\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} 2 & -2 \\ -2 & 2 \end{bmatrix}$

5. If a right handed circularly polarized wave is incident on a place perfect conductor, then the reflected wave will be _______.

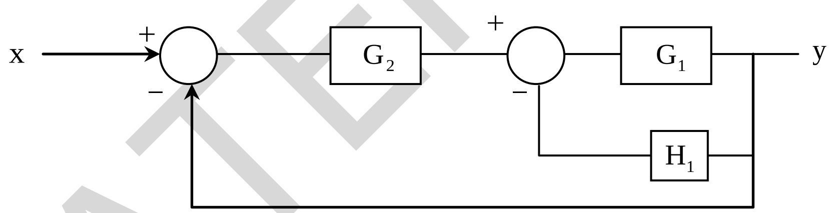
(A) Right handed circularly polarized (B) left handed circularly polarized

(C) Elliptical with all angle 45^o (D) horizontally polarized

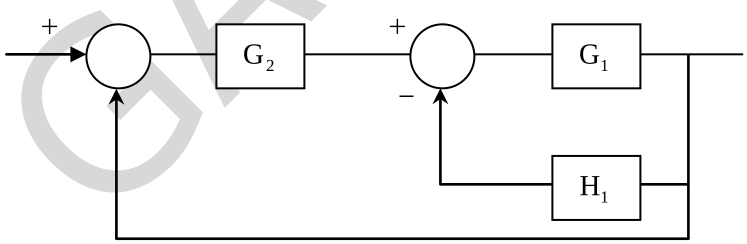
Key: (B)

Exp: If incident wave is right handed polarized then the reflected wave is left handed polarized.

6. The block diagram of a feedback system is shown in figure the overall closed loop gain of the system is _________.



Exp:



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

$$\frac{Y}{x} = \frac{G_1G_2}{1+G_1H_1+G_1G_2}$$

7. $\int_0^1 \frac{dx}{\sqrt{1-x}}$ is equal to _______.

Key: 2

Exp: $\int_0^1 \frac{1}{\sqrt{1-x}} d_0 = \left(-2\sqrt{1-x}\right)_0 = 0+2 = 2$

8. $f(z) = \frac{\sin(z)}{-z^2}$, the residue of the pole at z = 0 is _______.

Key: -1

Exp: $z = 0$ is a simple pole as

$$f(z) = \frac{\sin(z)}{-z^2} = \frac{-1}{z^2}\left[z - \frac{z^3}{3!} + \frac{z^5}{5!} - ......\right]$$

$$= -\frac{1}{z-0} + \frac{(z-0)}{3!} - \frac{(z-0)^3}{5!} + ...$$

$\therefore$ Residue of $f(z)$ at $t = 0$ is -1

9. The first two rows in the routh table for characteristics of a closed loop control system are given as

s^3	1	$(2k+3)$
s^2	2k	4

The range of 'k' for which the system is stable is

(A) $-2.0 < k < 0.5$ (B) $0 < k < 0.5$
(C) $0 < k < 8$ (D) $0.5 < k < \infty$

Key: (D)

Exp:

S^3	1	$2k+3$
S^2	2k	4

From the table we can find characteristic equation

$s^3 + 2ks^2 + (2k+3)s + 4 = 0$

For stability $(2k)(2k+3) > 4$

$4k^2 + 6k - 4 > 0$

$\left(k - \frac{1}{2}\right)(k+2) > 0$

So the conditions are $k > \frac{1}{2}$ and $k > -2$ combiningly $k > -2$

10. A triangle in the xy plane is bounded by the straight lines 2x =3y, y = 0 and x = 3. The volume above the triangle and under the plane x + y + z = 6 is _________.

