

GATE 2019 Electronics Engineering Solutions

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GATE_SOLUTION

GA

- 1. The strategies that the company uses to sell its products include house to house marketing.
- 2. The boat arrived at down
- 3. As the positions of book R & S are fixed. The books P, Q and T can be arranged in 3! = 6 ways
- 4. When he did not come home, she pictured him lying dead on the roadside somewhere.
- 5. Let *t* be the time taken by the machines when they work simultaneously.

$$\therefore \frac{1}{t} = \frac{1}{4} + \frac{1}{2}$$
$$\therefore \frac{1}{t} = \frac{3}{4}$$
$$\therefore t = \frac{4}{3}$$

6. Given is the % of illiterates

So % of literates will be

| | F | Μ |
|------|-----|-----|
| 2001 | 40% | 50% |
| 2011 | 60% | 60% |

And population distribution is

| F | Μ |
|---|---|
| | |

| 2001 | 40% | 60% |
|------|-----|-----|
| | | |

2011 50% 50%

Let total population in both the years as T.

So total literate in 2001 will be

 $0.4 \times 0.4 + 0.5 \times 0.6 = 0.46T$

And total literate in 2011 will be

 $0.5 \times 0.6 + 0.5 \times 0.6 = 0.6T$

∴ Increase = 0.6T – 0.46T = 0.14T

:. % increase =
$$\frac{0.14T}{0.46T} \times 100 = 30.43$$

7. Lohit Seema Rahul Mathew

Doctor Dancer Teacher Engineer

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8. As first line says Indian history was written by British historians was extremely well documented and researched, but not always impartial.

So option (C) can be interfered from given passage.

| 9. | Р | Q |
|------------|--------------------------------|--------------------------------|
| Start time | 8 AM | 8 AM |
| Working | $\frac{210}{360}$ × 12 = 7 hrs | $\frac{210}{360}$ × 12 = 8 hrs |
| Breaks | 15 minutes each | 20 minute break |
| | (2 breaks) | (1 break) |
| | = 30 minutes | = 20 minutes |

∴ paid working hours = 7 hrs + 8 hrs – 30 minutes – 20 minutes

= 14 hrs 10 minutes

$$\therefore \text{ Paid} = 14 \times 200 + \frac{10}{60} \times 200$$

∴ Paid = 2833.33

- ∴ Budget left = 3000 2833.33 = 166.67
- 10. As it is given that R is sharing an office with T. So only option (D) is correct.

Electronics Engineering

1. A function F(z) is said to be analytic at a point z = a then F(z) has a derivative at z = a and derivative exists at each neighbouring point of z = a in domain D.

$$e^{\frac{1}{2}}$$
 at $z = 0 \longrightarrow e^{\infty} \longrightarrow No$ derivative

 $\ln z \text{ at } z = 0 \rightarrow \ln(0) = -\infty \rightarrow \text{does not exists}$

$$\frac{1}{1-z} \text{ at } z = 1 \rightarrow \frac{1}{0} = \infty \rightarrow \text{does not exists}$$

But cos z exists for all values of z so it is analytic over the entire complex plane.

2. As no supply is connected hence fermi level will be constant.

In P type semiconductor Fermi level should be closer to EV.

In N type semiconductor Fermi level should be closer to EC.

In P⁺⁺ type semiconductor due to large doping Fermi level enters into valance band.

Hence answer is (B).

3. By reciprocity theorem,

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$$\frac{1}{5} = \frac{1}{5}$$

∴ I = 1A

4. let output of NAND gate is M and output of NOR gate is N

$$\therefore M = \overline{E_N \cdot D}$$

And
$$N = \overline{E_N} + D$$

$$\therefore N = E_N \cdot \overline{D}$$

When $E_N = 0$

So both PMOS and NMOS will be OFF

So F will be at high impedance

When $E_N = 1$

$$M = \overline{D} \& N = \overline{D}$$

So this CMOS will act as not gate

- ∴ F will be D
- : Option (A) is correct.
- 5. Since it is a upper triangular matrix eigen values will bee 2, 1, 3, 2

 \therefore distinct eigen values are three

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

When n = -1

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

 \therefore Iny = - In(x) + In(c)

 $\therefore \ln(xy) = \ln(c)$

∴xy = c

This represents rectangular hyperbola.

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Now for
$$n = +1$$

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

$$\therefore ydy = -x dx$$

$$\therefore \frac{y^2}{2} = \frac{-x^2}{2} + c$$

$$\therefore x^2 + y^2 = 2c$$

This represents family of circles.

