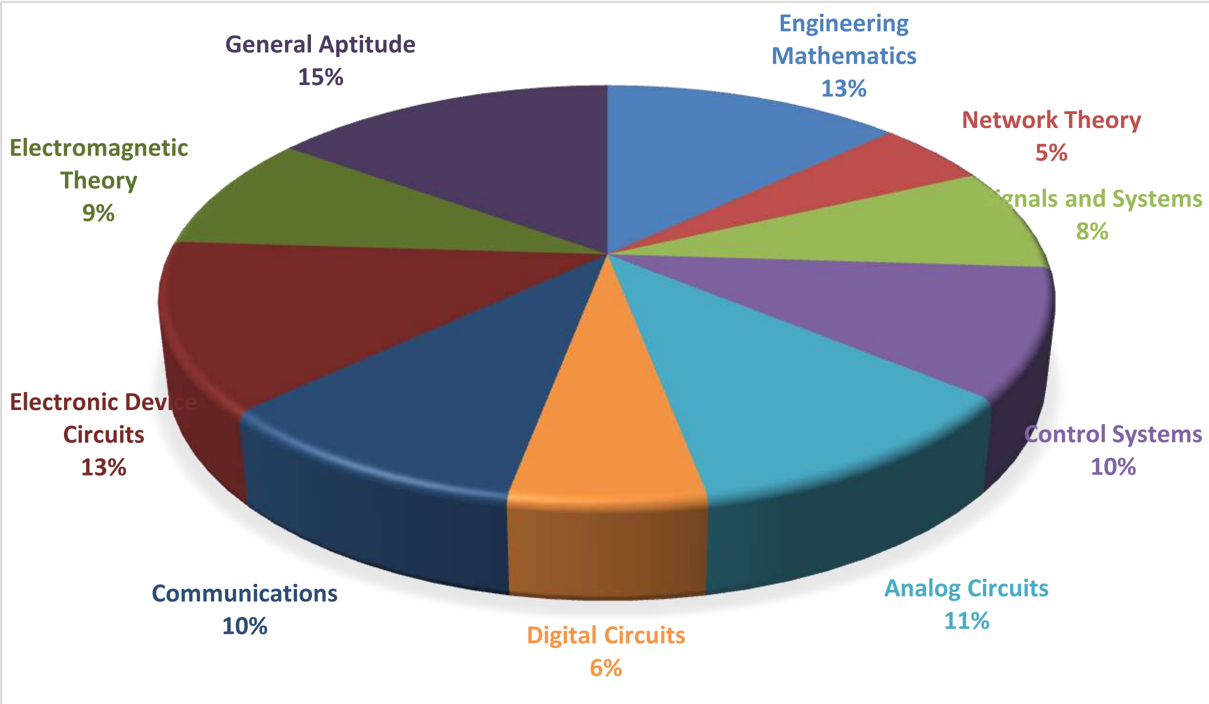
ANALYSIS OF GATE 2019

Electronics and Communication Engineering



ECE ANALYSIS-2019_Feb-9_Morning

SUBJECT	No. of Ques.	Topics Asked in Paper	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 7 2 Marks: 3	Double integral, Calculus, Random variable, Differential equations, Men values, Eigen values, Residue Theorem	Moderate	13
Network Theory	1 Marks: 1 2 Marks: 2	2-port network, RC circuit, Star-Delta conversion	Moderate	5
Signals and Systems	1 Marks: 2 2 Marks: 3	Time period, z-transforms, DTTF, FFT	Difficult	8
Control Systems	1 Marks: 2 2 Marks: 4	Bode Plot, 2nd older domain time response, Routh Hurwitz circuit, State space	Moderate	10
Analog Circuits	1 Marks: 1 2 Marks: 5	Diodes, UJT, Diodes, Zener diodes	Moderate	11
Digital Circuits	1 Marks: 4 2 Marks: 1	Logic family, MOS, Counter, Noise margin, State diagram	Moderate	6
Communications	1 Marks: 2 2 Marks: 4	Hamming codes, Modulation keying, PCM, Error probability, PSD	Moderate	10
Electronic Device Circuits	1 Marks: 3 2 Marks: 5	Energy band, Fermi level, IC fabrication responsivity, Drain current, CMOS	Difficult	13
Electromagnetic Theory	1 Marks: 3 2 Marks: 3	Radiation resistance, Electric flux, Maxwell's equations, Linear current group velocity, Wave guide	Moderate	9
General Aptitude	1 Marks: 5 2 Marks: 5	Data interpretation, Grammar, Seating arrangement, Time and work	Moderate	15
Total	**65**			**100**
Faculty Feedback	Overall paper is moderate to difficulty level. Compared to last year, the 2019 ECE paper is easy			

GATE 2019 Examination

Electronics and Communication Engineering

Test Date: 9-FEB-2019

Test Time: 9.30 AM to 1:30 PM

Subject Name: Electronics and Communication Engineering

General Aptitude

Q.1 - Q.5 Carry One Mark each.

1. It would take one machine 4 hours to complete a production and another machine 2 hours to complete the same order. If both machines work simultaneously at their respective constant rates, the time taken to complete the same order is _____ hours.
(A) 7/3
(B) 2/3
(C) 4/3
(D) 3/4
[Ans. C]
Time taken by **Machine 1** to complete a production = 4 hours
Means in 1 hour, part of production completed by Machine 1 =1/4
Time taken by **Machine 2** to complete a production = 2hours
Means in 1 hour, part of production completed by Machine 2 =1/2
If both machine work simultaneously at their respective constant rates; part of work completed in 1 hour $= \frac{1}{4} + \frac{1}{2} = \frac{3}{4}$
So, complete production will be done in $\frac{4}{3}$ hours.

2. The boat arrived ________ dawn.
(A) in
(B) at
(C) under
(D) on
[Ans. B]
Dawn: the early morning phase of a day.

3. the strategies that the company ______ to sell it products ______ house-to-house
(A) used, includes
(B) uses, include
(C) use, includes
(D) uses, including
[Ans. B]

The strategies that the company uses to sell its products include house–to–house marketing.

4. Five different books (P, Q, R, S, T) are to be arranged on a shelf. The books R and S are to be arranged first and second, respectively from right side of the shelf. The number of different orders in which P, Q and T may be arranged is _______ .
(A) 2
(B) 6
(C) 120
(D) 12
[Ans. B]
__, __, __, S, R
P, Q & T = $3 \times 2 \times 1 = 3! = 6$

5. When he did not come home, she _________ him lying dead on the roadside somewhere.
(A) concluded
(B) notice
(C) looked
(D) pictured

[Ans. D]

When he didn't come home, she pictured him lying dead on road side somewhere

Q.6 - Q.10 Carry Two Mark each.

6. Four people are standing in a line facing you. They are Rahul, Mathew, Seema and Lohit. One is engineer, one is a doctor, one a teacher and another a dancer.
You are told that:-
1. Mathew is not standing next to Seema.
2. There are two people standing between Lohit and engineer.
3. Rahul is not a doctor.
4. The teacher and the dancer are standing next to each other.
5. Seema is turning to her right to speak to the doctor standing next to her.
Who among them is an Engineer?
(A) Lohit
(B) Rahul
(C) Seema
(D) Mathew
[Ans. D]
So, the sequence is **L, S, R, M**

Where Lohit is a doctor because Lohit is in immediate right to Seema. Lohit will be at corner as there must be two people between Lohit and engineer. Since, Mathew cannot be adjacent to Seema; means Mathew will be at the right most place and since the right most is an Engineer means Mathew is an Engineer. Both Seema and Rahul can be either teacher or dancer.

Profession/person	Rahul	Mathew	Seema	Lohit
Engineer		√		
Doctor				√
Teacher	√		√	
Dancer	√		√	

7. Two design consultants, P and Q, started working from 8 AM for a client. The client budgeted a total of USD 3000 for the consultants. P stopped working when hour hand moved by 210 degrees on the clock. Q stopped working when the hour hand moved by 240 degrees. P took two tea breaks of 15 minutes each during her shift, but took no lunch break. Q took only one lunch break of 20 minutes, but no tea breaks. The market rate for consultants is USD 200 per hour and breaks are not paid. After paying the consultants, the clients shall have USD _________remaining in the budget

(A) 000.00
(B) 166.67
(C) 300.00
(D) 433.33

[Ans. B]

In a clock, a hour hand moves 360° in 12 hours; means in 1 hours, it moves $\frac{360}{12} = 30°$

P worked till hour hand of the clock moved 210°; means $\frac{210}{30} = 7$ hours, but he takes two tea breaks of 15 minutes each

So, P worked total of $7 - \frac{1}{2} = \frac{13}{2}$ hours for which he will be paid.

So, P will be paid total of $\left(\frac{13}{2} \times 200\right) = 1300$

Q worked till hour hand of the clock moved 240°; means $\frac{240}{30} = 8$ hours, but he takes one lunch break for 20 minutes

So, Q worked total of $8 - \frac{1}{3} = \frac{23}{3}$ hours for which he will be paid.

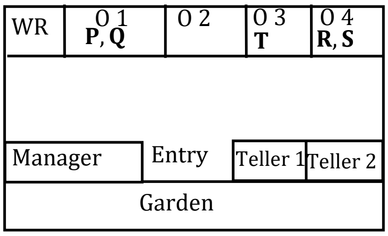
So, Q will be paid total of $\left(\frac{23}{3} \times 200\right) = \frac{4600}{3}$

So, total amount paid to P and Q collectively $= 1300 + \frac{4600}{3} = \text{USD}\ \frac{8500}{3}$

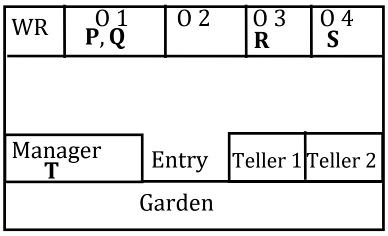
So, money left with client $= \text{USD}\ 300 - \text{USD}\ \frac{8500}{3} = \text{USD}\ \frac{500}{3} = \text{USD}\ 166.67$

8. Five people P, Q, R, S and T work in a bank. P and Q don't like each other but have to share an office till T gets a promotion and moves to the big office next to the garden. R, who is currently sharing an office with T wants to move to the adjacent office with S, the handsome new intern. Given the floor plan, what is the current location of Q, R and T?
(O = Office, WR = Wash room)

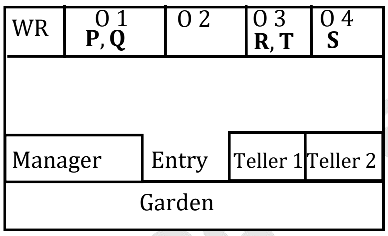
(A)



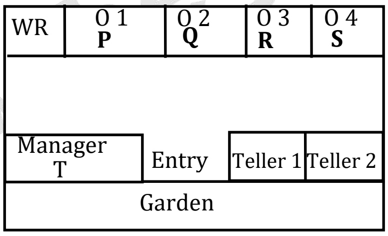
(B)



(C)



(D)

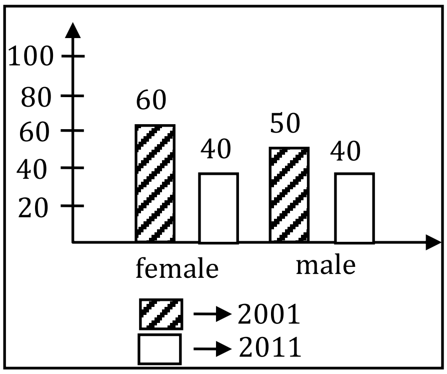


[Ans. C]

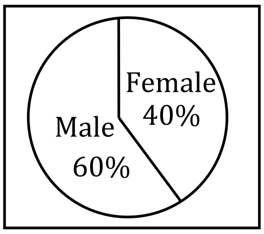
According to question P and Q are sharing a common office and R and T are sharing a common office.

So the current location of Q, R and T belongs to **option C**.

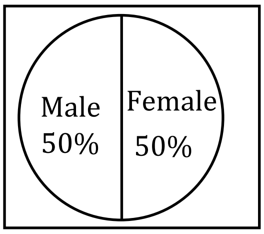
9. The bar graph in Panel (a) shows the proportion of male and female illiterates in 2001 and 2011. The proportion of males and females in 2001 and 2011 are given in panel (b) and (c), respectively. The total population did not change during their period.
The percentage increase in the total number of literates from 2001 to 2011 is _______.



Panel(a)



Panel(b)



Panel(c)

(A) 30.43
(B) 34.43
(C) 33.43
(D) 35.43

[Ans. A]

Let total population be 100.

In **2001**:

Number of females=40% of 100=40 [from panel (b)]
Number of males=60% of 100=60 [from panel (b)]
Out of 40, number of illiterate females=60% of 40=24 [from panel (a)]
Out of 60, number of illiterate males=50% of 60=30 [from panel (a)]
So, number of literate females =40 − 24=16
And, number of literate males =60 − 30=30
So, total literate people in 2001 = 16+30=46 ______________ ①

In **2011**:

Number of females=50% of 100=50 [from panel (c)]
Number of males=50% of 100=50 [from panel (c)]
Out of 50, number of illiterate females=40% of 50=20 [from panel (a)]
Out of 50, number of illiterate males=40% of 50=20 [from panel (a)]
So, number of literate females =50 − 20=30
And, number of literate males =50 − 20=30
So, total literate people in 2011 = 30+30=60 ______________ ②

So, % increase in total number of literate people from 2001 t0 2011

$$= \frac{60-46}{46} \times 100 = \frac{14}{46} \times 100 = 30.43\%$$

10. "Indian history was written by British historians - extremely well documented and researched, but not always impartial. History had to serve its purpose. Everything was made subservient to the glory of the Union Jack. Latter - day Indian scholars presented a contrary picture."
From text above we can infer that:

Indian history written by British historians ________

(A) Was well documented and not researched but was always biased

(B) Was not well documented and researched and was always biased

(C) Was well documented and researched but was sometimes biased

(D) Was not well documented and researched and was sometimes biased

[Ans. C]

Indian history written by British Historians was well documented & researched but was sometimes biased.

Technical

Q.1 - Q.25 Carry One Mark each.