Key: 10

Exp: Volume $= \iint\limits_R z\,dx\,dy$

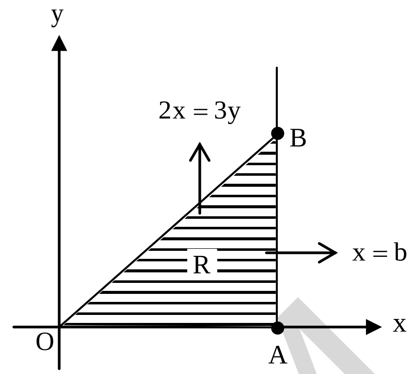
$$= \int_{x=0}^{3}\int_{y=0}^{\frac{2}{3}x}(6-x-y)\,dy\,dx$$

$$= \int_{x=0}^{3}\left[(6-x)y-\frac{y^2}{z}\right]_{y=0}^{\frac{2}{3}x}.dx$$

$$= \int_{\infty}^{3}\left[(6-x)\left(\frac{2x}{3}\right)-\frac{1}{2}\left(\frac{4}{9}x^2\right)\right]dx$$

$$= \int_{\infty}^{3}\left(4x-\frac{2}{3}x^2-\frac{2}{9}x^2\right)dx$$

$$= \left[2x^2-\frac{8}{9}\left(\frac{x^3}{3}\right)\right]_0^3 = 2(9)-\frac{8}{27}(3^3) = 10\text{ cubic units}$$



x limits : 0 to 3

y limits: 0 to $\frac{2}{3}x$

11. An analog baseband signal, band limited to 100MHz, is sampled at the nyquist rate. The samples are quantized into four message symbols that occur independently with probabilities $P_1 = P_4 = 0.125$ and $P_2 = P_3$. The information rate (bits/sec) of the message source is _____.

Key: 213.9

Exp: Information rate = rH

$H \rightarrow \text{bits/symbol}$

$r \rightarrow \text{symbols/sec}$

If we assume each sample is mapped to symbol

Then r = 200 MHz

$$P_1 + P_4 + 2P_2 = 1$$

$$2P_2 = 1-\frac{1}{4} = \frac{3}{4}$$

$$P_2 = \frac{3}{8}$$

$$P_2 = P_3 = \frac{3}{8}$$

$$H = \frac{2}{8}\log_2 8 + \frac{6}{8}\log_2\left(\frac{8}{3}\right) = 1.069$$

I.R = 213.9 Mbps

12. Faraday's law of electromagnetic s induction is mathematically described by which one of the followers.

(A) $\nabla.\overline{B} = 0$

(B) $\nabla.\overline{D} = \rho_V$

(C) $\nabla \times \overline{E} = -\frac{\partial B}{\partial t}$

(D) $\nabla \times \overline{H} = \sigma\overline{E} + \frac{\partial\overline{D}}{\partial t}$

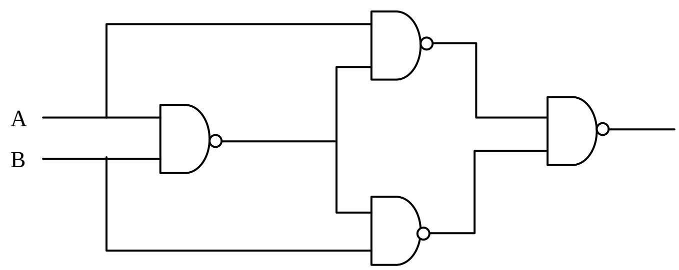
Key: (C)

13. The minimum number of 2 -input NAND gates required to implement a 2 – input XOR gate is

(A) 4 (B) 5 (C) 6 (D) 7

Key: (A)

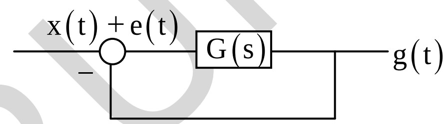
Exp:



$\bar{A}B + A\bar{B} = A \oplus B$

14. For the unity feedback control system shown in below figure the open loop transfer function G(s) $= 2/s(s+1)$

The steady state error due to unit step i/p is _______.



Key: 0.33

Exp: For the unit feedback system $G(S) = \frac{2}{S(S+1)}$

For unit step input the steady state error is

$$e_{ss} = \frac{1}{1+k_p}$$

Where $k_p = \lim_{s\to\infty} sG(s) = \lim_{s\to 0} s\frac{2}{s(s+1)} = 2$

$$\Rightarrow e_{ss} = \frac{1}{1+2} = \frac{1}{3} = 0.33$$

15. The bit error probability of a memory less BSc is 10^{-5}. If 10^5 bits are sent over this channel, then the probability that not more than one bit will be in error is _________.