7.

$$\operatorname{let} H(z) = \frac{(z-a)(z-b)}{(z-c)(z-d)}$$

$$\therefore H\left(\frac{1}{z}\right) = \frac{\left(\frac{1}{z}-a\right)\left(\frac{1}{z}-b\right)}{\left(\frac{1}{z}-c\right)\left(\frac{1}{z}-d\right)}$$

$$\therefore H\left(\frac{1}{z}\right) = \frac{\left(z-\frac{1}{a}\right)\left(z-\frac{1}{b}\right)}{\left(z-\frac{1}{c}\right)\left(z-\frac{1}{d}\right)}$$

$$\therefore H(z) \cdot H\left(\frac{1}{z}\right) = \frac{\left(z-a\right)(z-b)\left(z-\frac{1}{a}\right)\left(z-\frac{1}{b}\right)}{\left(z-c\right)(z-d)\left(z-\frac{1}{c}\right)\left(z-\frac{1}{d}\right)}$$

$$\therefore \operatorname{zeros are } a, b, \frac{1}{a}, \frac{1}{b}$$

given zero is $a = \frac{1}{2} + \frac{1}{2}j$

as h(n) is real valued signal another zero must be complex conjugate of this

$$\therefore b = \frac{1}{2} - \frac{1}{2}j$$

Now $z_3 = \frac{1}{a} = \frac{1}{\frac{1}{2} + \frac{1}{2}j}$

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$$=\frac{2}{1+j}$$
$$=\frac{2(1-j)}{2}$$
$$z_{3}=1-j$$

as h(n) is real valued signal another zero must be complex conjugate of this

$$z_4 = 1 + j$$

 $\therefore z_1 = \frac{1}{2} + \frac{1}{2}j \quad z_2 = \frac{1}{2} - \frac{1}{2}j \quad z_3 = 1 - j \quad z_4 = 1 + j$

8.

9.



By changing order of integration

$$\int_{x=0}^{x=\pi} \left(\int_{y=0}^{y=x} dy \right) \frac{\sin x}{x} dx$$
$$\therefore \int_{x=0}^{\pi} x \frac{\sin x}{x} dx$$
$$\therefore \int_{x=0}^{\pi} x \sin x dx$$
$$\therefore [-\cos x]_{0}^{\pi} = 2$$
$$R_{rad} = 80\pi^{2} \left(\frac{dl}{\lambda} \right)^{2}$$
$$80\pi^{2} \left(\frac{dlf}{C} \right)^{2}$$

 $:: \mathbb{R}_{rad} \propto I^2 f^2$

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Now frequency is constant

 $\therefore R_{rad} \propto f^{2}$ $\therefore \frac{\Delta R}{R} = 2\frac{\Delta I}{I}$ $= 2 \times 1\%$ $\therefore \frac{\Delta R}{R} = 2\%$

10. y(s) is unit step response

$$\therefore y(s) = G(s) \times \frac{1}{s}$$
$$= \frac{3-s}{s(s+1)(s+3)}$$
$$= \frac{A}{s} + \frac{B}{s+1} + \frac{C}{s+3}$$
$$\therefore y(s) = \frac{1}{s} - \frac{2}{s+1} + \frac{1}{s+3}$$

 \therefore y(t) = u(t) - 2e^{-t} u(t) + e^{-3t} u(t)

11.





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If we consider a total cylinder then by gauss law

○ →sed

But $Q_{enclosed} = Q \cdot H$

And we are considering only $\frac{1}{4}$ th of the cylinder

$$\therefore D = \frac{Q \cdot H}{4}$$
$$\therefore E = \frac{Q \cdot H}{4 \in 0}$$

13. By rearranging the circuit,



Truth table:

| А | В | F |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

So it is XNOR gate.

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14. When Vs is +ve

Diode will be reserve biased



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16. We know that

$$\begin{split} \mathsf{NM}_{\mathsf{L}} &= \mathsf{V}_{\mathsf{I}\mathsf{L}} - \mathsf{V}_{\mathsf{O}\mathsf{L}} \\ \mathsf{NM}_{\mathsf{H}} &= \mathsf{V}_{\mathsf{O}\mathsf{H}} - \mathsf{V}_{\mathsf{I}\mathsf{H}} \\ \mathsf{Now}, \ \mathsf{V}_{\mathsf{I}\mathsf{L}} &= \frac{2\mathsf{V}_{\mathsf{0}} - \big|\mathsf{V}_{\mathsf{TP}}\big| - \mathsf{V}_{\mathsf{D}\mathsf{D}} + \mathsf{k}\mathsf{V}_{\mathsf{Tn}}}{1 + \mathsf{k}} \\ \mathsf{V}_{\mathsf{O}\mathsf{L}} &= \mathsf{V}_{\mathsf{in}} - \mathsf{V}_{\mathsf{TP}} + \sqrt{\left(\mathsf{V}_{\mathsf{in}} - \mathsf{V}_{\mathsf{D}\mathsf{D}} - \mathsf{V}_{\mathsf{TP}}\right)^{2} + \mathsf{k}\left(\mathsf{V}_{\mathsf{in}} - \mathsf{V}_{\mathsf{TP}}\right)^{2}} \\ \mathsf{V}_{\mathsf{O}\mathsf{H}} &= \mathsf{V}_{\mathsf{in}} - \mathsf{V}_{\mathsf{Tn}} + \sqrt{\left(\mathsf{V}_{\mathsf{in}} - \mathsf{V}_{\mathsf{TD}}\right)^{2} + \frac{1}{\mathsf{k}}\left(\mathsf{V}_{\mathsf{in}} - \mathsf{V}_{\mathsf{D}\mathsf{D}} - \mathsf{V}_{\mathsf{TP}}\right)^{2}} \\ \mathsf{V}_{\mathsf{O}\mathsf{H}} &= \frac{\mathsf{V}_{\mathsf{D}\mathsf{D}} + \mathsf{V}_{\mathsf{TP}} + \mathsf{k}\left(2\mathsf{V}_{\mathsf{O}} + \mathsf{V}_{\mathsf{TP}}\right)}{1 + \mathsf{k}} \\ \end{split}$$