1. A linear Hamming code is used to map 4-bit messages to 7-bit code-words. The encoder mapping is linear. If the message 0001 is mapped to the code-word 0000111, and the message 0011 is mapped to the code-word 1100110, then the message 0010 is mapped to

(A) 0010011

(B) 1100001

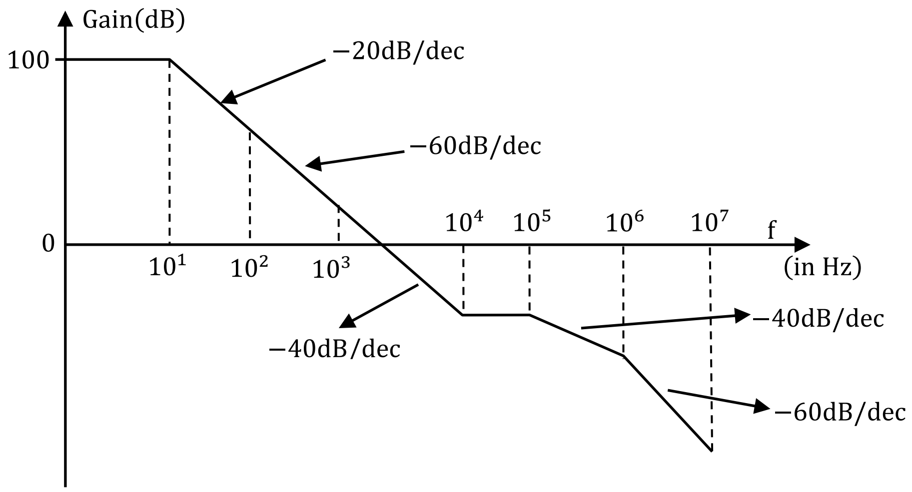
(C) 1111000

(D) 1111111

[Ans. B]

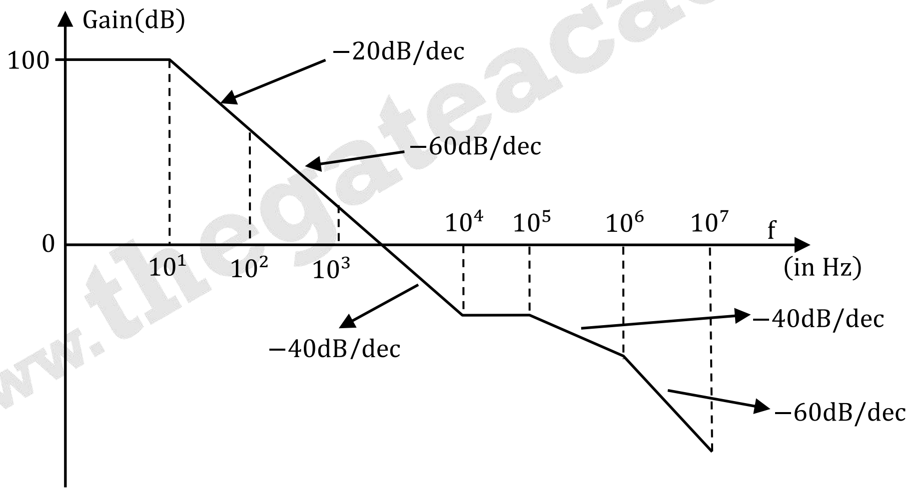
$$\begin{array}{ccc} 0\,0\,0\,1 & \longrightarrow & 0\,0\,0\,0\,1\,1\,1 \\ \oplus & & \oplus \\ 0\,0\,1\,1 & \longrightarrow & 1\,1\,0\,0\,1\,1\,0 \\ \hline 0\,0\,1\,0 & \longrightarrow & 1\,1\,0\,0\,0\,0\,1 \\ \hline \end{array}$$

2. For an LTI system, the Bode plot for its gain is as illustrated in the figure shown. The number of system poles N_p and the number of system zeros N_z in the frequency range $1\text{ Hz} \leq f \leq 10^7\text{ Hz}$ is



(A) $N_p = 7, N_z = 4$
(B) $N_p = 6, N_z = 3$
(C) $N_p = 5, N_z = 2$
(D) $N_p = 4, N_z = 2$

[Ans. B]



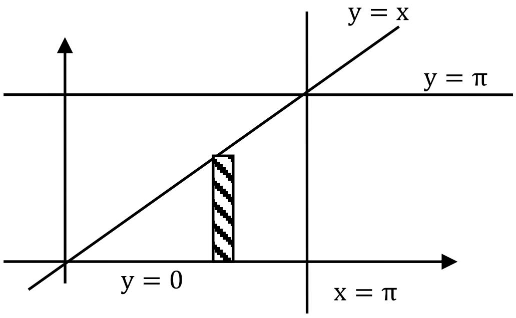
1 pole contributes - -20 dB/dec of slope.
1 pole contributes - $+20$ dB/dec of slope
At 10 Hz corner frequency →change in slope is -20 dB/dec
→1 pole is at 10 Hz
At 10^2 Hz →Overall change in slope = -40 dB/dec
→2 poles are at 10^2 Hz
At 10^3 Hz →Overall change in slope = $+40$ dB/dec
→1 zero is at 10^3 Hz
At 10^4 Hz →Overall change in slope = $+40$ dB/dec
→2 zeros are at 10^4 Hz

At 10^5Hz →Overall change in slope = −40 dB/dec
→2 poles are at 10^5 Hz
At 10^6 Hz →Overall change in slope = −20 dB/dec
→1 pole is at 10^6 Hz
So, Np = 6 and Nz = 3

3. The value of the integral $\int_0^{\pi}\int_y^{\pi}\frac{\sin x}{x}\,dx\,dy$, is equal to ________.

[Ans. *]Range : 1.99 to 2.01

$$\int_0^{\pi}\int_y^{\pi}\frac{\sin x}{x}\,dx\,dy$$



After changing the order of integration,

$$\int_0^{\pi}\int_y^{x}\frac{\sin x}{x}\,dy\,dx$$

$$\int_0^{\pi}\frac{\sin x}{x}[y]_0^x\,dx$$

$$\int_0^{\pi}\frac{\sin x}{x}x\,dx$$

$$\int_0^{\pi}\sin x\,dx$$

$$[-\cos x]_0^{\pi}$$

$$-[\cos\pi-\cos 0]$$

$$=[-1-1]=2$$

4. Let Z be an exponential random variable with mean 1. That is, the cumulative distribution function of Z is given by

$$F_Z(x)=\begin{cases}1-e^{-x} & \text{if } x\geq 0\\ 0 & \text{if } x<0\end{cases}$$

Then $\Pr(Z>2|Z>1)$, rounded off to two decimal places, is equal to ________.

[Ans. *]Range 0.36 to 0.38

To get probability density function from cumulative density function
Differentiate c.d.F w.r.t. 'x'

$P_r(Z) = \frac{d\,F(z)}{dx}$

$P_r(Z) = \begin{cases} e^{-x} & x \geq 0 \\ 0 & x < 0 \end{cases}$

To find $P_r\left(\frac{Z>2}{Z>1}\right) = \frac{P_r(Z>2 \cap Z>1)}{P_r(Z>1)}$

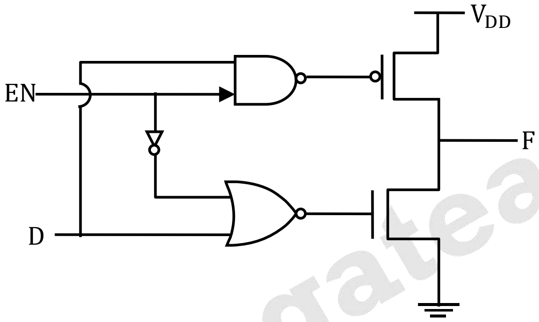
so $P(Z > 2 \cap Z > 1) = P(Z > 2)$

$$P_r\left(\frac{Z > 2}{Z > 1}\right) = \frac{P_r(Z > 2)}{P_r(Z > 1)}$$

$$= \frac{\int_2^\infty e^{-x}\,dx}{\int_1^\infty e^{-x}\,dx} = \frac{-[e^{-x}]_2^\infty}{-[e^{-x}]_1^\infty} = \frac{e^{-\infty} - e^{-2}}{e^{-\infty} - e^{-1}}$$

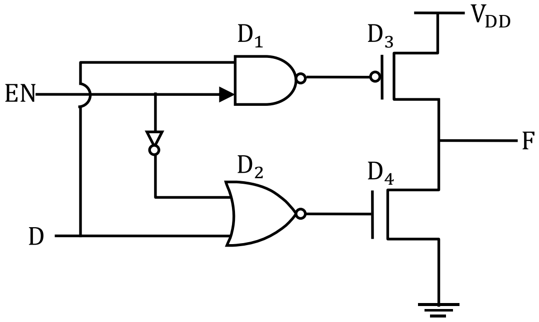
$$= \frac{1}{e} = 0.3678$$

5. In the circuit shown, what are the values of F for EN=0 and EN=1, respectively?



(A) Hi-Z and D
(B) 0 and D
(C) Hi-Z and $\overline{D}$
(D) 0 and 1

[Ans. D]



In the given circuit if EN=0. Then output of D_1 is '1' and D_2 is '0'

$\Rightarrow$ D_3 is OFF and D_4 is OFF

Hence output will be high impedance and if EN=1 then output controlled by 'D' input
$\Rightarrow$ if $D = 0$ then output is 0[as D_1 is 1, D_2 is 1, D_3 is OFF, D_4 is ON]
if $D = 1$ then output is 1[as D_1 is 0, D_2 is 0, D_3 is ON, D_4 is OFF]

6. The families of curves represented by the solution of the equation

$$\frac{dy}{dx} = -\left(\frac{x}{y}\right)^n$$

For $n = -1$ and $n = +1$, respectively, are
(A) Parabolas and Circles
(B) Circles and Hyperbolas
(C) Hyperbolas and Circles
(D) Hyperbolas and Parabolas
[Ans. C]
For $n = -1$

$$\frac{dy}{dx} = -\left(\frac{\theta x}{y}\right)^{-1} \Rightarrow \frac{dy}{dx} = \frac{-y}{x}$$

$$\int \frac{1}{y} dy = \int \frac{-1}{x}.dx + \ln C$$

$$\ln y = -\ln x + \ln C$$

we get $xy = C$
It is an equation of Hyperbola
for $n = 1$

$$\frac{dy}{dx} = -\frac{x}{y}$$

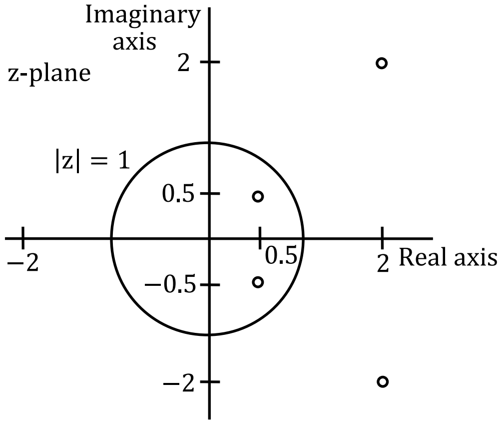
$$y\,dy + x\,dy\,x = 0$$

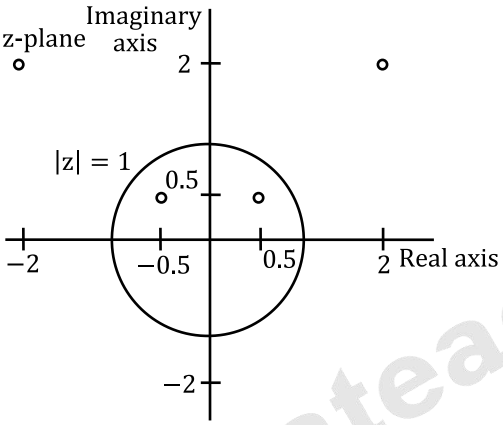
$$\frac{y^2}{2} + \frac{x^2}{2} = C$$

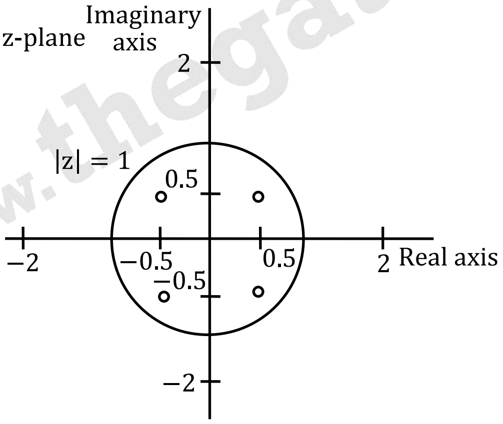
$$x^2 + y^2 = 2C$$

It is an equation of 'Circle'

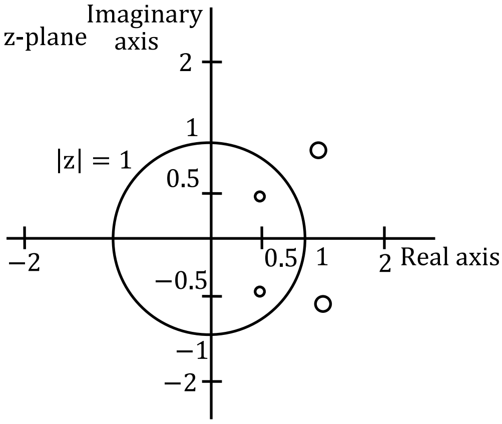
7. Let $H(z)$ be the z-transform of a real-valued discrete-time signal $h[n]$.
if $P(z) = H(z)H\left(\frac{1}{2}\right)$ has a zero at $z = \frac{1}{2} + \frac{1}{2}j$, and $P(z)$ has a total of four zeros, which one of the following plots represents all the zeros correctly?