Key: 1

Exp: $P_{ebit} = 10^{-5}$

$n = 10^5$ bits

$x = \text{no. of bits (error)}$

$P(x \le 1) = P(x=0) + P(x=1)$

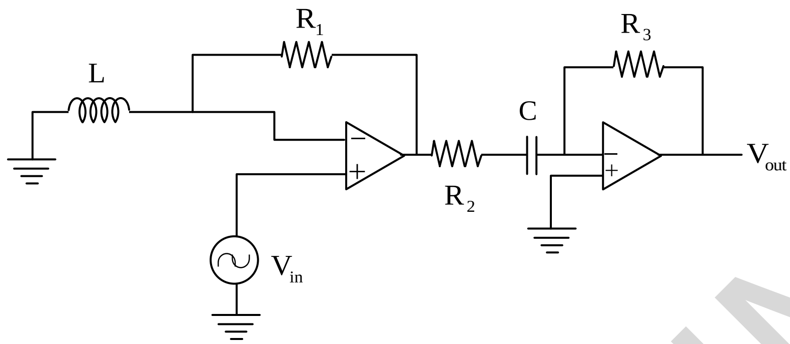
$$= \binom{10^5}{0}(10^{-5})(1-10^{-5})^{10^5-0} + \binom{10^5}{1}(10^{-5})^1(1-10^{-5})^{10^{-5}-1}$$

$$= \left(\frac{10^5-1}{10^5}\right)^{10^5} + \binom{10^5}{1}(10^{-5})^1(1-10^{-5})^{10^{-5}-1}$$

≈ 1 (very close)

16. For the circuit shown in figure $R_1 = R_2 = R_3 = 1\Omega,\ L = 1\mu H,\ C = 1\mu F.$

If input $V_{in} = \cos(10^6 t)$, then the overall voltage gain of the circuit is _________.



Key: -1

Exp: $A_1 = \left(1 + \frac{R_1}{|j\omega L|}\right) = \left(1 + \frac{1}{10^6 \times 10^{-6}}\right) = 2$

$$A_2 = -\frac{R_3}{R_2 + |X_C|} = -\frac{1}{1 + \frac{1}{10^6 \times 10^{-6}}} = \frac{-1}{1+1} = \frac{-1}{2}$$

The overall voltage gain $A_v = \frac{V_{out}}{V_{in}} = A_1 \times A_2$

$$\frac{V_{out}}{V_{in}} = 2\left(-\frac{1}{2}\right) = -1$$

17. The forward path transfer function and the feedback path transfer function of single loop negative feedback control system is given as

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

If the variable perimeter k is real positive, then the location of the breakaway point on the root locus diagram of the system is _______.

Key: -3.414

Exp: To find break point, from characteristic equation we need to arrange k as function of s, then the root of $\frac{dk}{ds} = 0$ gives break point.

Characteristic equation is given by

$$s^2 + 2s + 2 + k + 2k = 0$$

$$\Rightarrow k(s+2) = -(s^2 + 2s + 2)$$

$$\Rightarrow k = -\left[\frac{s^2 + 2s + 2}{s+2}\right]$$

$$\Rightarrow \frac{dk}{ds} = -\left[\frac{(s+2)\frac{d}{ds}(s^2 + 2s + 2) - (s^2 + 2s +)\frac{d}{ds}(s+2)}{(s+2)^2}\right]$$

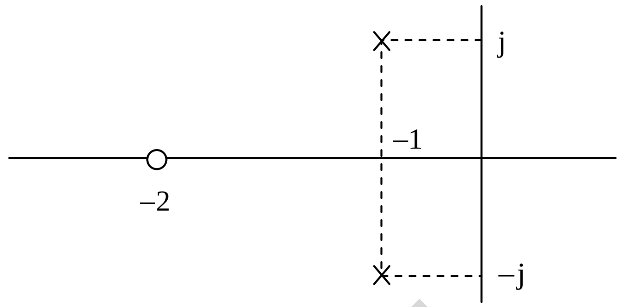
$$\Rightarrow \frac{dk}{ds} = -\left[\frac{(s+2)(2s+2)-(s^2+2s+2)}{(s+2)^2}\right]$$