 \therefore as $W_{P} \uparrow \rightarrow NM_{L} \uparrow$ and $NM_{H} \downarrow$

17.
$$\nabla \cdot \overline{D} = \rho_V$$

This is Gauss law

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

This is faraday law of electromagnetic induction

$$\nabla \times \overline{B} = 0$$

This is Gauss law in magnetostatics which states magnetic monopole does not exists.

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

This is modified form of ampere's circuital law.

18. at F = 10 Hz we have one pole

At $F = 10^2$ Hz we can see two more poles are added as slope is decreased by 40 dB/decade

At $F = 10^3$ Hz we have a zero

At $F = 10^4$ Hz we have two zero's

At $F = 10^5$ Hz we have two pole's

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At $F = 10^6$ we have one pole

 \therefore Total poles N_P = 6

And total zeros N_z = 3

19. $x(t) = cos(2\pi fct + km(t))$

 \therefore Q(t) = 2 π fct + km(t)

And
$$fi = \frac{1}{2\pi} \frac{\partial}{\partial t} (Q(t))$$

$$= \frac{1}{2\pi} \frac{\partial}{\partial t} [2\pi fct + km(t)]$$

$$fi = fc + \frac{k}{2\pi} \frac{\partial}{\partial t}m(t)$$

$$\therefore fi_{max} = fc + \frac{k}{2\pi} [\frac{\partial}{\partial t}m(t)]_{max}$$

$$\therefore fi_{max} = 50 \text{ kHz} + 5 \times \frac{1 - (-1)}{(7 - 6) \times 10^{-3}}$$

$$\therefore fi_{max} = 50 \text{ kHz} + 10 \text{ kHz}$$

$$\therefore fi_{max} = 60 \text{ kHz}$$

And
$$fi_{min} = fc + \frac{k}{2\pi} \left[\frac{\partial}{\partial t} (m(t)) \right]_{min}$$

$$50$$
kHz $+5 \times \frac{-1-1}{(9-7) \times 10^{-3}}$

= 50 kHz – 5kHz

 fi_{min} = 45 kHz

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

20.
$$D_1 = \overline{Q}_1 \cdot \overline{Q}_2$$

$$\mathsf{D}_2=\mathsf{Q}_1$$

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| Presen | t State | Excitation | | Next state | |
|--------|----------------|------------|-------|------------|---------|
| Q1 | Q ₂ | D_1 | D_2 | Q_1^+ | Q_2^+ |
| 0 | 0 | 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 0 | 0 |

As three states are there

Frequency of output = Frequency of $Q_2 = \frac{12 \text{ kHz}}{3} = 4 \text{ kHz}$

21. As it is given that it is linear hamming code addition of two codes will produce another code.

(Here we are talking about mod 2 addition)

 $\begin{array}{c} 0 \ 0 \ 0 \ 1 \ \rightarrow \ 0 \ 0 \ 0 \ 0 \ 1 \ 1 \\ \\ 0 \ 0 \ 1 \ 0 \ \rightarrow \ 1 \ 1 \ 0 \ 0 \ 1 \ 1 \\ \hline \hline 0 \ 0 \ 1 \ 0 \ \rightarrow \ 1 \ 1 \ 0 \ 0 \ 0 \ 1 \end{array}$

22. Ans. 0367

Sol. Probability density function (Pdf) =
$$\frac{d}{dx}(CDF)$$

$$\therefore \operatorname{Pdf} = \begin{cases} e^{-x} , & x \ge 0\\ 0 , & x < 0 \end{cases}$$
Now $\operatorname{Pr}(z > 2|z > 1) = \frac{\operatorname{Pr}[(z > 2) \cap (z > 1)]}{\operatorname{Pr}(z > 1)}$

$$= \frac{\operatorname{Pr}(z > 2)}{\operatorname{Pr}(z > 1)}$$

$$= \frac{\int_{-\infty}^{\infty} e^{-x} dx}{\int_{1}^{\infty} e^{-x} dx}$$

$$= \frac{-1(e^{-\infty} - e^{-2})}{-1(e^{-\infty} - e^{-1})}$$

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$$= \frac{e^{-2}}{e^{-1}} = \frac{1}{e}$$