(A)

Imaginary axis
z-plane
2
|z| = 1
0.5
−2
0.5
2
Real axis
−0.5
−2

(B)

Imaginary axis
z-plane
2
|z| = 1
0.5
−2
−0.5
0.5
2
Real axis
−2

(C)

Imaginary axis
z-plane
2
|z| = 1
0.5
−2
−0.5
−0.5
0.5
2
Real axis
−2

(D)



[Ans. D]

Given $H\left(\frac{1}{Z}\right)$

$P(Z) = H(Z).H\left(\frac{1}{Z}\right) \cdots (1)$

So at $Z = \frac{1}{2} + \frac{1}{2j}$, is a point of P(Z), and this point is complex. So another point will be $Z = \frac{1}{2} - \frac{1}{2j}$

Replace Z with 1/Z in equation (1)

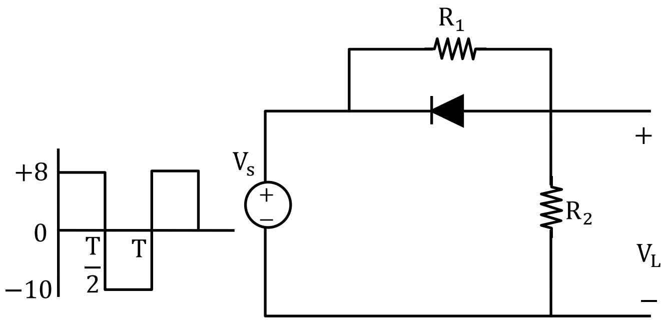
So $P\left(\frac{1}{Z}\right) = H\left(\frac{1}{Z}\right).H(Z) \cdots (2)$

since equation (1) and (2) are equal $\Rightarrow \frac{1}{Z}$ is also a zero of P(Z)

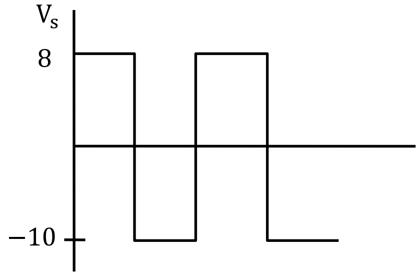
$$\frac{1}{Z} = \frac{1}{\frac{1}{2}+\frac{1}{2}j} = \frac{2}{1+1j} = 1 - 1j$$

another point of $\frac{1}{Z}$ is $(1 + 1j)$

8. In the circuit shown, V_s is a square wave of period T with maximum and minimum values of 8 and −10 V, respectively. Assume that the diode is deal and $R_1 = R_2 = 50\ \Omega$. The average value of V_L is _____ volts (round off to 1 decimal place).



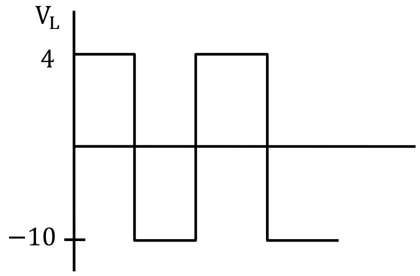
[Ans. *]Range −3.1 to −2.9



$R_1 = R_2 = 50\ \Omega$

$\therefore V_L$ in positive half of $V_s = \frac{8\times 50}{100}$

And V_L in negative half $= -10$ V



$\therefore$ Average value $= \frac{1}{T}\int_0^T V_L\ dt$

$= \frac{1}{T}\left[\int_0^{\frac{T}{2}} V_L\ dt + \int_{\frac{T}{2}}^{T} V_L\ dt\right]$

$= \frac{1}{T}\left[4\times\left(\frac{T}{2}\right) + (-10)\left(T-\frac{T}{2}\right)\right]$

$= \frac{1}{T}[2T - 5T]$

$= -3$ V

9. The number of distinct eigen values of the matrix

$$A = \begin{bmatrix} 2 & 2 & 3 & 3 \\ 0 & 1 & 1 & 1 \\ 0 & 0 & 3 & 3 \\ 0 & 0 & 0 & 2 \end{bmatrix}$$

is equal to ________.

[Ans. *]Range 3 to 3

The given matrix is an upper triangular matrix. Hence its Eigen values are the principal diagonal elements which are 2, 1, 3, 2. Among these '2' is repeating. Hence 3 distinct eigen values.

10. The value of the contour integral $\frac{1}{2\pi j}\oint\left(z+\frac{1}{z}\right)^2 dz$

Evaluated over the unit circle |z|=1 is ______.

[Ans. *]Range:0.0001 to 0.0001

$$\oint\left(z+\frac{1}{z}\right)^2 da = \oint\left(\frac{z^2+1}{z}\right)^2 dz$$

Here $f(z) = \left(\frac{z^2+1}{z}\right)^2$

f(z)has singular points $z = 0, 0$

Using residue theorem

$$\text{Res}|z = 0 \Rightarrow \frac{1}{(2-1)!} \overset{\text{lt}}{z\to 0} \frac{d}{dz}\left(\frac{z^2+1}{z}\right)^2$$

$$\Rightarrow \overset{\text{lt}}{z\to 0}\ 2(z^2+1)2z$$

$$= 0$$

$\therefore$ Reaidue $= 0$

$$\Rightarrow \oint\left(\frac{z^2+1}{z}\right)^2 lz = 2\pi j(0) = 0$$

$$= 0$$

11. Let Y(s) be the unit-step response of a casual system having a transfer function

$$G(s) = \frac{3-s}{(s+1)(s+3)}$$

that is, $Y(s) = \frac{G(s)}{s}$. The forced response of the system is

(A) $2u(t)$

(B) $u(t) - 2e^{-t}u(t) + e^{-3t}u(t)$

(C) $2u(t) - 2e^{-t}u(t) + e^{-3t}u(t)$

(D) $u(t)$

[Ans. D]

$$G(s) = \frac{3-s}{(s+1)(s+3)}$$

$$Y(s) = \frac{G(s)}{s} = \frac{3-s}{s(s+1)(s+3)}$$

$$Y(s) = \frac{A}{s} + \frac{B}{s+1} + \frac{C}{s+3}$$

After solving, $A = 1, B = -2, C = 1$

$$Y(s) = \frac{1}{s} - \frac{2}{s+1} + \frac{1}{s+3}$$

$$L^{-1}[Y(s)] = y(t) = [1 - 2e^{-t} + e^{-3t}]u(t)$$

Forced response means the steady state response

[after apply $t \to \infty$]

$y(\infty) = u(t) + 0 + 0 = u(t)$
Forced response $= u(t)$

12. Radiation resistance of a small dipole current element of length l at a frequency of 3 GHz is 3 ohms. If the length is changed by 1%, then the percentage change in the radiation resistance, rounded off to two decimal places, is ___________ %.

[Ans. *]Range : 1.98 to 2.02

$R_{rad} = 80\pi^2 \left(\frac{l}{\lambda}\right)^2$

Let l is changed to (1.01)L

$R'_{rad} = 80\pi^2 \left(\frac{1.01l}{\lambda}\right)^2$

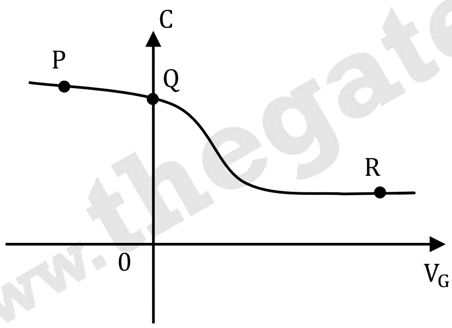
$= (1.01)^2 R_{rad}$

$= 1.0201 R_{rad}$

% change in Radiation resistance $= \frac{R'_{rad} - R_{rad}}{R_{rad}} \times 100$

$= 2.01\%$

13. The figure shows the high-frequency C-V curve of a MOS capacitor (at T = 300°K) with $\emptyset_{ms} - 0V$ and no oxide charges. The flat-band inversion, and accumulation conditions are represented, respectively, by the points



(A) P, Q, R
(B) Q, R, P
(C) R, P, Q
(D) Q, P, R

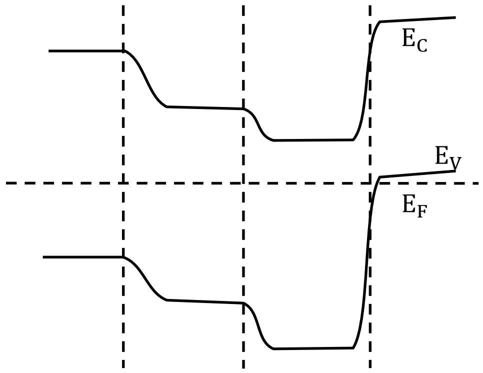
[Ans. B]

For C-V characteristics
P→ Accumulation Region
Q→ Flat band Region
R→ Inversion Region

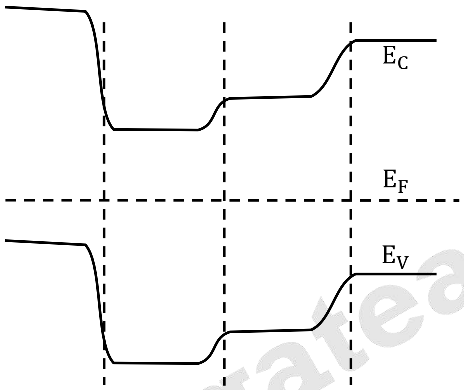
14. Which of the following options describes correctly the equilibrium band diagram at $T = 300$ K of a silicon pnn^+p^{++} configuration shown in the figure?

p	n	n^+	p^{++}

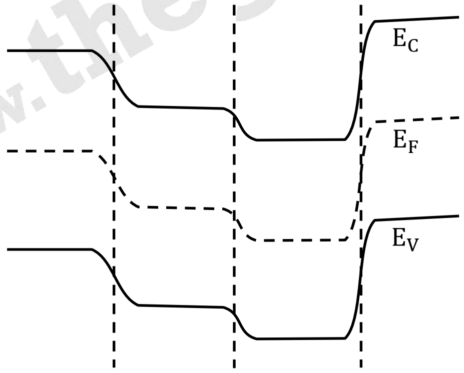
(A)



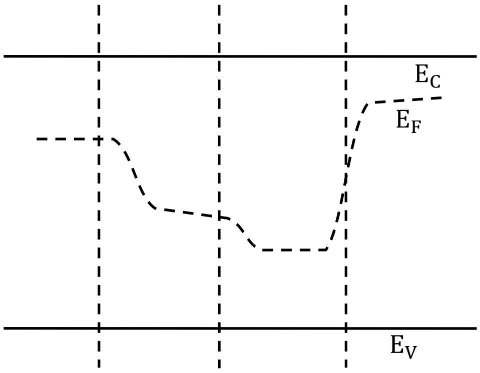
(B)



(C)



(D)



[Ans. C]

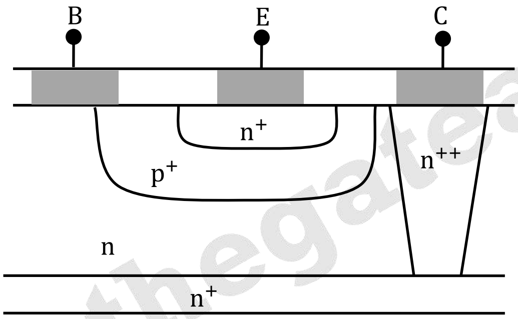
In equilibrium fermi level is straight horizontal line

∴option (A) and (D) are eliminated

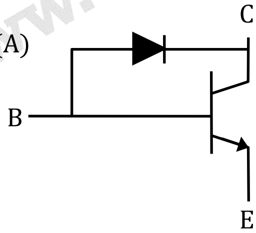
P^{++} → is degenerated ty6pe of semiconductor so in p^{++} region fermi level will be inside valence band

∴ option C is satisfied

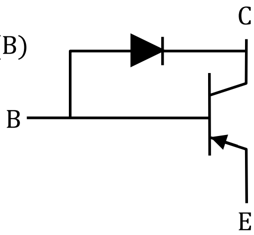
15. The correct circuit representation of the structure shown in the figure is



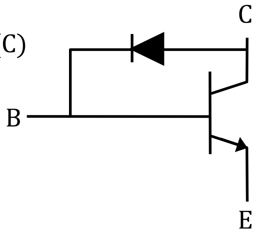
(A)



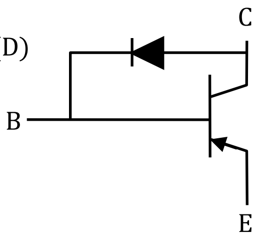
(B)



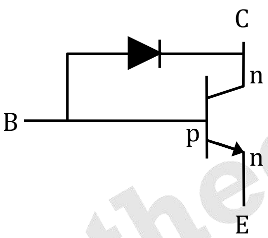
(C)



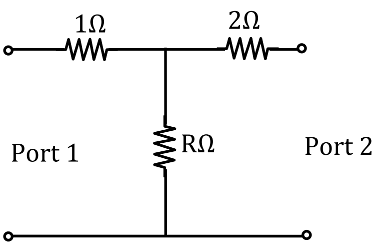
(D)

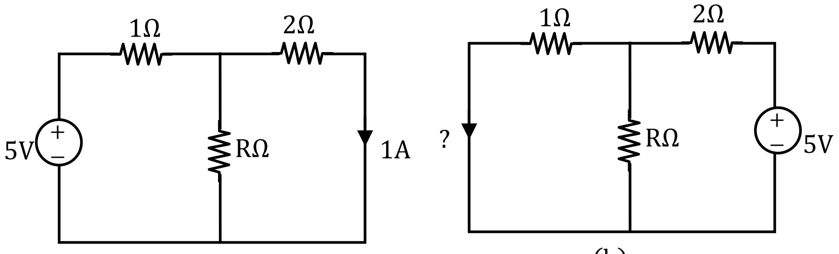


[Ans. A]
Base→p type
Emitter and collector →n type
∴This is npn transistor
Base is p type and collector is n^{++}
∴Structure will be



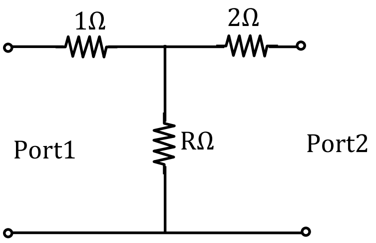
16. Consider the two-port resistive network shown in the figure. When an excitation of 5V is applied across port 1, and port 2 is shorted, the current through the short circuit at port 2 is measured to be 1 A (see (a) in the figure).
Now, if an excitation of 5V is applied at port 2, and port 1 is short circuited (see (b) in the figure), what is the current through the short circuited at port 1?





(a) (b)

(A) 2 A
(B) 1 A
(C) 0.5 A
(D) 2.5 A
[Ans. B]



Given 2 port network is a reciprocal network.

$$\frac{I_1}{V_1} = \frac{I_2}{V_2}$$

$$\frac{1A}{5V} = \frac{I_2}{5V} \Rightarrow I_2 = 1A$$

17. Consider the signal $f(t) = 1 + 2\cos(\pi t) + 3\sin\left(\frac{2\pi}{3}t\right) + 4\cos\left(\frac{\pi}{2}t + \frac{\pi}{4}\right)$, where t is in seconds. Its fundamental time period, in seconds, is ____________.
[Ans. *]Range: 11.99 to 12.01
Given

$$f(t) = 1 + 2\cos(\pi t) + 3\sin(\frac{2\pi}{3}t) + 4\cos(\frac{\pi}{2}t + \frac{\pi}{4})$$

$$T = \text{LCM}\ (T_1, T_2, T_3)$$

$$T_1 = \frac{2\pi}{\pi} = 2\text{sec}$$

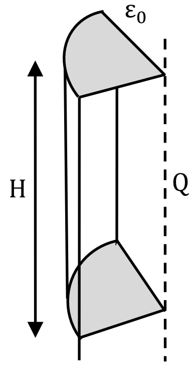
$$T_2 = \frac{2\pi}{\left(\frac{2\pi}{2}\right)} = 3\text{ sec}$$

$$T_3 = \frac{2\pi}{\pi/2} = 4\text{sec}$$

$$T = \text{LCM}(2, 3, 4)$$

$$= 12\text{sec}$$

18. What is the electric flux $\left(\int \vec{E} \cdot d\hat{a}\right)$ through a quarter-cylinder of height H (as shown in the figure) due to an infinitely long line charge along the axis of the cylinder with a charge density of Q?