$$\Rightarrow \frac{dk}{ds} = 0$$

$$\Rightarrow 2s^2+2s+4s+4-s^2-2s-2=0$$

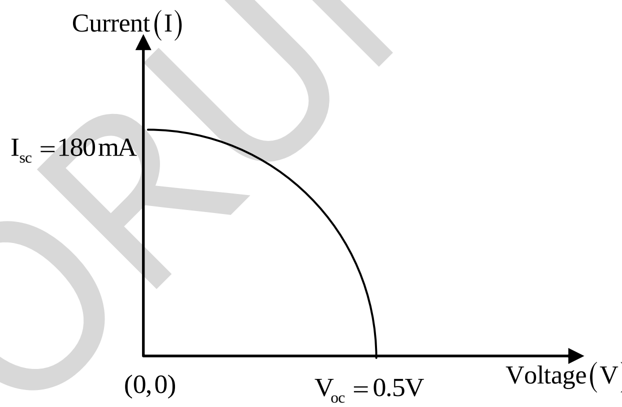
$$\Rightarrow s^2+4s+2=0$$

$$\Rightarrow s = -0.58 \text{ and } -3.414$$



- To find the valid break point we need to find that lies on root locus
- – 3.414 lies on root locus
- So break point – 3.414.

18. The $I-V$ characteristics of a solar cell is as shown in figure, when it is illuminated uniformly with solar light of power 100 mW/cm^2. The solar cell has an area of 3 cm^2 and fill factor is 0.7. The maximum efficiency of the cell is _________%.

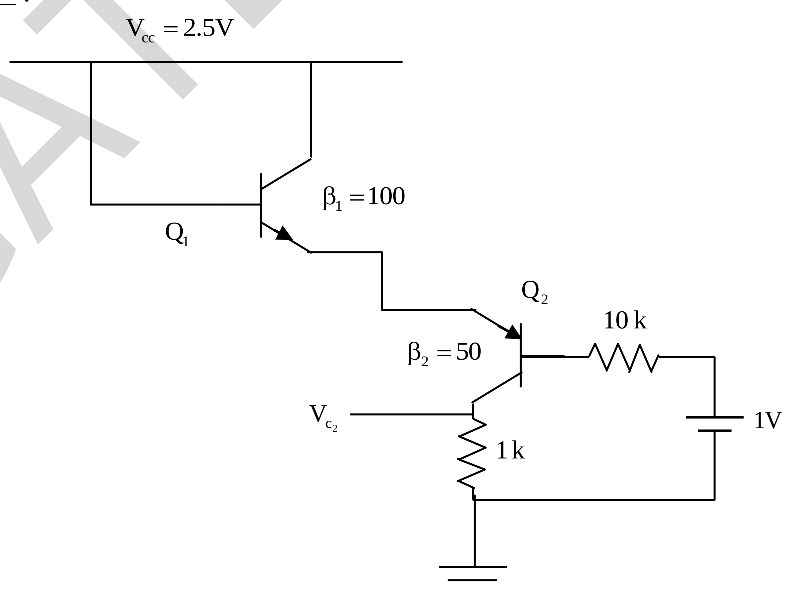


Key: 21

Exp: $\text{Efficiency} = \frac{FF.V_{oc}I_{sc}}{P_{in}} = \frac{0.7\times0.5\times180}{(100\times3)}\times100\%$

= 21%.

19. Consider the circuit shown below, Assuming $V_{BE1} = V_{EB2} = 0.7V$. The value of D.C voltage $V_{c_2}(V)$ is ____ .