∴ Pr(Z>2|Z>1)=0.367

23. DC value and phase shift does not affect time period of a signal.

So it is equivalent to find time period of

$$x(t) = 2\cos(\pi t) + 3\sin\left(\frac{2\pi}{3}\right) + 4\cos\left(\frac{\pi}{2}t\right)$$

$$\therefore \omega_1 = \pi$$
 $T_1 = \frac{2\pi}{\omega_1} = 2$ second

$$\omega_2 = \frac{2\pi}{3}$$
 $T_2 = \frac{2\pi}{\omega_2} = 3$ second

$$\omega_3 = \frac{\pi}{2}$$
 $T_3 = \frac{2\pi}{\omega_3} = 4$ second

Now overall $T = LCM (T_1, T_2, T_3)$



$$\frac{1}{2\pi i} \frac{(z^2 + 1)^2}{z^2} dz$$

25.

For poles :

Consider $z^2 = 0 \Longrightarrow z = 0,0$

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Now $f(z) = (z^2 + 1)^2$

$$= \frac{1}{2\pi i} \left[\frac{2\pi i}{(2-1)!} f^{n-1}(a) \right] = f'(a) = f'(0)$$

Now $f'(z) = 2(z^2 + 1)(2z)$

$$f'(0) = 2(0 + 1)(0) = 0$$

 \div So answer is zero.

26. Let output of MUX is M

So M =
$$\overline{A}\overline{Q} + AQ$$

And D = MQ

$$=\overline{M}+\overline{Q}$$

$$D = A \oplus Q + \overline{Q}$$

| Present State | Input | Next State |
|---------------|-------|--------------------|
| Q | А | Q ⁺ = D |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

State Diagram:-



27. Given V_{TN} = 0.6V, $~V_{SB}$ = 0 and λ = 0

In figure (i)

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In figure (ii)



Ever MOS transistor has same $V_G = 3V$

$$\therefore V_1 = V_2 = Vout \ 2 = VG - VT$$

∴ Vout 2 = 2.4 V

28.



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

$$\therefore TF = \frac{s^{2} + 1}{s^{3} + 2s^{2} + s + 1}$$
29. $P_{o}(-1 + N > Vth)$
 $P_{o}(N > Vth + 1) = \int_{vth+1}^{2} \frac{1}{4} dx = \frac{1}{4}[2 - Vth - 1] = \frac{1}{4}(1 - Vth)$
 $P_{1}(1 + N < Vth)$
 $P_{1}(N < Vth - 1) = \int_{-2}^{vth-1} \frac{1}{4} dx = \frac{1}{4}[Vth - 1 + 2] = \frac{1}{4}(Vth + 1)$
 $P_{e} = P(0)P_{o}(N > Vth + 1) + P(1)P_{1}(N < Vth - 1)$
 $P_{e} = 0.2 \times \frac{1}{4}(1 - Vth) + 0.8 \times \frac{1}{4}(Vth + 1)$
 $= 0.05 - 0.5Vth + 0.2Vth + 0.2$
 $P_{e} = 0.25 + 0.15Vth$
For $Vth = 0 \rightarrow Pe = 0.25$
For $Vth = 1 \rightarrow Pe = 0.1$
 \therefore Minimum probability of error = 0.1
30. Ans. 0.231

Sol. $1 - e^{-\alpha x} = 0.5$

e^{-∝ x} = 0.5

now \propto = 3 \times 10⁴ cm⁻¹

$$\therefore x = \frac{-\ln(0.5)}{3 \times 10^4}$$

$$I_{D} = \frac{1}{2} \mu_{P} cox \left(\frac{\omega}{L}\right)_{P} \left(V_{GSP} - \left|V_{TP}\right|\right)^{2}$$
31.

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$$= \frac{1}{2} \times 30 \times 10^{-6} \times 10 \times (2 - 1)^{2}$$

$$I_{D} = 150 \ \mu\text{A}$$
Now, $g_{m} = \sqrt{2I_{D}\mu_{n} \cos\left(\frac{\omega}{L}\right)_{N}}$

$$g_{m} = \sqrt{2 \times 150 \times 10^{-6} \times 60 \times 10^{-6} \times 5}$$

$$\therefore \ gm = 300 \times 10^{-6} \text{ s}$$
Now $A_{v} = -gm \ (r_{ds} \mid \mid r_{ds})$

$$= -300 \times 10^{-6} \left(\left(6 \times 10^{6}\right) \mid \right)$$

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

$$\therefore \ A_{v} = -900$$

32. Given that

h(0) = 1, h(1) = a, h(2) = b and h(n) = 0 otherwise

$$\therefore H(e^{jw}) = 1 + ae^{-jw} + be^{-j2v}$$

Now y(n) = 0 for all n

Now
$$x(n) = C_1 e^{\left(\frac{-j\pi n}{2}\right)} + C_2 e^{\left(\frac{j\pi n}{2}\right)}$$