(A) $\frac{HQ}{\varepsilon_0}$

(B) $\frac{HQ}{4\varepsilon_0}$

(C) $\frac{H\varepsilon_0}{HQ}$

(D) $\frac{4H}{Q\varepsilon_0}$

[Ans. B]

For infinite line change

$$E = \frac{Q}{2\pi\,\varepsilon_0 \rho}\hat{a}_\rho$$

$$\text{Electric Flux} \int E \cdot \hat{a} = \frac{1}{4}\iint E \cdot ds$$

$$= \frac{1}{4}\frac{Q}{2\pi\,\varepsilon_0\,S} \times 2\pi\,\rho\,H$$

$$\int E.\hat{a} = \frac{QH}{4\varepsilon_0}$$

19. If X and Y are random variables such that $E[2X + Y] = 0$ and $E[X + 2Y] = 33$, then $E[X] + E[Y] =$ ________

[Ans. *]Range 11 to 11

Given $E[2X + Y] = 0$

$E[X + 2Y] = 33$

Using the property of Expectation

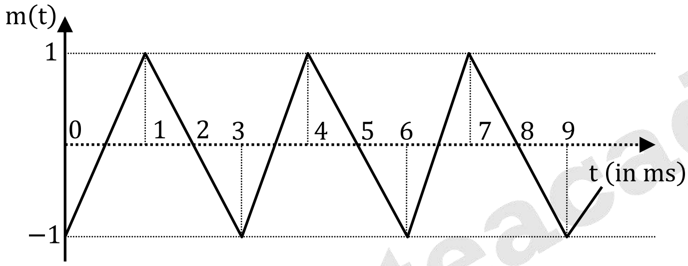
i.e. $E[aX + bY] = aE[X] + bE[Y]$

we can write

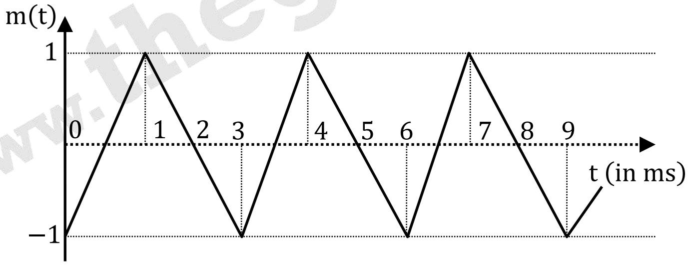
$2E[X] + E[Y] = 0 \cdots \text{(i)}$

$E[X] + 2E[Y] = 33 \cdots (ii)$
Apply 2 (ii) $\cdots$ (i)
$4E[Y] - E[Y] = 66 \cdots 0$
$E[Y] = 22$
And put in 0 equation (i)
$E[X] = \frac{-22}{2} = -11$
To find $E[X] + E[Y] = -11 + 22$
$E[X] + E[Y] = 11$

20. The baseband signal m(t) shown in the figure is phase-modulated to generate the PM signal $\phi(t) = \cos(2\pi f_c t + k\, m(t))$. the time t on the x-axis in the figure is in milliseconds. If the carrier frequency is $f_c = 50$ kHz and $k = 10\pi$, then the ratio of the minimum instantaneous frequency (in kHz) to the maximum instantaneous frequency (in kHz) is __________ (rounded off to 2 decimal places).



[Ans. *]Range 0.74 to 0.76
Given PM signal= $\text{Cos}[2\pi F_c t + Km(H)]$
M(H) given as



and$F_c = 50\text{KHz}$ and $K = 10\pi$
→ asked ratio of $\frac{fi_{max}}{fi_{min}}$
→ we know $fi = \frac{1}{2\pi}\frac{d}{dt}0(t)$
→ $fi = \frac{1}{2\pi}\frac{d}{dt}[2\pi f_c t + Km(H)]$
$f_c + \frac{K}{2\pi}\frac{d}{dt}\, m(t)$
$= 50K + \frac{10\pi}{2\pi}\frac{d}{2\pi}\, m(t) = 50K + 5\frac{d}{dt}\, m(t)$

$$fi_{max} = 50K + 5\left|\frac{d}{dt}m(t)\right|_{max} \quad \text{[from 0 to 1 ; slope = 2K]}$$

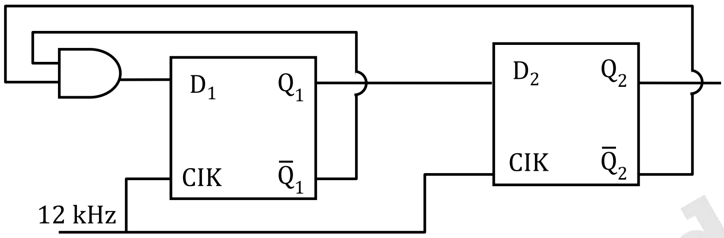
$$50K + 5\left[\frac{2}{1m}\right] = 60KHz$$

$$fi_{min} = 50K + 5\left|\frac{d}{dt}m(t)\right|_{min} = 50K + 5\left[\frac{-1}{1m}\right]$$

$$= 50K - 5K = 45K$$

$$\frac{fi_{max}}{fi_{min}} = \frac{45}{60} = 0.75$$

21. In the circuit shown, if the frequency, i.e., the frequency of CIK signal, is 12KHz. The frequency of the signal at Q2 will be ________KHz.



[Ans. *]Range: 4 to 4

CIK	$D_1 = \frac{\overline{Q_1}\,\overline{Q_2}}{Q_1 + Q_2}$	Q_1	Q_2
0	1	0	0
1	0	1	0
2	0	0	1
3	1	0	0

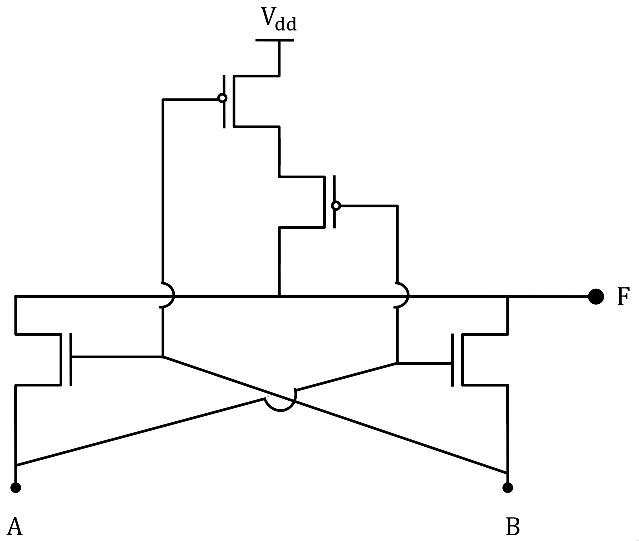
The given circuit is a mod-3 counter

The output frequency of mode-3 counter= $\frac{fCIK}{3}$

$$= \frac{12K}{3}$$

$$= 4KHz$$

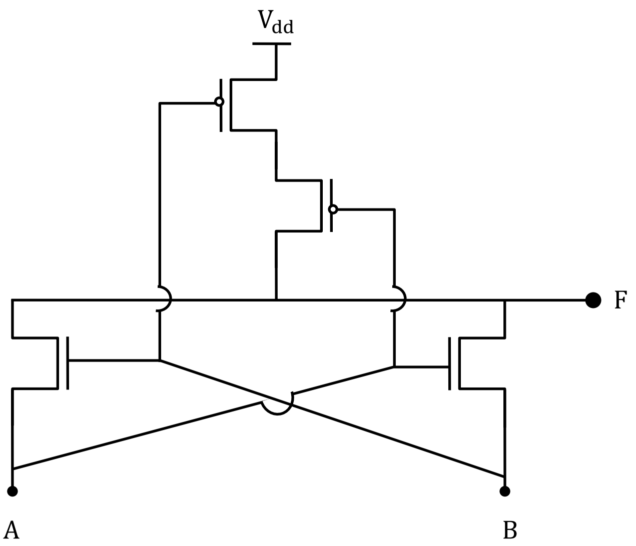
22. In the circuit shown, A and B are the inputs and F is the output. What is the functionality of the circuit?



(A) SRAM cell
(B) XNOR
(C) XOR
(D) Latch

[Ans. B]

The given circuit is



→ the given table is

A	B	F
0	0	1
0	1	0
1	0	0
1	1	1

→As it satisfies X-NOR condition.

23. In the table shown, List I and List II, respectively, contain terms appearing on the left-hand side and the right-hand side of Maxwell's equations (in their standard form). Match the left-hand side with the corresponding right-hand side.

List-I	**List-II**
1. $\Delta . D$	P. 0
2. $\nabla \times E$	Q. ρ_v
3. $\nabla . B$	R. $\frac{-\partial B}{\partial t}$
4. $\nabla \times H$	S. $J + \frac{\partial D}{\partial t}$

(A) 1-Q, 2-S, 3-P. 4-R
(B) 1-Q, 2-R, 3-P, 4-S
(C) 1-R, 2-Q, 3-S, 4-P
(D) 1-P, 2-R, 3-Q, 4-S

[Ans. B]

Maxwell Equations are

$\nabla . D = S$

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

$$\nabla \times H = J + \frac{\partial D}{\partial t}$$

$\nabla . B = 0$

24. Which one of the following functions is analytic over the entire complex plane?

(A) $\frac{1}{1-z}$
(B) $\ln(z)$
(C) $e^{1/z}$
(D) $\cos(z)$

[Ans. D]

(a) $f(z) = \frac{1}{1-z}$, we see that at z=1
f(z) is not analytic function.

(b) f(z)=ln z

$$f(z) = \underbrace{\frac{1}{2}\ln(x^2+y^2)}_{u} + i\underbrace{\tan^{-1}\left(\frac{y}{x}\right)}_{v}$$

$$\frac{\partial u}{\partial x} = \frac{1}{2}\frac{1}{x^2+y^2}(2x) = \frac{x}{x^2+y^2}$$

$$\frac{\partial v}{\partial y} = \frac{1}{1+\left(\frac{y}{x}\right)^2}\frac{1}{x} = \frac{x}{x^2+y^2}$$

So, $\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$ 1st C − R equation is satisfied.

Now,

$$\frac{\partial u}{\partial y} = \frac{1}{2}\frac{1}{x^2+y^2}(2y) = \frac{y}{x^2+y^2}$$

And

$$\frac{\partial v}{\partial x} = \frac{1}{1+\left(\frac{y}{x}\right)^2}\frac{y}{-x^2} = \frac{-y}{x^2+y^2}$$

So, $\frac{\partial u}{\partial y} = \frac{-\partial v}{\partial x}$ 2nd C − R equation is satisfied.

Let at x=0 and y=0, ln z is not analytic.

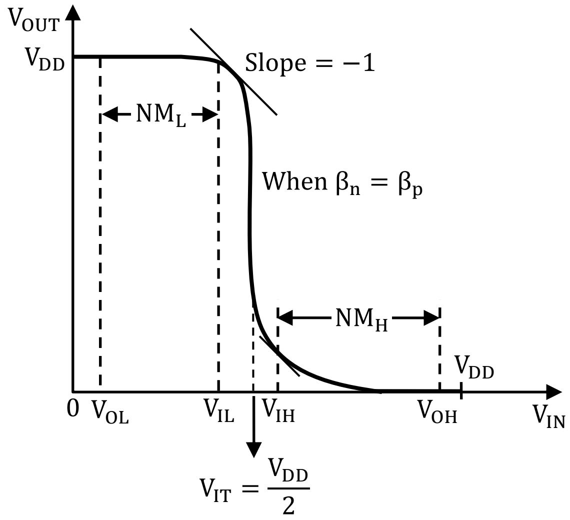
(c) Cos z is analytic, everywhere in z-plane

(d) $e^{1/z}$ is not analytic at z=0

25. A standard CMOS inverter is designed with equal rise and fall times ($\beta_n = \beta_p$). If the width of the PMOS transistors in the invertor is increased, what would be the effect on the Low Noise Margin(NM_L) & the high Noise Margin (NM_H)?

(A) NM_L increases & NM_H decreses
(B) NM_L decreases & NM_H increses
(C) Both NM_L & NM_H increses
(D) No change in the noise margins

[Ans. A]



Making PMOS wider, shift input transition point (V_{IT}) towards V_{DD}.
Making NMOS wider, shifts input transition point (V_{IT}) towards zero
So, as PMOS made wider, NM_L increases and NM_H decreases.

Q.26 - Q.65 Carry Two Mark each.