Key: 0.5

Exp: $V_{E_2=2.5} - V_{BE1} = 1.8V$

$V_{B_2} = V_{E_2} - 0.7 = 1.1V$

$I_{B_2} = \frac{0.1}{10k} = 10^{-5} A$

$I_{C_2} = 50 \times 10^{-5} A$

$V_{C_2} = 5 \times 10^{-4} \times 10^{3} = 0.5V$

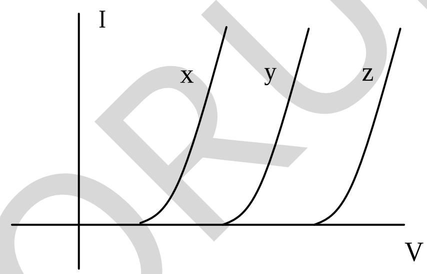
20. The I-V characteristics of three types of diodes at room temperature made of semiconductors x, y, z are shown in the figure. Assume that the diodes are uniformly doped and identical in all respects except their materials. If E_{gx}, E_{gy}, E_{gz} are the band gaps of x,y,z respectively then

(A) $E_{gx} > E_{gy} > E_{gt}$

(B) $E_{gx} = E_{gy} = E_{g2}$

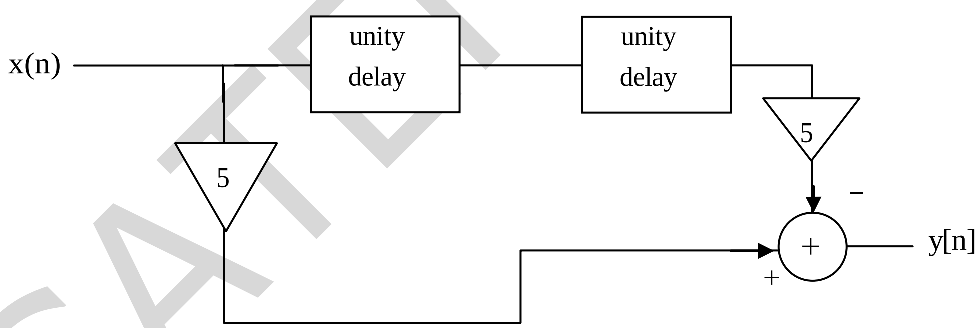
(C) $E_{gx} < E_{gy} < E_{gz}$

(D) No relation



Key: (C)

21. The direct form structure of an FIR filter is shown in figure



The filter can be used to approximate a

(A) LPF (B) HPF (C) BPF (D) BSF

Key: (C)

Exp: $y[n] = 5x[n] - 5x[n-2]$

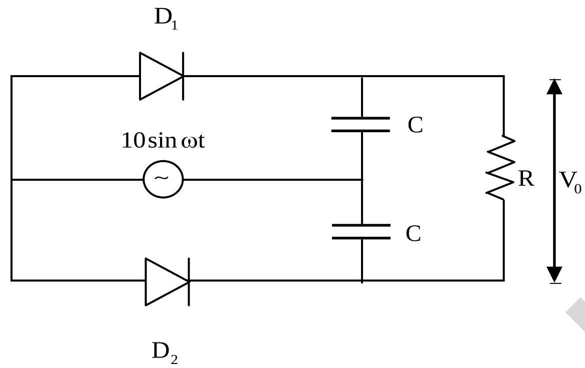
$\therefore H(e^{j\omega}) = 5(1 - e^{-2j\omega})$

At $\omega = 0, \left|H(e^{j\omega})\right| = 0$

At $\omega = \pi; \left|H(e^{j\omega})\right| = 0$

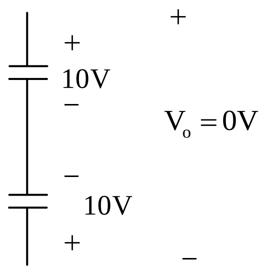
Thus the filter is band pass filter

22. Two diodes D_1 and D_2 shown in figure are Ideal. The two capacitors are identical and the value of RC is very large than time period of ac signal. If the diodes don't breakdown in reverse bias, the value of output voltage V_0(volts) in steady state is __________



Key: 0

Exp: $V_o = 0\text{volts}$



23. A discrete sequence $x[n] = \delta[n-3] + 2\delta[n-5]$ has a z-transform X(z); if Y(z) = X(-z) is the z-transform for another sequence y[n], then,

(A) $y[n] = x[n]$ (B) $y[n] = x[-n]$

(C) $y[n] = -x[n]$ (D) $y[n] = -x[-n]$

Key: (B)