If we consider $C_1 e^{\left(\frac{-j\pi n}{2}\right)}$ as input then

Output =
$$C_1 \left[1 + ae^{+j\frac{\pi}{2}} + be^{-j2\left(-\frac{\pi}{2}\right)} \right]$$

Output =
$$C_1 \begin{bmatrix} 1 + ae^{j\frac{\pi}{2}} + be^{j\pi} \end{bmatrix}$$
 ...(i)

If we consider $C_2 e^{\left(\frac{j\pi n}{2}\right)}$ as input then

$$Output = C_2 \left[1 + ae^{-j\frac{\pi}{2}} + be^{-j2\left(\frac{\pi}{2}\right)} \right]$$

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$$=C_{2}\left[1+ae^{-j\frac{\pi}{2}}+be^{-j\pi}\right]$$
 ...(ii)

Both output (i) and (ii) will be zero if

$$I_{D} = \frac{\mu_{n}c_{ox}}{2} \cdot \left(\frac{\omega}{L}\right) \cdot \left(V_{gs} - V_{T}\right)^{2}$$
33.

$$=\frac{300\times3.45\times10^{-7}}{2}\times\left(\frac{10}{1}\right)\times(5-0.7)^{2}$$

34. Current through FET having
$$\left(\frac{\omega}{L}\right) = 3$$
 will be I₁

$$\therefore I_1 = \frac{(\omega/L)_2}{(\omega/L)_1} \times 1 \text{mA}$$

$$I_1 = \frac{3}{2} mA$$

Now,

$$I_{out} = \frac{(\omega/L)4}{(\omega/)_3} \times I_1$$
$$= \frac{40}{10} \times \frac{3}{2} mA$$

∴l_{out} = 6mA

35. Quantum Efficiency $\eta = \frac{R_e}{R_p}$

R_e = Corresponding Electron Rate (electrons/sec)

Rp = Incident Photon Rate (Photons/sec)

$$R_{e} = \frac{I_{p}}{q}, R_{p} = \frac{P_{in}}{h\nu}, R = \frac{I_{p}}{P_{in}}$$
$$\eta = \frac{I_{p/q}}{P_{p}}$$

P_{in/hv}

Now

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$$\eta = \frac{l_{P/q}}{P_{in/hv}} = \frac{l_P hv}{qP_{in}} = \frac{hvR}{q}$$

$$\Rightarrow R = \frac{q\eta}{hv} = \frac{q\eta\lambda}{hc} = \eta \times \left(\frac{q}{hc}\right)$$

$$q = 1.6 \times 10^{-19} c, h = 6.63 \times 10^{-34} Js, C = 3 \times 10^8 m/s$$

$$R = \frac{\eta \lambda}{1.24}$$

36.



Performing star to delta conversion



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Where
$$Z_1 = 2 \left[\frac{R}{1 + \frac{jWCR}{3}} \right]$$

$$\therefore Z_{eq} = Z_1 || \left[1 + \frac{jWCR}{3} \right]$$

$$\therefore Z_{eq} = \frac{2}{3} \left(\frac{R}{1 + \frac{jWCR}{3}} \right)$$

Now R = 1kW, C = 1 μ F and W=1000 rad/sec

$$\therefore I = \frac{V}{Z_{eq}}$$

$$= \frac{2\sin(1000t)}{0.66 - 0.2178j}$$

$$= \frac{2}{\sqrt{0.66^2 + 0.2178^2}} \cdot \sin\left(1000t - \tan^{-1}\left(\frac{1}{3}\right)^2\right)$$

$$= 3.16\sin(1000t + 18.43^\circ)$$

$$\therefore I \approx 3\sin(1000t) + \cos(1000t)$$

37.



 I_{Zmax} = 60 mA

$$I_{\rm L} = \frac{20}{1000} = 20 \,{\rm mA}$$

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As I_{Zmin} not given,

 $I_{Zmin} = 0 \text{ mA}$

Now
$$I_s = I_z + I_L$$

 $:: I_{Smin} = I_{Zmin} + I_{L}$

= 0 + 20 mA

∴I_{Smin} = 20 mA

Now
$$I_S = \frac{V_S - V_Z}{200}$$

$$\therefore 20\text{mA} = \frac{\text{V}_{\text{S}} - 20}{200}$$

∴ V_S = 24V

Now $I_{Smax} = I_{Zmax} + I_{L}$

I_{Smax} = 80 mA

$$\therefore I_{\rm S} = \frac{V_{\rm S} - V_{\rm Z}}{200}$$

$$\therefore 80\text{mA} = \frac{\text{V}_{\text{S}} - 20}{200}$$

38.