26. The quantum efficiency (η) and respectively (R) at a wavelength λ (in μm) in a $p-i-n$

(A) $R=\dfrac{\eta\times\lambda}{1.24}$

(B) $R=\dfrac{1.24}{\eta\times\lambda}$

(C) $R=\dfrac{\lambda}{\eta\times 1.24}$

(D) $R=\dfrac{1.24\times\lambda}{\eta}$

[Ans. A]

Direct formula, relating Responsivity and efficiency is

$$R=\left(\frac{\lambda}{1.24}\right)\eta$$

27. Consider a long-channel MOSFET with a channel length 1 μm and width 10μm. The device parameters are acceptor concentration $N_A=5\times10^{16}\ \text{cm}^{-3}$, electron mobility $\mu_n=800\frac{\text{cm}^2}{\text{V}}-\text{s}$, oxide capacitance/area $C_{OX}=3.45\times10^{-7}\ \text{F/cm}^2$, threshold voltage $V_T=0.7\text{V}$. The drain saturation current (ID_{sat}) for a gate voltage of 5 V is ______mA (Rounded off to two decimal places). [$\varepsilon_0=8.854\times10^{-14}\text{F/cm}, \varepsilon_{ST}=11.9$]

[Ans. *]Range: 25.40 to 25.60

$L=1\ \mu\text{m}$

$W=10\ \mu\text{m}$

$N_A=5\times10^{16}\ \text{cm}^{-3}$

$\mu_n=800\dfrac{\text{cm}^2}{\text{v}-\text{sec}}$

$C_{ox}=3.45\times10^{-7}\dfrac{\text{F}}{\text{cm}^2}$

$V_T=0.7\ \text{V}$

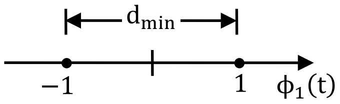
$V_G=4\ \text{V}$

$$ID_{(sat)}=\mu_n C_{ox}\left(\frac{W}{C}\right)\left[\frac{(V_{Gs}-V_T)^2}{2}\right]$$

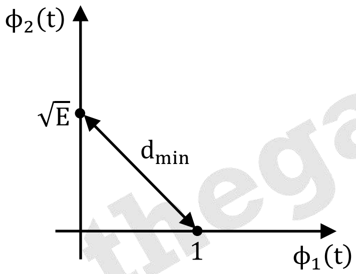
$$=800\times3.45\times10^{-7}\times10\left[\frac{(4.3)^2}{2}\right]$$

$$=25.5\ \text{mA}$$

28. A single bit, equally likely to be 0 and 1 is to be sent across an additive white Gaussian noise (AWGN) channel with power spectral density $N_0/2$. Binary signaling with $0 \rightarrow P(t)$ and $1 \rightarrow q(t)$ is used for the transmission along with optimal receiver that minimizes bit error probability.
Let $\varphi_1(t)$and $\varphi_2(t)$ form orthonormal set, if we choose
$p(t) = \varphi_1(t), q(t) = -\varphi_1(t)$. we would obtain a certain bit-error probability p_b
if we keep $p(t) = \phi_1(t)$, but take $q(t) = \sqrt{E}\,\phi_2(t)$, for what value of E would we obtain the same bit-error probability P_b?
(A) 1
(B) 2
(C) 0
(D) 3
[Ans. D]
When $p(t) = \phi_1(t)$ and $q(t) = -\phi_1(t)$

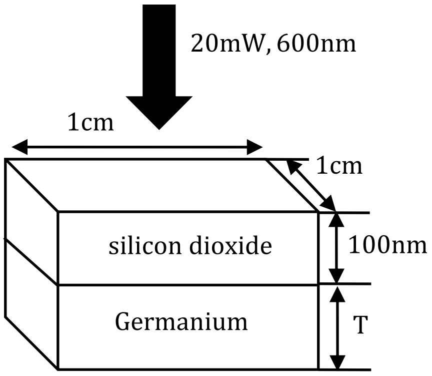


$d_{min} = 2$
When $p(t) = \phi_1(t)$ and $q(t) = \sqrt{E}\phi_2(t)$:

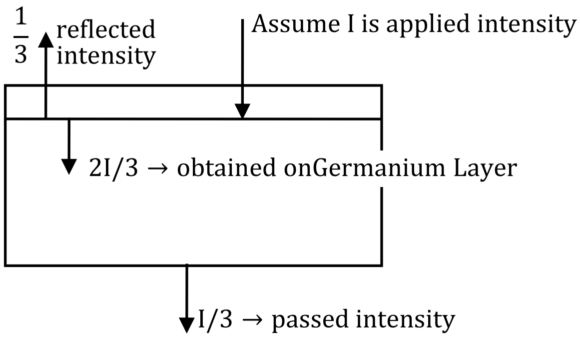


$d_{min} = \sqrt{(\sqrt{E})^2 + 1} = \sqrt{E+1}$
To obtain same bit − error probability, d_{min} should be same.
So, $\sqrt{E+1} = 2$
$E = 3$

29. A germanium sample of dimensions 1 cm × 1cm is illuminated with a 20Mw, 600nm laser light source in the figure. The illuminated sample surface has a 100nm of loss-less silicon dioxide layer that reflects one-fourth of the incident light. From the remaining light, one-third of the power is reflected from the silicon dioxide- Germanium interface, one-third is absorbed in the Germanium layer, and one-third is transmitted through the other side of the sample. If the absorption coefficient of Germanium at 600 nm is $3 \times 10^4\ cm^{-1}$ and the bandgap is 0.66 eV, the thickness of the Germanium layer, rounded off to 3 decimal places, is ___________μm



[Ans. *]Range 0.230 to 0.232



Absorption coefficient $\mu \to 3 \times 10^4$ cm

$$\frac{I}{3} = \frac{2I}{3} e^{-\mu T}$$

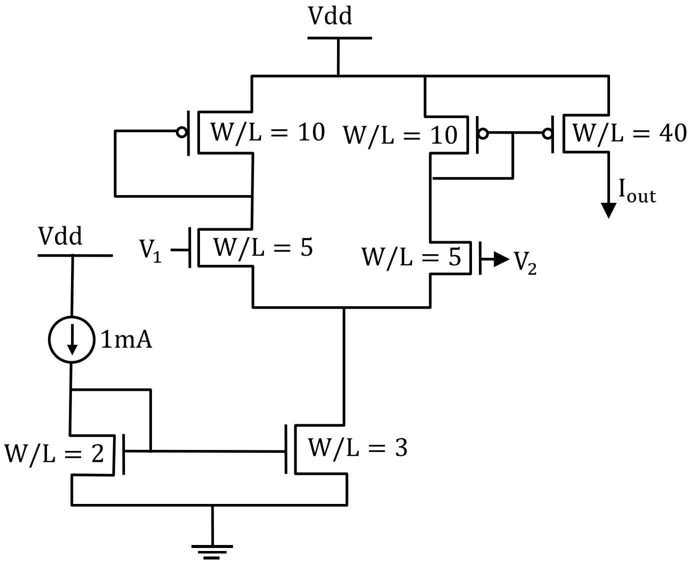
$$1 = 2\, e^{-3\times10^4\, T}$$

$$-\ln 2 = -3 \times 10^4\, T$$

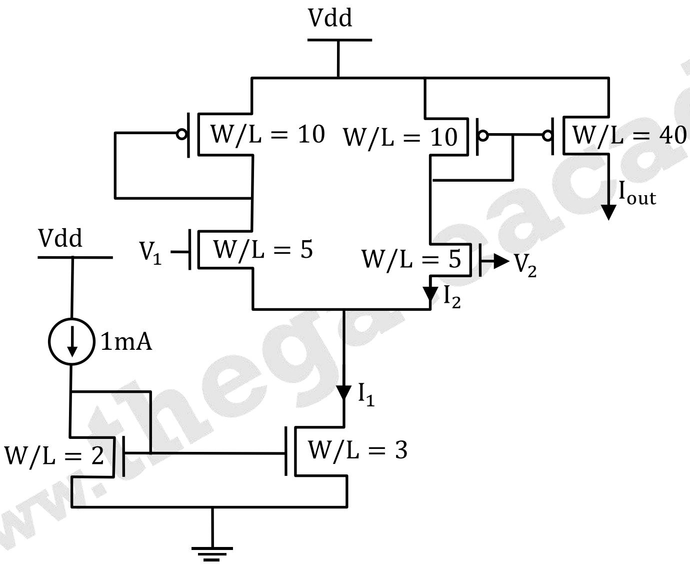
$$T = \frac{\ln 2 \times 10^{-2}}{3 \times 10^4}$$

$$T = 0.231\ \mu\text{m}$$

30. In the circuit shown, $V_1 = 0$ and $V_2 = V_{dd}$. The other relevant parameters are mentioned in the figure. Ignoring the effect of channel length modulation and the body effect, the value of I_{out} is _______mA(rounded off to 1 decimal place).



[Ans. *]Range: 5.9 to 6.1



$I_1 = \frac{3}{2} \times 1\text{ m} = 1.5\text{ mA}$

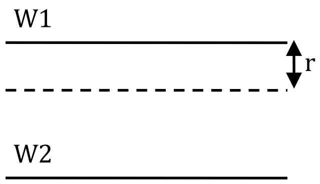
$\because$ VC_1 $= 0$ V, $\therefore I_3 = 0$

$\therefore I_2 = I_1 = 1.5\text{ mA}$

$\therefore I_{out} = \left(1.5 \times \frac{40}{10}\right)\text{mA}$

$= 6\text{ mA}$

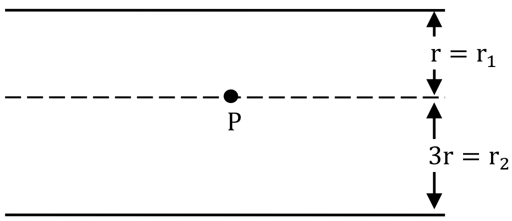
31. Two identical copper wires W1 and W2 , placed in parallel as shown in the figure, carry currents I and 2I, respectively, in opposite dirctions. If the two wires are separted by a distance of 4r, then the magnitude of the magnetic field $\vec{B}$ between the wires at a distance r from W1 is



(A) $\frac{\mu_0^2 I^2}{2\pi r^2}$
(B) $\frac{\mu_0 I}{6\pi r}$
(C) $\frac{5\mu_0 I}{6\pi r}$
(D) $\frac{6\mu_0 I}{5\pi r}$

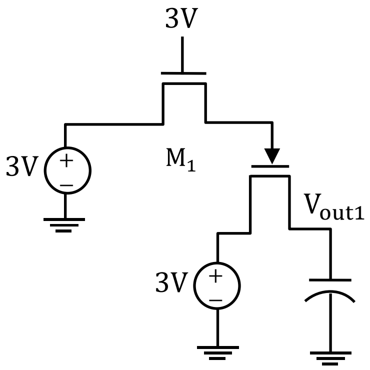
[Ans. C]

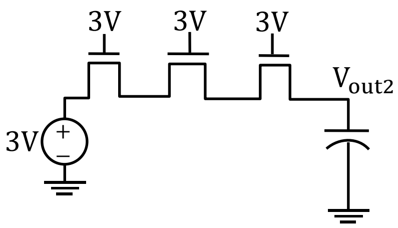
As currents are in opposite direction, Magnetic field strengthens between wires



$$B = B_1 + B_2$$
$$= \frac{\mu_0 I}{2\pi r_1} + \frac{\mu_0 2I}{2\pi r_2}$$
$$= \frac{\mu_0 I}{2\pi}\left[\frac{1}{r} + \frac{2}{3r}\right]$$
$$= \frac{5\mu_0 I}{6\pi r}$$

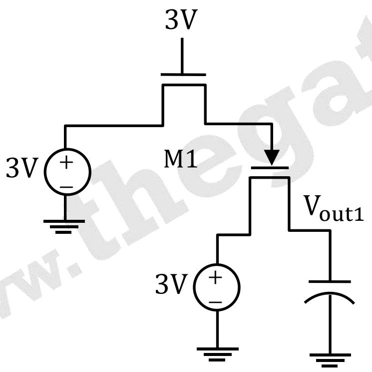
32. In the circuit shown, the threshold voltage of each NMOS transistor is 0.6V. ignoring the effect of channel length length modulation and body bias, the value of V_{out1} *and* V_{out2} respectively , in volts, are





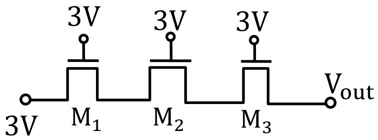
(A) 1.8 and 1.2
(B) 2.4 and 1.2
(C) 1.8 and 2.4
(D) 2.4 and 2.4

[Ans. C]



$V_{DS} \geq V_{GS} - V_T$
$I_D = 0$
$V_{GS} - V_T = 0$
$3 - V_x - 0.6 = 0$
$V_x = 2.4$
Let us assume M_2 is in saturation mode
$V_{DS} =\geq V_{GS} - V_T$
$3 - V_0 \geq 2.4 - V_o - 6$
$3 \geq 1.8$
Hence M_2 in saturation for DC analysis
$C \rightarrow$ open circuited

$V_{GS} = V_T$
$V_x - V_o = 0.6$
$V_{o1} = 1.8$



All transistors in saturation mode
$V_{DS} \geq V_{GS} - V_T \Rightarrow V_{x-3} \geq 3$
$V_{GS} = V_T$
$V_{GS1} = V_{DS1} \Rightarrow$ (Saturation)
$V_{GS_3} = V_T = 0.6$
$V_{G3} = 3$ V
$\therefore V_{G3} - V_{S3} = 0.6$
$\Rightarrow 3 - V_{S3} = 0.6$
$\Rightarrow V_{S3} = 3 - 0.6 = 2.4$
$\therefore V_{out\,2} = V_{S3} = 2.4$ V

33. The dispersion in rectangular waveguide, which relates the wavenumber k to the frequency $K(w) = \left(\sqrt{w^2 - w_0^2}\right)\frac{1}{C}$. Where the speed of light $c = 3 \times 10^8$ m/s. And ω_0 is a constant If the group velocity
$V_g = 2 \times 10^8$, then the phase velocity is ________.
(A) 1.5×10^8m/s
(B) 3×10^8m/s
(D) 2×10^8m/s
(D) 4.5×10^8m/s
[Ans. D]
We know
$V_p \times V_g = C^2$
Where V_p – phase velocity
V_g – group velocity

$$V_p = \frac{C^2}{V_g} = \frac{(3 \times 10^8)^2}{2 \times 10^8} = 4.5 \times 10^8 \text{ m/s}$$

34. Consider a Causal 2nd order system with transfer function $G(s) = \frac{1}{1+2s+s^2}$ with unit step $R(s) = \frac{1}{s}$ as input , Le C(s) be the corresponding output. The time taken by the system output, c(t) to reach 94% of its steady state value $\text{lt}_{t\to\infty}$ c(t), rounded off to two decimal places, is
(A) 3.89

(B) 4.50
(C) 2.81
(D) 5.25
[Ans. B]

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

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

$$\Rightarrow C(s) = \frac{1}{s^2+2s+1} \cdot R(s) = \frac{1}{s^2+2s+1}\frac{1}{s}$$

$$\Rightarrow C(s) = \frac{1}{s} - \frac{s+2}{(s+1)^2}$$

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

$$L^{-1}[C(s)] = C(t) = [1 - e^{-t} - te^{-t}]u(t)$$

at $t \to \infty$, i.e $\lim_{t\to\infty}[L(t)] = 1$

$$\therefore 0.94 = 1 - e^{-t}(1+t)$$

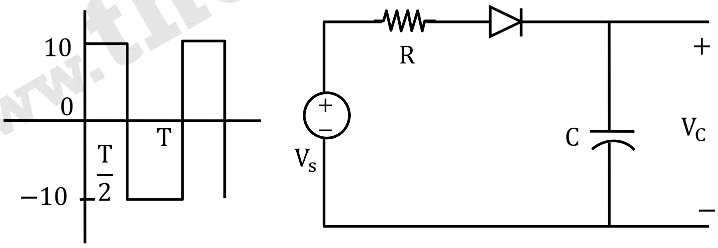
$$\Rightarrow e^{-t}(1+t) = 0.06$$

Above equation will satisfy if $t = 4.5$ sec

So, toreach 94% of the final value

$t = 4.50$ sec

35. In the circuit shown, V_s is 10V square wave with $T = 4$ m sec $R = 500\Omega$ and $C = 10\mu F$. The capacitor is initially uncharged at t=0. And the diode is assumed to be ideal. The voltage across the capacitor V_c at $t = 3$ m sec is equal to_________ Volts (rounded off to one decimal place).