Exp: $X(z) = z^{-3} + 2z^{-5}$

$\therefore Y(z) = X(-z) = z^3 + 2z^5$

On applying inverse z-transform,

$y[n] = \delta[n+3] + 2\delta[n+5]$

Consider

$x[-n] = \delta[-n-3] + 2\delta[-n-5]$

$= \delta[n+3] + 2\delta[n+5]$

$\therefore y[n] = x[-n]$

24. A continuous time signal x(t) $= \cos 6\pi t + \sin 8\pi t$, the Nyquist sampling rate (samples/sec) of y(t)=x(2t+5) is

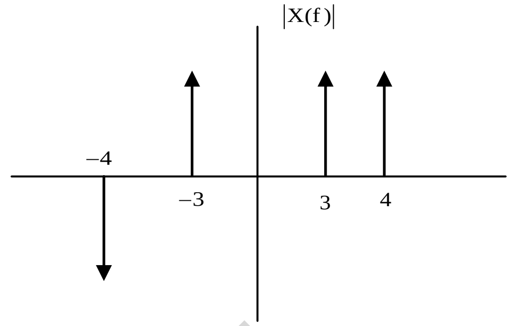
(A) 8 (B) 12 (C) 16 (D) 20

Key: (C)

Exp: Shifting doesn't effects the sampling rate due to scaling by a factor '2' spectral components are doubled.

Thus maximum frequency of $|Y(f)| = 8.$

$\therefore$ Nyquist rate $= 8 \times 2 = 16\text{Hz}$



25. An input signal $x(t) = 2\cos\frac{2\pi}{3}t - \cos\pi t$ is passed through an LTI system with impulse transfer function $H(s) = e^{s} + e^{-s}$. If c_k represents k^{th} coefficient of exponential Fourier series of output then the value of c_3 is

(A) 0 (B) 1 (C) 2 (D) 3

Key: (C)

Exp: $H(j\omega) = 2\cos\omega$

For $2\cos\left(\frac{2\pi}{3}t\right)$, output $= 2k_1\cos\left(\frac{2\pi}{3}t\right)$

$$k_1 = \left(2\cos\omega\right)\Big/_{\omega = \frac{2\pi}{3}} = 2\cos\left(\frac{2\pi}{3}\right) = -1$$

For $\cos\pi t$, output $= k_2\cos\pi t$

$$k_2 = 2\left(\cos\omega\right)\Big/_{\omega = +\pi} = -2$$

$\therefore$ output $= -2\cos\frac{2\pi}{3}t + 2\cos\pi t$ $\therefore c_3 = 2$

26. $x(t) = \frac{\sin t}{\pi t} * \frac{\sin t}{\pi t}$, If * is the convolution then the value of $x(t)$ is

(A) $\frac{\sin t}{\pi t}$ (B) $\frac{\sin 2\pi t}{2\pi t}$ (C) $\frac{2\sin\pi t}{\pi t}$ (D) $\frac{\sin^2\pi t}{(\pi t)^2}$

Key: (A)

Exp: $\frac{\sin t}{\pi t} = \frac{1}{\pi}\text{sa}(t)$

$\because \text{sa}(t) \xrightarrow{F} \pi\,\text{rect}\left(\frac{\omega}{2}\right)$

$\frac{1}{\pi}\text{sa}(t) \xrightarrow{F} \text{rect}\left(\frac{\omega}{2}\right)$

Convolution in time domain leads to multiplication in frequency domain

$\therefore \text{rect}\left(\frac{\omega}{2}\right)\text{rect}\left(\frac{\omega}{2}\right) = X(\omega) \Rightarrow x(t) = \frac{1}{\pi}\text{sa}(t) = \frac{\sin t}{\pi t}$

27. Figure I and II shows MOS capacitors of unit area. The capacitor in figure I has insulator X (with thickness $t_1 = 1m$ and $\in_{r1} = 4$) and Y (thickness $t_2 = 3nm$ and $\in_{r2} = 20$). The capacitor in figure II has only insulator material X of thickness $t_{\in q}$. Find $t_{\in q}$ = ____________ nm.