 $=\frac{1}{2\pi\rho}a\rho$

For wire ω_1

$$H_1 = \frac{I}{2\pi I}$$

For wire ω_2

$$H_2 = \frac{2I}{2\pi 3r}$$

Magnetic field will be circular and can be find out by right hand rule

Both fields will add at middle region

 \div at dotted line





$$H = H_{1} + H_{2}$$

$$\therefore H = \frac{5I}{6\pi r}$$
Now B = μoH

$$B = \frac{\mu_{0} 5I}{6\pi r}$$
39.
Sol.
$$V_{g} = \frac{d\omega}{d\beta}$$
Now, $\frac{d\beta}{d\omega} = \frac{dk(\omega)}{d\omega} = \frac{d}{d\omega} \cdot \frac{1}{c} \sqrt{\omega^{2} - \omega_{0}^{2}} = \frac{1}{2c\sqrt{\omega^{2} - \omega_{0}^{2}}} \times 2\omega$

$$\frac{d\beta}{d\omega} = \frac{\omega}{c\sqrt{\omega^{2} - \omega_{0}^{2}}}$$

$$V_{g} = \frac{\frac{1}{\omega}}{c\sqrt{\omega^{2} - \omega_{0}^{2}}} = 2 \times 10^{8} \Rightarrow \frac{c\sqrt{\omega^{2} - \omega_{0}^{2}}}{\omega} = 2 \times 10^{8}$$

$$\Rightarrow \sqrt{\omega^{2} - \omega_{0}^{2}} = \frac{2\omega}{3}$$
Now, $V_{p} = \frac{\omega}{\beta} = \frac{\omega}{k} = \frac{\omega}{\frac{1}{c}\sqrt{\omega^{2} - \omega_{0}^{2}}} = \frac{\omega c}{2\frac{\omega}{3}} = \frac{3c}{2}$

$$V_{p} = \frac{3}{2} \times 3 \times 10^{8} = 4.5 \times 10^{8} \text{ m/s}$$
40.
$$f(-1) = 0$$

So only option (B) and (C) are possible

Let's try option (B)

f(x) = 2|x+1|

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$$\therefore f(x) = \begin{cases} 2(x+1) \text{ for } x+1 > 0\\ -2(x+1) \text{ for } x+1 < 0 \end{cases}$$

$$\therefore f(x) = \begin{cases} 2(x+1) \text{ for } x > -1\\ -2(x+1) \text{ for } x < -1 \end{cases}$$

$$\therefore f'(x) = \begin{cases} 2 \text{ for } x > -1\\ -2 \text{ for } x < -1 \end{cases}$$

$$\therefore f'(x) | \le 2$$

$$\therefore \text{ option (B) \text{ is correct.}}$$

$$G(s) = \frac{C(s)}{R(s)}$$

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

$$\therefore C(s) = G(s) \cdot R(s)$$

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

$$\therefore C(s) = \frac{A}{s} + \frac{B}{(s+1)} + \frac{C}{(s+1)^2}$$

$$\therefore A(s+1)^2 + Bs(s+1) + Cs = 1$$

$$\therefore As^2 + 2As + A + Bs^2 + Bs + Cs = 1$$

$$\therefore A + B = 0$$

$$\therefore 2A + B + C = 0$$

$$\therefore A = 1$$

So $B = -1$
And $C = -1$
$$\therefore C(s) = \frac{1}{s} + \frac{-1}{s+1} + \frac{-1}{(s+1)^2}$$

$$\therefore C(t) = (1 - e^{-t} - te^{-t}) u(t)$$

At t $\rightarrow \infty$ stedy state will occur

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∴ C(∞) = 1

Now we are asked to find time at which 94% of the steady state value reached.

$$\therefore C(t) = 1 - e^{-t} - te^{-t} = 0.94$$
$$\therefore e^{-t} + te^{-t} = 0.06$$

Now from the given options try all option you will get t = 4.50 sec.

$$X(k) = \sum_{n=0}^{N-1} x(n) W_N^{kn}$$

42.

We are obtaining X(1) correctly

∴ k = 1

$$\therefore x(1) = x(0) + x(1)W_6^1 + x(2)W_6^2 + x(3)W_6^3 + x(4)W_6^4 + x(5)W_6^5$$

We know that

$$W_{N}^{k+\frac{N}{2}} = -W_{N}^{K}$$

∴ $W_{6}^{3} = -W_{6}^{0} = -1$
 $W_{6}^{4} = -W_{6}^{1}$
 $W_{6}^{5} = -W_{6}^{2}$

 \therefore comparing with given graph

$$a_1 = 1$$
, $a_2 = W_6$, $a_3 = W_6^2$

43.