[Ans. *]Range: 3.2 to 3.4

$V_C(0) = 0$

$V_C(\infty) = 10$

$t = 2$ m sec

$$V_C(t) = V_C(\infty) - [V_C(\infty) - V_C(0)]C^{-th}$$

$$V(2 \text{ m sec}) = 10 - 10e^{-th}$$

$$= 10\left[1 - e^{-\frac{2}{5}}\right]$$

$\tau = RC$

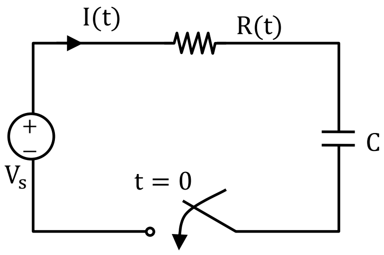
$= 5K \times 10m$

$= 5\text{m}$

$= 3.296\text{V}$

$V_C(3\text{ M sec}) = 3.296\text{V}$

36. The RC circuit shown below has a variable resistance R(t) given by the following expression $\left(R(t) = R_0\left(1-\frac{t}{T}\right)\right.$ for $0 \le t < T$ where $R_0 = 1\Omega$ and $C = 1F$ .We are also given that $T = 3R_0C$ and the source voltage is $V_s = 1V$. If the current at time $t = 0$ is 1A , then the current I(t) in amperes at time $t = T/2$ is ________(rounded off to 2 decimal places)



[Ans. *]Range 0.23 to 0.27

$$-1 + I\,R(t) + \frac{1}{C}\int I\,dt = 0$$

After differentiating:

$$\frac{R(t)dI}{dt} + I\frac{dR(t)}{dt} + \frac{1}{C}I = 0$$

$$\frac{R(t)dI}{dt} - \frac{I}{3} + I = 0$$

$$\left(1-\frac{t}{3}\right)\frac{dI(t)}{dt} + \frac{2I(t)}{3} = 0$$

$$\left(\frac{t}{3}-1\right)\frac{dI(t)}{dt} = \frac{2}{3}I(t)$$

$$\frac{dI}{I} = \frac{2}{3}\times\frac{3}{t-3}\,dt$$

$$\ln I = \ln(t-3)^2 + C$$

$$0 = \ln g + C$$

$$C = \ln\frac{1}{g}$$

$$\ln I = \ln(t-3)^2 + \ln\left(\frac{1}{g}\right)$$

$$\ln I = \ln\left(\frac{t-3}{3}\right)^2 = \ln\left(\frac{t}{3}-1\right)^2$$

$$I = \left(\frac{t}{3}-1\right)^2$$

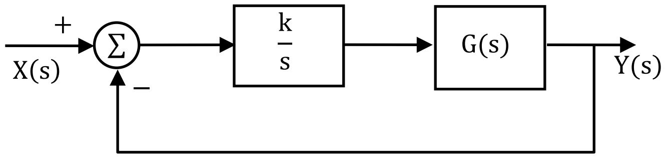
$$I = \left(\frac{3}{2\times 3}-1\right)^2$$

$$= \frac{1}{4}$$

$= 0.25$ Amp

37. Consider a unity feedback system as shown in the figure with integral compensator k/s and Open-loop transfer function.

$G(s) = \frac{1}{s^2 + 3s + 2}$ whene $k > 0$?

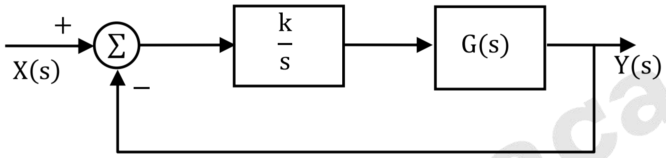


The +ve value of k for which there are exactly 2 poles of unity feedback system on the $j\omega =$ axis is ________

(Rounded off to 2 decimal place)

[Ans. *]Range: 5.99 to 6.01

$G(s) = \frac{1}{s^2 + 3s + 2}$



$C \cdot E = 1 + \frac{k}{s} \cdot G(s)\,H(s)$

Syatem is UFB so, $H(s) = 1$

$\therefore C \cdot E = 1 + \frac{k}{s} \cdot \frac{1}{s^2 + 3s + 2} = 0$

$\Rightarrow s(s^2 + 3s + 2) + k = 0$

$\Rightarrow s^3 3s^2 + 2s + k = 0$

R-Array

s^3	1	2	By applying the sufficient condition.
s^2	3	K	For stability k>0 and k<6
s^1	$\frac{6-k}{3}$	0	
s^0	k		

But system will have 2-poles on j_ω_axis if auxiliary equation will be formed. Auxiliary equation will be formed if odd order row becomes zero.

if $k = 6$, s^1row becomes zero.

So, $k = 6$

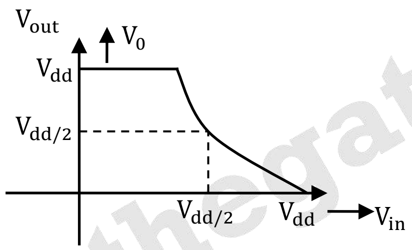
38. A voice signal $m(t)$ is in the frequency range 5kHz to 15kHz. The signal is amplitude-modulated to generate an AM signal l $f(t) = A(1 + m(t))\cos 2\pi f_c t$. $f_c = 600$KHz.

The AM signal f(t) is to be digitized and achieved. This is done by first sampling f(t) at 1.2 times Nyquist frequency, and then and quantized each sample using 256 – level quantizes. Finally each quantized sample is binary coded using K-bits, *where* K is the minimum number of bits required for the encoding. The rate, in Megabits per second (rounded off to 2 decimal places), of the resulting stream of coded bits is ________Mbps.

[Ans. *]Range: 11.80 to 11.82

$m(t) \rightarrow$ 5K to 15KHz
AM $\quad f(t) = A(1 + m(t)) \cos 2\pi f_c t$
where $f_c = 600\text{KHz}$
f(t)sampled at 1.2 timed NR
sampling rate $= 1.2 \times [2\ f_{max}][f_m = fc + f_m]$
$= 1.2 \times 2 \times 615K$
$= 1476$ sample/sec
$\rightarrow$ it is quantized using 256 level quantizes
$L = 256 = 2^K \Rightarrow K = 8$
Bit rate $(R_b) = n \times f_s = 8 \times 1476$ Kbps
$= 11.808$ Mbps.

39. A CMOS inverter designed to have a midpoint voltage $V_1 = \frac{V_{dd}}{2}$ as shown in figure. The value of $V_{dd} = 3V$..
$\mu_n Co_x = 100\mu A/V^2, V_{th} = 0.7V, \mu_p Co_x = 40\mu A, V_{t_p} = 0.9$ V. The ratio of $\left(\frac{W}{L}\right)_n$ to $\left(\frac{W}{L}\right)_p$ is __________(3 decimal accuracy)



[Ans. *]Range 0.210 to 0.230

$$\frac{\mu_n C_{ox}}{2}\left(\frac{W}{L}\right)_n [1.5 - 0.7]^2 = \frac{\mu_p C_{ox}}{2}\left(\frac{W}{L}\right)_p [1.5 - 0.9]^2$$

$$\frac{\left(\frac{W}{L}\right)_n}{\left(\frac{W}{L}\right)_p} = \frac{\mu_p (C_{ox})_p}{\mu_n (C_{ox})_n} = \frac{[0.6]^2}{[0.8]^2} = 0.4 \times 0.75^2$$

$= 0.225$

40. Consider a differential function f(x) on the set of real numbers such that $f(-1) = 0$ and $|f'(x)| \leq 2$. Given these conditions, which one of the following inequalities is necessarily true for all $x \in [-2, 2]$?
(A) $f(x) \leq 2\,|x|$
(B) $f(x) \leq 2\,|x + 1|$
(C) $f(x) \leq \frac{1}{2}\,|x|$

(D) $f(x) \le \frac{1}{2}|x+1|$

[Ans. B]

Given, $|f'(x)| \le 2$

$-2 \le f'(x) \le 2$

Integrate with respect to 'x'

$-2x + C \le f(x) \le 2x + C$

Let us consider one inequality at a time,

$-2x + C \le f(x) \cdots (i)$

we know, f(−1)=0

$-2(-1) + C \le 0$

$C \le -2 \cdots (ii)$

Subtract (i) by (ii)

$-2x + C - C \le f(x) + 2$

$f(x) \ge -2x - 2$

Again, consider another inequality,

$f(x) \le 2x + C \cdots (iii)$

put $f(-1) = 0$

$0 \le -2 + C$

$2 \le C \cdots (iv)$

Subtract equation (iii) by (iv)

$f(x) - 2 \le 2x + C - C$

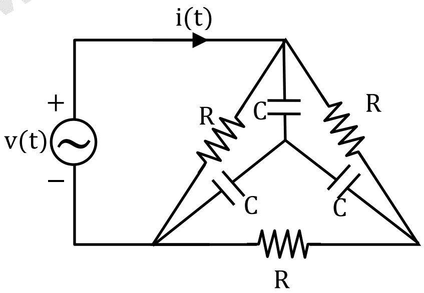
$f(x) \le 2x + 2$

Finally, we get the equation

$-2(x+1) \le f(x) \le 2(x+1)$

$f(x) \le 2|x+1|$

41. In the circuit shown, if $v(t) = 2\sin(1000t)$ volts, $R = 1K\Omega$ and $C = 1\mu F$, then the steady state current i(t) in milli amperes (MA)is



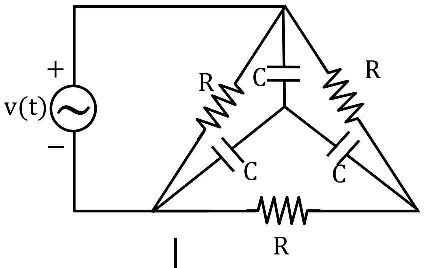
(A) $\sin(1000t) + 3\cos(1000t)$

(B) $\sin(1000t) + \cos(1000t)$

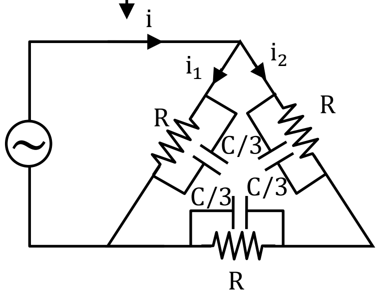
(C) $3\sin(1000t) + \cos(1000t)$

(D) $2\sin(1000t) + 2\cos(1000t)$

[Ans. C]



Star to Delta



$i = i_1 + i_2 \cdots (1)$

$$Z = \frac{R \times \frac{3}{j\omega C}}{R + \frac{1}{j\omega \frac{C}{3}}} = \frac{3R}{3 + j\omega CR} = \frac{3\,R}{3 + j}$$

$$i_1 = \frac{2\sin 1000\ t}{\frac{3R}{3+j}} = \frac{2\sin 1000\ t}{3\,R}(3+j)$$

$$i_2 = \frac{2\sin 1000\ t}{\frac{6\,R}{3+j}} = \frac{2\sin(1000\,t)}{\sigma\,R}(3+j)$$

$i = i_1 + i_2$

$= 3\sin(1000\,t) + \cos(1000\,t)$

42. A random variable X takes values $-1$and $+1$ with probabilities 0.2 and 0.8 respectively. It is transmitted across a channel a channel which adds noise N, so that the random variable at the channel output $Y = X + N$. The noise N is independent of X, and is uniformly distributed over the interval $[-2, 2]$. The receiver makes a decision

$$\begin{cases} -1\,, \text{if } Y \le \theta \\ +1, \text{if } Y > \theta \end{cases}$$

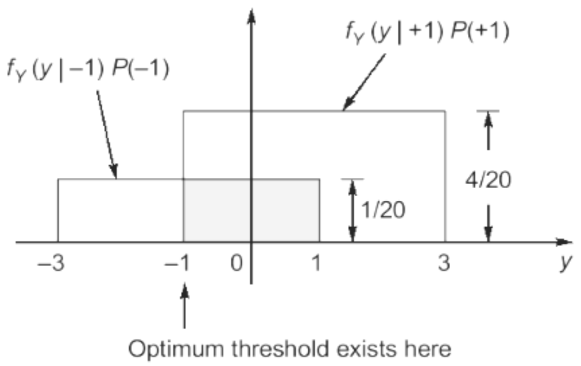
where the threshold $\theta \in [-1, 1]$ is chosen so as to minimize the probability of error $\Pr[\hat{X} \neq X]$. The minimum probability of error, rounded off to 1 decimal place is _________.

[Ans. *]Range 0.1 to 0.1

MAP Criteria should be used to minimize the probability of error

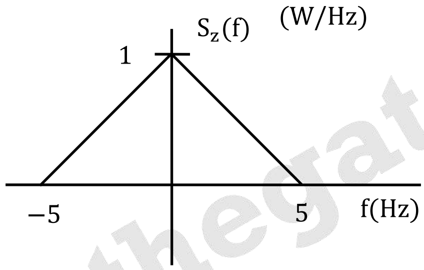
$$f_Y(Y|_{+1})P(+1) \sum_{-1}^{1} f_y\,(Y|_{-1})\ P(-1)$$

$P(+1) = 0.80$ and $P(-1) = 0.20$



$$P_{e(min)} = \text{Shaded area} = 2 \times \frac{1}{20} = 0.10$$

43. Let a random process y(t) be described as $y(t) = h(t) + x(t) + z(t)$where x(t) is a white noise process with power spectral density $S_x(F) = 5W/Hz$. The filter h(t) has a magnitude response given by $|H(f)| = 0.5$ for $-5 < f < 5$ and zero elsewhere, z(t) is a stationary random process, uncorrelated with x(t), with power spectral density as shown in the figure. The power in y(t), in watts, is equal to ______W(rounded off to two decimal places).