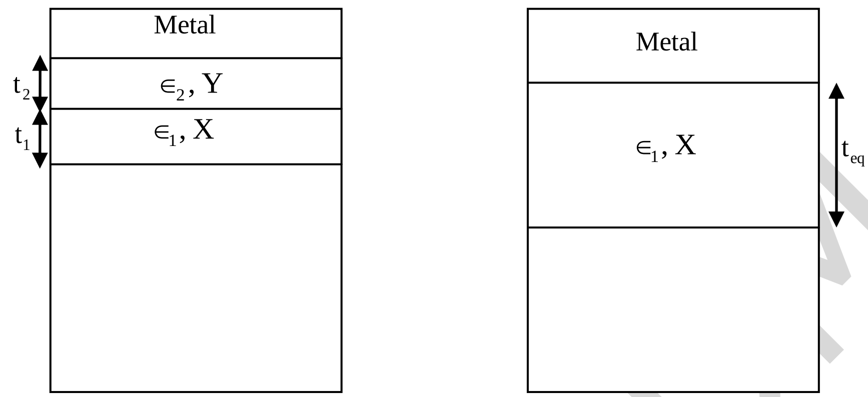


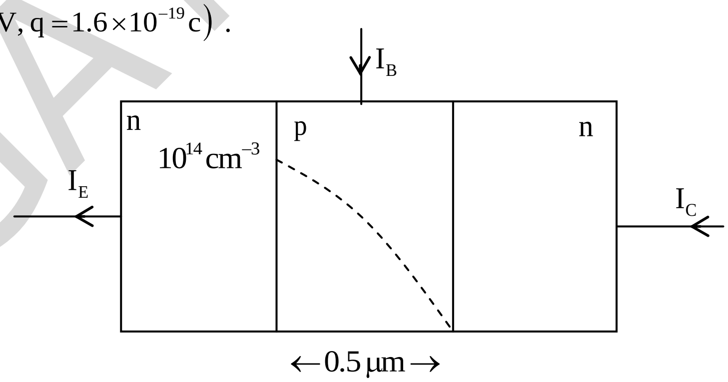
Figure I   Figure II

Key: 1.6

Exp:
$$C_I = \frac{\frac{E_1}{t_1} \cdot \frac{E_2}{t_2}}{\frac{E_1}{t_1} + \frac{E_2}{t_2}} = \frac{E_1 E_2}{E_1 t_2 + E_2 t_1} = \frac{4 \times 20}{(4 \times 2) + (20 \times 1)} = 2.5$$

$$C_{II} = \frac{E_1}{t_{Eq}} \Rightarrow \frac{4}{t_{Eq}} = 2.5 \Rightarrow \boxed{t_{Eq} = 1.6nm}$$

28. The injected electron concentration profile in the base region of npn BJT, biased in the active region is linear as shown in figure. If the area of the emitter – base junction is 0.001 cm^2, $\mu n = 800\, cm^2/V - s$
in the base region, the collector current $I_c(mA)$ at room temperature is __________ $\left(V_T = 26mV, q = 1.6 \times 10^{-19} c\right)$.