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

∴ $\begin{bmatrix} \dot{x}_1 & 0 & 1 & 0 \\ \dot{x}_2 & 0 & 0 & 1 \\ \dot{x}_3 & -1 & -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \begin{bmatrix} u \end{bmatrix}$
& $\begin{bmatrix} y \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \end{bmatrix} \begin{bmatrix} u \end{bmatrix}$

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$$\therefore A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix} \text{ and } C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}$$

Same current will flow through both NMOS & PMOS

$$\therefore ID1 = ID2$$

$$\therefore \frac{\mu_{n} \cos x}{2} \cdot \left(\frac{\omega}{L}\right)_{N} (V_{GSN} - V_{TN})^{2} = \frac{\mu_{p} \cos x}{2} \cdot \left(\frac{\omega}{L}\right)_{p} (V_{GSP} - |V_{TP}|)^{2}$$

$$\therefore 100 \times \left(\frac{\omega}{L}\right)_{N} \cdot (1.5 - 0.7)^{2} = 400 \times \left(\frac{\omega}{L}\right)_{p} (1.5 - 0.9)^{2}$$

$$\therefore \frac{(\omega/L)_{N}}{(\omega/L)_{p}} = \frac{9}{16} \times \frac{4}{10}$$

$$= 0.225$$

$$\left(\because \qquad l_{GSP} = \frac{V_{dd}}{2} = 1.5V\right)$$

45.

$$f_{c} = \frac{V}{2} \sqrt{\left(\frac{m}{a}\right)^{2} + \left(\frac{n}{b}\right)^{2}}$$

For $T\varepsilon_{10}$, $m = 1$, $n = 0$
$$fc_{1} = \frac{V}{2} \sqrt{\left(\frac{1}{a}\right)^{2} = 0} = \frac{V}{2a}$$

For $T\epsilon_{11}$, m = 1, n = 1

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$$f_{c_2} = \frac{V}{2} \sqrt{\frac{1}{a^2} + \frac{1}{b^2}}$$
Given $\frac{f_{c_1}}{f_{c_2}} = \frac{1}{2}$

$$\frac{\frac{V}{2a}}{\frac{V}{\sqrt{\frac{1}{a^2} + \frac{1}{b^2}}}} = \frac{1}{2}$$

$$\frac{\frac{1}{a}}{\sqrt{\frac{1}{a^2} + \frac{1}{b^2}}} = \frac{1}{2} \Rightarrow \frac{\frac{1}{a}}{\frac{\sqrt{a^2 + b^2}}{ab}} = \frac{1}{2}$$

$$\frac{b}{\sqrt{a^2 + b^2}} = \frac{1}{2}$$

$$\Rightarrow 4b^2 = a^2 + b^2$$

$$\Rightarrow 3b^2 = a^2$$

$$\Rightarrow \frac{b^2}{a^2} = \frac{1}{3}$$

$$\Rightarrow \frac{b}{a} = \frac{1}{\sqrt{3}}$$

$$\Rightarrow \frac{a}{b} = \sqrt{3}$$

$$\frac{width}{hight} = \sqrt{3} = 1.732$$

46.

$$p(t) = x(t) * h(t)$$
and $y(t) = z(t) + p(t)$

$$\therefore Ryy (\tau) = R_{zz} (\tau) + R_{pp}(\tau) + R_{pz}(\tau) + R_{zp}(\tau)$$
now $x(t) \& z(t)$ are uncorrelated.
$$\therefore Rpz(\tau) = R_{zp}(\tau) = 0$$

 $\therefore \mathsf{R}_{\mathsf{y}\mathsf{y}}(\tau) = \mathsf{R}_{\mathsf{z}\mathsf{z}}(\tau) + \mathsf{R}_{\mathsf{p}\mathsf{p}}(\tau)$

So the power spectral relation can be given by Fourier transform of the above relation.

$$\therefore S_{yy}(f) = S_{zz}(f) + S_{pp}(f)$$
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now power of y(t)=



47. For the minimization of the energy in the error signal there are different approaches like, Prony's method, Pade approximation. As g(n) has three samples.

Consider them as g(-1), g(0), g(1) we can minimise E(h,g) by making h(n) = g(n) using rectangular window and Parseval's there of OTFT.

Based on which 10g(-1) + g(1) = 10(-3) + 3





= -27

48. I_r= 0.75 I₅

$$\label{eq:starses} \begin{split} & \therefore \mbox{ Forward current} = I_D = -\ 0.75\ I_S \\ & \therefore \ I_S(e^{vo/nvt}-1) = -\ 0.75\ I_S \end{split}$$

Now Take n = 1

 $\therefore e^{vo/vT} = 0.25$

$$:: V_{R} = -VTIn (0.25)$$

$$= -\frac{1.38 \times 10^{-23} \times 300}{1.6 \times 10^{-19}} \times -1.386$$

∴ V_R = 35.87 mv

49. Given differential equation is of Cauchy – Euler differential equation type.

So let
$$x = e^z$$
 $\therefore z = \ln x$

The differential equation can be written as,

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

 $\therefore D^2 - 4 D + 3 = 0$
 $\therefore D = 1, 3$
 $\therefore y = C_1 e^2 + C_2 e^{32}$
 $\therefore y = C_1 x + C_2 x^3$
Now y (1) = 1
 $\therefore C_1 + C_2 = 1$...(i)
And y(2) = 14
 $\therefore 2C_1 + 8C_2 = 14$...(ii)
From (i) and (ii)
 $C_1 = -1, C_2 = 2$
 $\therefore y = -x + 2x^3$
 $\therefore y(1.5) = -1.5 + 2(1.5)^3$
 $\therefore y(1.5) = 5.25$