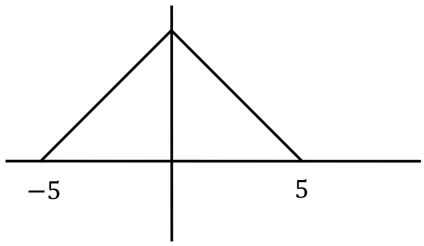
[Ans. *]Range 17.40 to 17.60

$y(t) = h(t) \times x(t) + z(t) \cdots ①$

$x(t) \to$ AWGN $\quad 5 \times (f) = 5W/Hz$

$h(t) = |H(f)| = 0.5$ for $-5 < f < 5$

$z(t) \to$ stationary power uncorrelated with x(t)



FT of ① is $y(f) = |H(f)|.|X(f)| + 2(f)$

PSD of y(t) is

$sy(F) = |y(F)|^2 = |H(f)|^2\,|x(f)|^2 + |z(f)|^2 + 2|H(f)|x(f)|z(f)|$

$\therefore$ output power $= \int_{\infty}^{\infty} Sy\,(5)df$

$= \int_{-\infty}^{\infty} [|H(f)|^2\,|x(f)|^2 + |z(f)|^2]at$

$= \int_{\infty}^{\infty} \left(\frac{1}{2}\right)^2 5df + \frac{1}{2} \times 10 \times 1$

$= \frac{5}{4} \times 10 + \frac{10}{2} = 17.5$ watts

44. Let h[n] be a length -7 discrete-time finite impulse response filter, given by
$h[0] = 4, h[1] = 3, h[2] = 2, h[3] = 1, h[-1] = -3, h[-2] = -2, h[-3] = -1$
and h[n] is zero for $|n| \ge 4$. A length -3 finite impulse response approximation g[n] of h[n] has to be obtained such that
$E(h,g) = \int_{-\pi}^{\pi} |H(e^{j\omega}) - G(e^{j\omega})|^2 d\omega$ is minimized, where $H(e^{j\omega})$ and $G(e^{j\omega})$ are the discrete-time fourier transforms of h[n]and g[n], respectively. For the filter that minimizes E(h, g), the value of $10g[-1] + g[1]$ rounded off to2 decimal places, is ______.
[Ans. *]Range −27.01 to −26.99
From Parseval's theorem

$$\sum_{n=-\infty}^{\infty} |x[n]|^2 = \frac{1}{2\pi} \int_{-\pi}^{\pi} |X(e^{j\omega})|^2 d\omega$$

So, $\int_{-\pi}^{\pi} |H(e^{j\omega})|^2 d\omega = 2\pi \sum_{n=-3}^{3} |h(n) - g(n)|^2$

The solution of g(n)that minimizes E(h, g) also minimizes $\sum_{n=-3}^{3} |h(n) - g(n)|^2$.

$$\sum_{n=-3}^{3} |h(n) - g(n)|^2 = |4 - g(0)|^2 + |3 - g(1)|^2 + |-3 - g(-1)|^2 + 10$$

The solution of g(n)that minimizes the above equation is

$g(n) = \{-3, \underset{\uparrow}{4}, 3\}$

So, $10g(-1) + g(1) = 10(-3) + 3 = -27$

45. Let the state-space representation of an LTI system br $\dot{x}(t) = A\,x(t) + B\,u(t)$. $y(t) = C\,x(t) + d\,u(t)$ where A,B,C are matrices, d is a scalar, u(t) is the input to the system, and y(t) is its output. Let $B = [0 \quad 0 \quad 1]^T$ and $d = 0$. Which one of the following options for A and C will ensure that the transfer function of this LTI system is

$H(s) = \frac{1}{s^3 + 3s^2 + 2s + 1}$?

(A) $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix}$ and $C = [1 \quad 0 \quad 0]$

(B) $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix}$ and $C = [0 \quad 0 \quad 1]$

(C) $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -1 \end{bmatrix}$ and $C = [0 \quad 0 \quad 1]$

(D) $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -1 \end{bmatrix}$ and $C = [1 \quad 0 \quad 0]$

[Ans. A]

$H(s) = \dfrac{1}{s^3 + 3s^2 + 2s + 1}$

In state space Analysis $H(s) = \dfrac{Y(s)}{U(s)}$

So, $\dfrac{Y(s)}{U(s)} = \dfrac{1}{s^3 + 3s^2 + 2s + 1}$

In time domain

$\dfrac{d^3y}{dt^3} + 3\dfrac{d^2y}{dt^2} + 2\dfrac{dy}{dt} + y = U$

OR, $\dddot{y} + 3\,\ddot{y} + 2\,\dot{y} + y = U \cdots\cdots (A)$

Now put $y = x_1$ and $\dot{x}_n = x_n + 1$

So, $xy = x_1 \cdots (1)$

$\dot{y} = \dot{x}_1 \cdots\cdots (2)$

$\ddot{y} = \ddot{x}_1 = \dot{x}_2 = x_3 \cdots\cdots (3)$

$\dddot{y} = \dddot{x}_1 = \ddot{x}_2 = x_3 \cdots\cdots (4)$

putting all the values in equation (A)

$\dot{x}_3 + 3x_3 + sx_2 + x_1 = U$

$\Rightarrow \dot{x}_3 = -x_1 - 2x_2 - 3x_3 + U \cdots\cdots (5)$

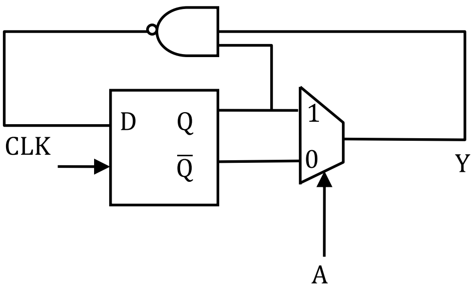
from equation (2), (3) and (5)

$[\dot{X}] = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} X + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} U$

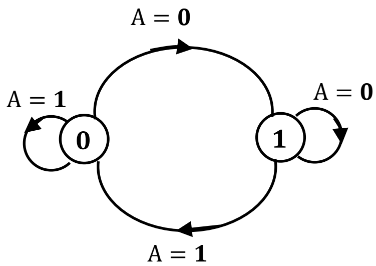
$Y = [1 \quad 0 \quad 0]X$

So, $S = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix}$ and $C = [1 \quad 0 \quad 0]$

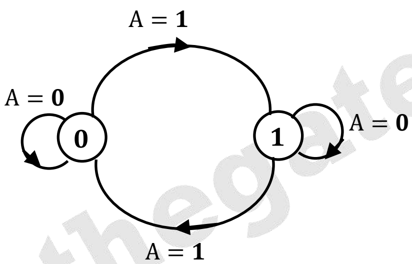
46. For the given circuit state diagram is ________. When A=1 or 0 [0 and 1 are the output states]



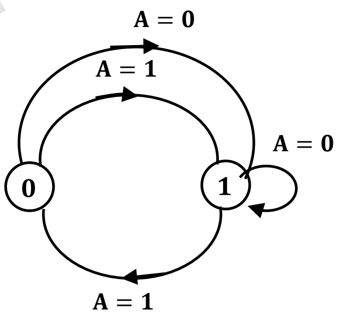
(A)



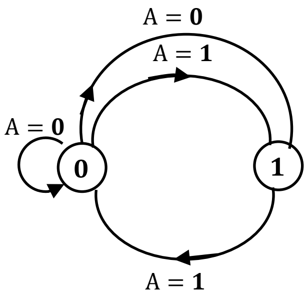
(B)



(C)



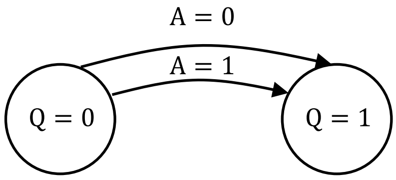
(D)



[Ans. C]

$D = \overline{Q}Y$

Case (i): If present state, Q = 0 then the next state, Q will be equal to 1 whether A = 0(or)A = 1

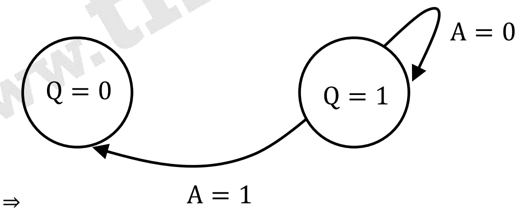


⇒

Case (ii):

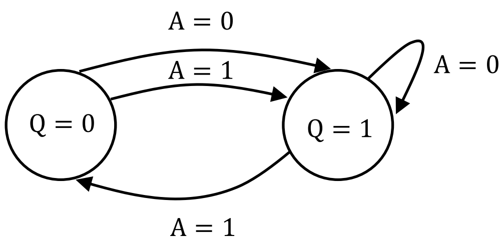
Present state, Q = 1

Present State				Next State
Q	$\overline{Q}$	$D = \overline{Q}Y$	A	Q
1	0	1	0	1
1	0	0	1	0



⇒

From case (i) case (ii) we will get the following state transaction diagram



47. In a rectangular waveguide with width w and height h, has cutoff frequency for TE_{10} to TE_{11} modes in the ratio 1:2, the aspect ratio w/h, rounded off to two decimal places, is ________

[Ans. *]Range 1.71 to 1.75

The cut off frequency of Rectangular Waveguide

$$f_{c(m,n)} = \frac{c}{2}\sqrt{\left(\frac{m}{w}\right)^2 + \left(\frac{n}{h}\right)^2}$$

$$f_{c(1,0)} = \frac{c}{2}\cdot\frac{1}{w}$$

$$f_{c(1,1)} = \frac{c}{2}\sqrt{\left(\frac{1}{w}\right)^2 + \left(\frac{1}{h}\right)^2}$$

$$\frac{f_{c(1,0)}}{f_{c(1,1)}} = \frac{\frac{1}{w}}{\sqrt{\left(\frac{1}{w}\right)^2 + \left(\frac{1}{h}\right)^2}} = \frac{1}{2}$$

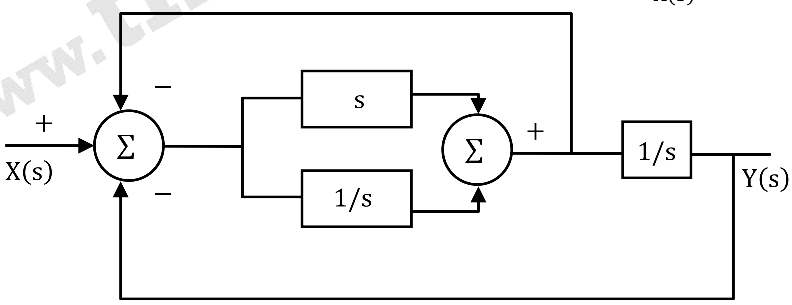
$$\left(\frac{1}{w}\right)^2 = \frac{1}{4}\left(\left(\frac{1}{w}\right)^2 + \left(\frac{1}{h}\right)^2\right)$$

$$3\left(\frac{1}{w}\right)^2 = \left(\frac{1}{h}\right)^2$$

$$\left(\frac{w}{h}\right)^2 = 3$$

$$\Rightarrow \frac{w}{h} = \sqrt{3} = 1.732$$

48. The block diagram of a system is illustrated in the figure shown, where X(s) is the input and Y(s) is the output. The transfer function $H(s) = \frac{Y(s)}{X(s)}$ is



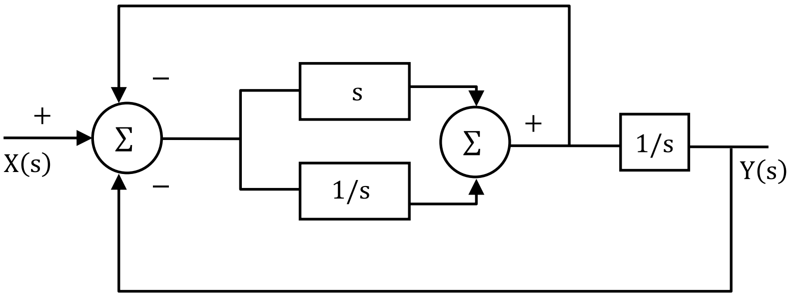
(A) $H(s) = \dfrac{s^2 + 1}{s^3 + s^2 + s + 1}$

(B) $H(s) = \dfrac{s^2 + 1}{s^3 + 2s^2 + s + 1}$

(C) $H(s) = \dfrac{s^2 + 1}{2s^2 + 1}$

(D) $H(s) = \dfrac{s + 1}{s^2 + s + 1}$

[Ans. B]



By (SFG) Masson's Gain formula

No. of forward path $= 2(P_1 \,\&\, P_2)$

$P_1 = \text{F } P_1 \text{ gain} = s \cdot \frac{1}{s} = 1$

$P_2 = \text{F } P_2 \text{ gain} = \frac{1}{s} \cdot \frac{1}{s} = \frac{1}{s^2}$

No. of Loops $= 4[L_1, L_2, L_3, L_4]$

$L_1 = \text{Loop gain } 1 = -s$

$L_2 = \text{Loop gain } 2 = -\frac{1}{s}$

$L_3 = \text{Lop gain } 3 = -\frac{1}{s} \cdot \frac{1}{s} = -\frac{1}{s^2}$

$L_4 = \text{Loop gain } 4 = -s \cdot \frac{1}{s} = -1$

$$\therefore \text{TF} = \frac{Y(s)}{X(s)} = \frac{P_1\Delta_1 + P_2\Delta_2}{\Delta} = \frac{1 + \frac{1}{s^2}}{1 - \left(-s - \frac{1}{s} - \frac{1}{s^2} - 1\right)}$$

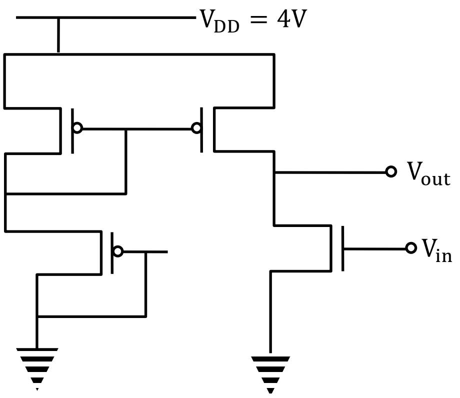
$$= \frac{1 + \frac{1}{s^2}}{2 + s + \frac{1}{s} + \frac{1}{s^2}} = \frac{s^2 + 1}{s^3 + 2s^2 + s + 1}$$

49. In the circuit shown, the threshold voltages of the Pmos $(|V_{tp}|)$ and nMOS (V_{th}) transistors are both equal to 1V. all the transistors have the same output resistance r_{ds} of

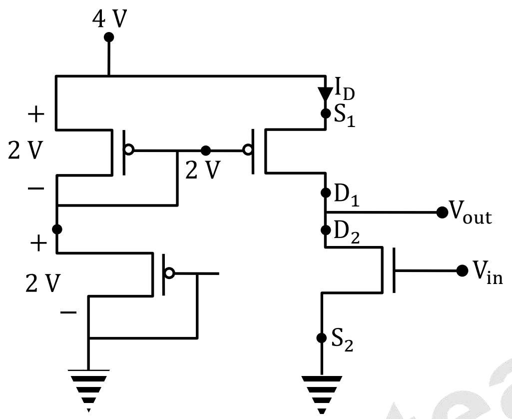
$M_x C_{ox} = \frac{60\mu A}{v^2}\left(\frac{W}{L}\right)_n = 5,$

$(\mu_p\, C_{ox}) = \frac{30\mu A}{v^2} : \left(\frac{W}{L}\right)_p = 10,$

μ_n and μ_p are the carrier mobilities, and C_{ox} is the oxide capacitance per unit area. Ignoring the effect of channel length modulation and body bias, the gain of the circuit is ________(rounded off to 1 decimal place).