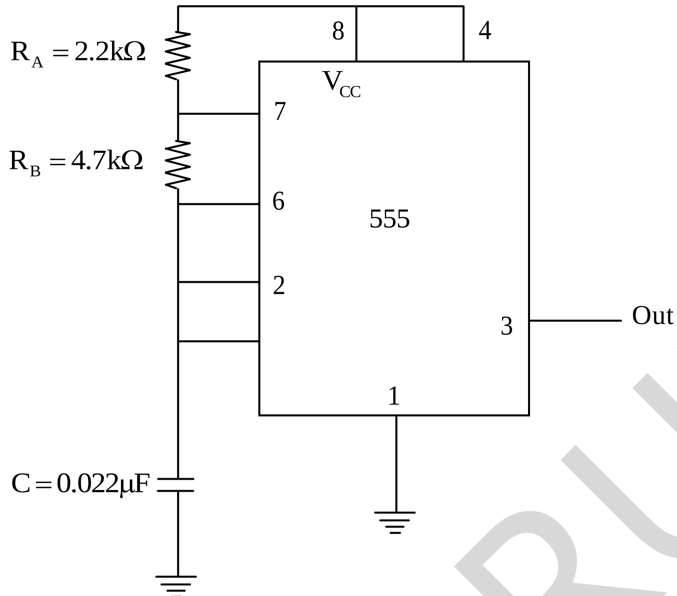


Key: 6.65

Exp:
$$|I_c| \approx qAD_n \frac{dn}{dx} = qA\mu_n V + \frac{dn}{dx} \quad = 1.6 \times 10^{-19} \times 0.001 \times 800 \times 26 \times 10^{-3} \left(\frac{10^{14} - 0}{0.5 \times 10^{-4}} \right)$$

$$|I_c| = 6.65mA$$

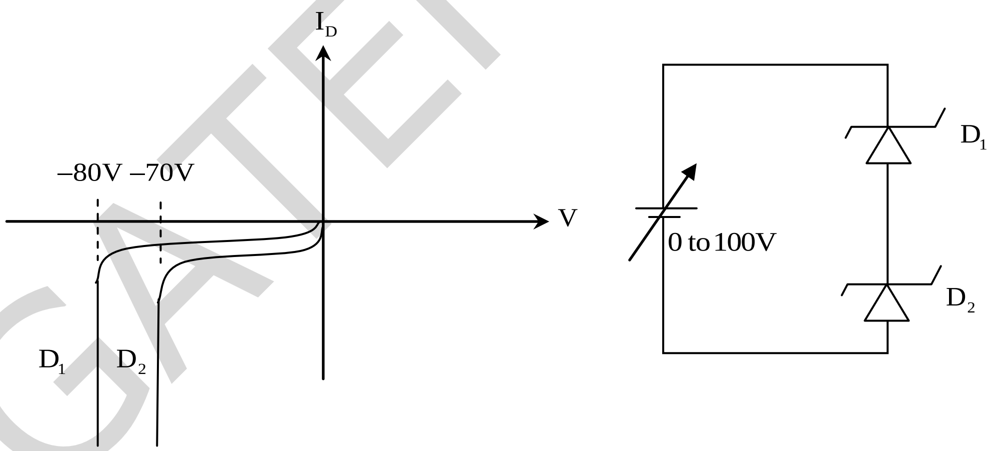
29. Frequency of oscillation at pin 3 is ___________kHz..



Key: 5.64

Exp: $f = \dfrac{1.44}{(R_A + 2R_B)C} = \dfrac{1.44}{[2200 + 2\pi 4700] \times 0.022 \times 10^{-6}} = 5.64\,kHz$

30. The I-V characteristics of diodes D_1 and D_2 are given in figure. The simply voltage is varied from 0 to 100V. The breakdown occurs at



(A) D_1 only (B) D_2 only (C) Both D_1 and D_2 (D) None of D_1 and D_2

Key: (D)

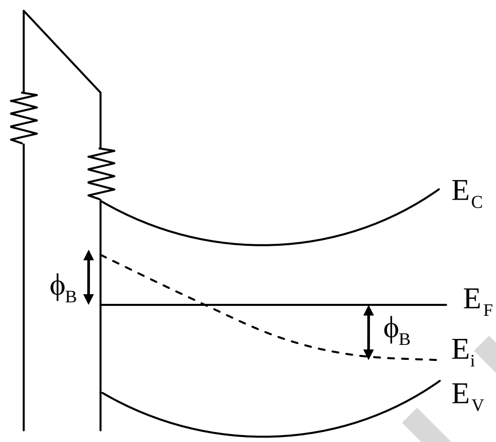
Exp: When two diodes are connected in series, the effective breakdown voltages becomes equal to the sum of their individual breakdown voltage.

$V_b = V_{b1} + V_{b2} = 80 + 70 = 150V$

Since the applied voltage has a maximum of 100V ($100 < V_b$), No diodes will be in breakdown region.

31. The surface region of the MOSFET is in

(A) Accumulation (B) Inversion (C) Depletion (D) None of the above



Key: (B)

Exp: The semiconductor used in the MOSFET is n-type. At the surface the intrinsic level is above E_F as it is found at the distance of below E_F, So, the surface is in inversion region.