50. We know that,

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$$I_{C}(t) = C \frac{dV_{C}(t)}{dt}$$

And capacitor will be charged by the following equation

$$V_{C}(t) = V_{S}(1 - e^{-t/\tau})$$

$$I_{C}(t) = C \cdot \frac{d}{dt} \left[V_{S}(1 - e^{-t/\tau}) \right]$$

$$\therefore I_{C}(t) = \frac{V_{S}}{R(t)} e^{-t/R(t) \cdot C}$$

Given R(t) = R₀
$$\left[1 - \frac{t}{T}\right]$$

Now $R_0 = 1$ and C=1

$$\therefore$$
 T = 3R₀C = 3

$$\therefore R(t) = \left[1 - \frac{t}{3}\right]$$

$$\& l_{c}(t) = \frac{1}{\sqrt{1 - \frac{t}{3}}} \times e^{\frac{-t}{\left(1 - \frac{t}{3}\right)}}$$

$$\& I_{C}(t) = \frac{1}{\left(1 - \frac{t}{3}\right)} \times e$$

At
$$t = \frac{T}{2} = \frac{3}{2} \sec \theta$$

$$I_{c}(t) = 2 e^{-t}$$

= 0.099

 $I_C(t) \approx 0.1 \text{ mA}$

51. $V_s = 10 V$

Voltage across capacitor will be $V_{c}(t) = 10(1 - e^{-t/RC})$ $R_{c} = 500 \times 10 \times 10^{-6} = 5 \times 10^{-3} \text{ sec}$ At t = 2 ms = 2 × 10⁻³ sec

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$$V_{c} (2 \text{ ms}) = 10 \left(1 - e^{\frac{-2}{5}} \right)$$

V_c (2 ms) = 3.3 V

For
$$\frac{T}{2}$$
 to T diode will be off so capacitor will not charge further

∴ V_c (3 msec) = 3.3V

52. By greens theorem

$$\int x dy - y dx = \bigcirc \qquad dx dy$$

$$\int (x dy - y dx) = \bigcirc$$

$$2 \bigcirc$$

$$= \text{ area of the region}$$

$$= \left[2 \times 3 + \frac{\pi(1)^2}{2} \right]$$

$$\left[6 + \frac{\pi}{2} \right]$$

$$\therefore \int (x dy - y dx) = 12 + \pi$$
53.

Overall
$$G_{C}(s) = \frac{k}{s(s^{2}+3s+2)}$$

$$\therefore q(s) = s^{3}+3s^{2}+2s+k = 0$$

$$\begin{vmatrix} s^{3} & | 1 & 2 \\ s^{2} & | 3 & k \\ s^{1} & | \frac{6-k}{3} \\ s^{0} & | k \end{vmatrix}$$

Auxiliary equation is $3s^2 + k = 0$

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And for roots on imaginary axis s¹ row = 0

$$\therefore \frac{6-k}{3} = 0$$
$$\therefore k = 6$$

54.

m(t) has frequency range 5 kHz to 15 kHz

Now it is amplitude modulated

- $f(t) = A (1 + m(t)) \cos 2\pi f_c t$ where $f_c = 600$ kHz
- \therefore AM signal will have highest frequency = f_c + f_m (max)
- = 600 + 15 = 615 kHz

And AM signal will have lowest frequency = $f_c - f_m$ (max)

= 600 – 15 = 585 kHz

It is a band pass signal so we use bandpass sampling

$$f_{s} = 1.2 \times \frac{2fH}{k}$$

$$K = \frac{f_{H}}{f_{H} - f_{L}}$$

$$= \frac{615}{615 - 585}$$

$$K = 20.5$$
We select K = 20

$$\therefore f_{s} = 1.2 \times \frac{2 \times 615}{20}$$

$$\therefore f_{s} = 73.8 \text{ kHz}$$
Now L = 256
And $2^{n} = L = 256$

$$\therefore n = 8$$
Bitrate = $R_{b} = nf_{s}$

$$\therefore R_{b} = 8 \times 73.8 \times 103$$

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55.

0 is represented by p(t)

And 1 is represented by q(t)

And $\psi_1(t)$ and $\psi_2(t)$ are orthogonal signal set

(i) $p(t) = \psi_1(t)$ and $q(t) = -\psi_1(t)$

So signal space diagram will be,



 \therefore dmin₁ = 2

(ii)
$$p(t) = \psi_1(t)$$
 and $q(t) = \sqrt{E}\psi_2(t)$

So signal space diagram will be



$$\therefore \text{dmin}_2 = \sqrt{E+1}$$

Now bit error probability is same in both cases

 \therefore dmin₁ = dmin₂

$$\sqrt{1+E}=2$$

∴ E = 3

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