[Ans. *]Range −905 to −895 or 895 to 905



Given $r_{ds} = 6\ \mu\Omega$ for all MOSFETS and $|V_T| = 1$ V for all MOSFETS.

$$\mu_n C_{ox} = 60 \frac{\mu A}{V^2}; \left(\frac{\omega}{L}\right)_{nmos} = 5$$

$$\mu_p C_{ox} = 30 \frac{\mu A}{V^2}; \left(\frac{\omega}{L}\right)_{pmos} = 10$$

$$I_D = \frac{1}{2} \mu_p\, C_{ox} \left(\frac{\omega}{L}\right)_p \left(V_{SG_p} - |V_T|\right)^2$$

$$= \frac{1}{2} \times 30\ \mu \times 10 \times (2-1)^2$$

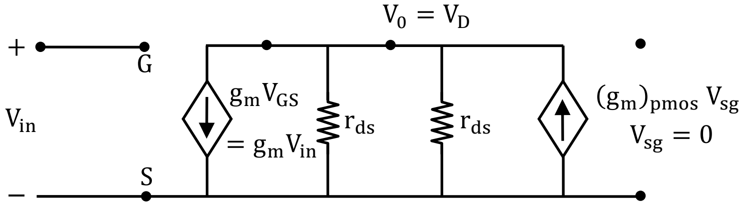
$$= 150\ \mu A$$

$$\text{Now, } (g_m)_{nmos} = \sqrt{2 I_D \mu_n C_{ox} \left(\frac{\omega}{L}\right)_n}$$

$$= \sqrt{2 \times 150 \text{ mu} \times 60 \times 10^{-6} \times 5}$$

$$= 300\ \mu$$

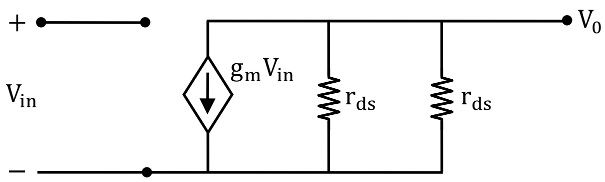
Small signal model:



$V_{SG} = 0\ V$ [$\because$ in small signal ground all DC source, $\therefore V_{dd}$ is grounded]

$\therefore (g_m)_{pmos} V_{sg} = 0$

$\therefore$ New small signal model



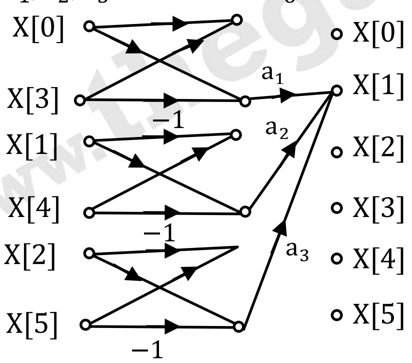
$V_0 = -g_m V_{in}(r_{ds}||r_{ds})$

$\Rightarrow \dfrac{V_0}{V_{in}} = -300\ \mu \times (6||6)M$

$= -300 \times 10^{-6} \times 3 \times 10^6$

$= -900$

50. Consider a six-point decimation-in-time fast Fourier Transform (FFT) algorithm, for which the signal-flow graph corresponding to X[1] is shown in the figure. Let $W_0 = \exp\left(-\frac{j2\pi}{6}\right)$. in the figure, what should be the values of the coefficient a_1, a_2, a_3 in terms of W_6 so that X[1]is obtained correctly?



(A) $a_1 = -1, a_2 = W_6^2, a_3 = W_6$

(B) $a_1 = -1, a_2 = W_6, a_3 = W_6^2$

(C) $a_1 = 1, a_2 = W_6, a_3 = W_6^2$

(D) $a_1 = 1, a_2 = W_6^2, a_3 = W_6$

[Ans. C]

$$X(1) = \sum_{n=0}^{5} x(n)\omega_6^n$$

$$X(1) = x(0) + x(1)\omega_6^1 + x(2)\omega_6^2 + x(3)\omega_6^3 + x(4)\omega_6^4 + x(5)\omega_6^5 \cdots\cdots (1)$$

$X(1) = x(0) + x(1)\omega_6^1 + x(2)\omega_6^2 - x(3) - x(4)\omega_6^1 - x(5)\omega_6^2$

$X(1) = \big(x(0) - x(3)\big) + \omega_6^1\big(x(1) - x(4)\big) + \omega_6^2\big(x(2) - x(5)\big) \cdots\cdots (2)$

From Diagram

$X(1) = a_1\big(x(0) - x(3)\big) + a_2\big(x(1) - x(4)\big) + a_3\big(x(2) - x(5)\big) \cdots\cdots (3)$

Comparing (2)and (3)

$a_1 = 1$

$a_2 = \omega_6^1$

$a_3 = \omega_6^2$

51. It is desired to find a tree-tap causal filter which gives signal as an output to an input of the form

$x[n] = c_1 \exp\left(-\frac{j\pi n}{2}\right) + c_2 \exp\left(\frac{j\pi n}{2}\right)$

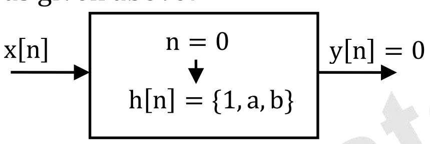
Where c_1 and c_2 are arbitrary real numbers. The desired three-tap filter is given by

$h[0] = 1, h[1] = a, h[2] = b$

and

$h[n] = 0$ for $n < 0$ or $n > 2$

what are the values of the filter taps a and b if the output is $y[n] = 0$ for all n, when x[n] is as given above?



(A) A=1, b=1

(B) $A = 0, b = -1$

(C) $A = -1, b = 1$

(D) A=0, b=1

[Ans. D]

Given

$x(n) = C_1\, e^{-jn\pi/2} + C_2\, e^{jn\pi/2} \;\cdots (1)$

$h(n) = \{1, a, b\} \cdots (2)$

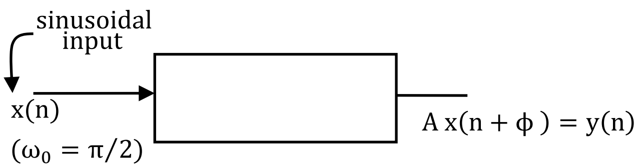
$\therefore$ The frequency of x(n)is $\omega_0 = \frac{\pi}{2}$

Apply ZT on (2)

$H(z) = 1 + az + bz^2$

For $z = e^{j\omega}$

$H(e^{j\omega}) = 1 + a\,e^{j\omega} + be^{2j\omega}$



where $A = |H(e^{j\omega})| \text{at } \omega = \frac{\pi}{2}$

$= |1 + ae^{j\pi/2} + be^{j\pi}|$

$= |1 + aj - b|$

As $y(n) = 0 \Rightarrow A = 0$

The above is satisfied for a=0, b=1

52. In an ideal pn junction with an ideality factor of 1 at T = 300 K, the magnitude of the reverse-bias voltage required to reach 75% of its reverse saturation current, rounded off to 2 decimal places, is ________mV.

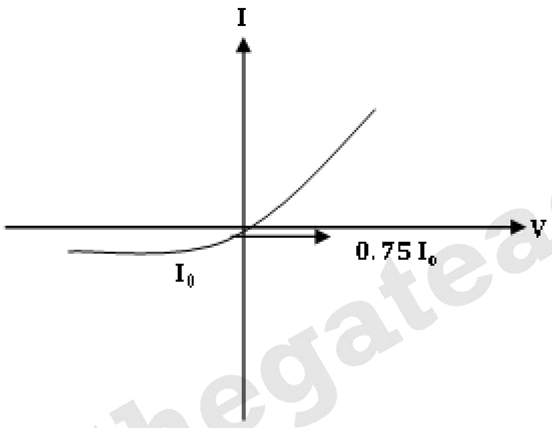
$[k = 1.38 \times 10^{-23}\ JK^{-1}, h = 6.625 \times 10^{-34} J - s, q = 1.602 \times 10^{-19} C]$

[Ans. *]Range: 34 to 38

Given

$\eta = 1$

T=300 k



$I_f = I_0 \left(e^{-\frac{V}{\eta V_T}} - 1 \right)$

From I-V Characteristic the equation will be

$-0.75\ I_0 = I_o \left(e^{\frac{-V_R}{V_T}} - 1 \right)$

$0.25 = e^{-\frac{V_R}{25m}}$

$\ln 0.25 = -\frac{V_R}{25m}$

$V_R = -25m \times \ln 0.25$

$V_R = 34.65\ mV$

53. Consider the homogeneous ordinary differential equation

$x^2 \frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 3y = 0\ x > 0$

With y(x) as a general solution. Given that y(1)=1 and y(2)=14

the value of y(1.5), rounded off to two decimal places, is _________.

[Ans. *]Range: 5.24 to 5.26

Let $x = e^z$

$x^2 \dfrac{d^2y}{dx^2} = D(D-1)y \;\; D = \dfrac{d}{dz}$

$x\dfrac{dy}{dx} = Dy$

$D(D-1)y - 3Dy + 3y = 0$

$(D^2 - D - 3D + 3)y = 0$

$(D^2 - 4D + 3)y = 0$

The auxiliary equation is:

$m^2 - 4m + 3 = 0$

$(m-1)(m-3) = 0$

$m_1 = 1, m_2 = 3$

$y_c = c_1e^{3z} + c_2e^z \,;\, y_c = c_1x^3 + c_2x$

Given: $y(1) = 1\,;\, y(2) = 14$

$1 = c_1 + c_2 \cdots (1)$

$14 = 8c_1 + 2c_2 \cdots (4)$

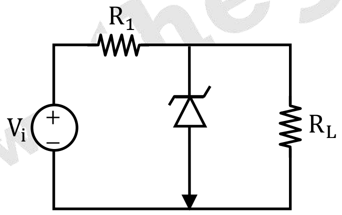
On solving two equations

$c_1 = 2, c_1 = 1$

$y_c = 2x^3 - x$

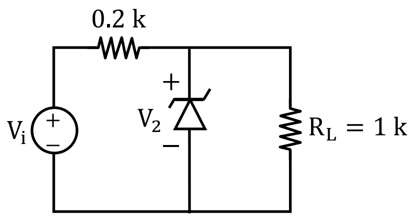
$y(1.5) = 2(1.5)^3 - 1.5 = 5.25$

54. In the circuit shown, the breakdown voltage and the maximum current of the zener diode are 20V and 60mA, respectively. The values of R_1 and R_L are 200Ω and 1kΩ, respectively. What is the range of V_1 that will maintain the zener diode in the 'on' state?



(A) 18V to 24V
(B) 24V to 36V
(C) 22V to 34V
(D) 20V to 28V

[Ans. B]

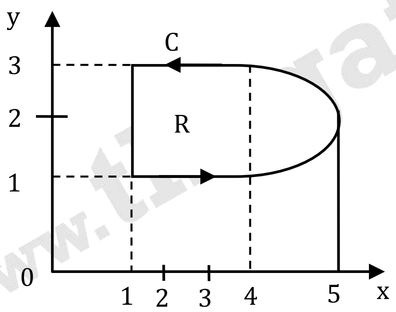


$I_2 max = 60\text{ mA}$
$V_2 = 20\text{ V}$
$V_L = V_2 = 20$
$I_L = \frac{20}{1k} = 20\text{ mA}$
$(IR)_{max} = I_2 max + I_2$
$= 60 + 20 = 80\text{ mA}$
$(V_i)_{max} = 0.2k \times (I_R)_{max} + V_2$
$= 0.2k \times 8\,0\text{ m} + 20$
$(V_i)_{max} = 36$
$(I_2)_{mn} = 0$
$(IR)_{mn} = 20\text{ mA}$
$(V_i)_{mn} = 0.2k \times I_{R.mn} + V_2$
$V_{i\,mn} = 24$

55. Consider the line integral

$$\int_C (xdy - ydx)$$

The integral being taken in a counter clockwise direction over the closed curve C that forms the boundary of the region R shown in the figure below. The region R is the area enclosed by the union of a 2×3 rectangle and a semi-circle of radius 1. The line integral evaluates to



(A) $8 + \pi$
(B) $16 + 2\pi$
(C) $12 + \pi$
(D) $6 + \pi/2$

[Ans. C]

Using Green's Theorem

$$\oint_c (M\,dx + N\,dy) = \iint \left(\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y}\right) dx\,dy$$

Here $M = -y$ and $N = x$

$$\therefore \iint \left[\frac{\partial}{\partial x}(x) - \frac{\partial}{\partial y}(-y)\right] dx\,dy$$

$$\iint (1+1) dx\,dy = 2\iint dx\,dy$$

Here, $\iint dx\,dy$ = Area of contour

Area of rectangle + Area of semicircle

$$2 \times 3 + \frac{\pi}{2}(1)^2 = 6 + \frac{\pi}{2}$$

$$\therefore \partial \iint dx\,dy = 2 \times \left(6 + \frac{\pi}{2}\right)$$

$$= 12 + \pi$$