All India Mock GATE Test Series
Test series 4
Instrumentation Engineering

Answer Keys and Explanations

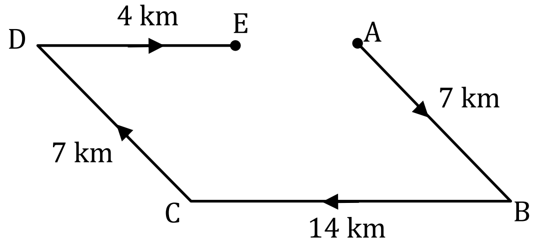
General Aptitude:

1. **[Ans. A]**
Meaning: slow to move or act
Part of Speech: Adjective

2. **[Ans. *] Range: 9 to 9**
Clearly $5 \times 2 = 10, 10 \times 2 = 20, 20 \times 2 = 40, \ldots$
So, the series is a G.P. in which $a_1 = 5$ and $r = 2$
To find the n^{th} term of a Geometric progression, the formula is $a_n = a_1 r^{n-1}$
Let 1280 be the n^{th} term of the series
Then, $5 \times 2^{n-1} = 1280 \Leftrightarrow 2^{n-1} = 256 = 2^8 \Leftrightarrow n - 1 = 8 \Leftrightarrow n = 9$

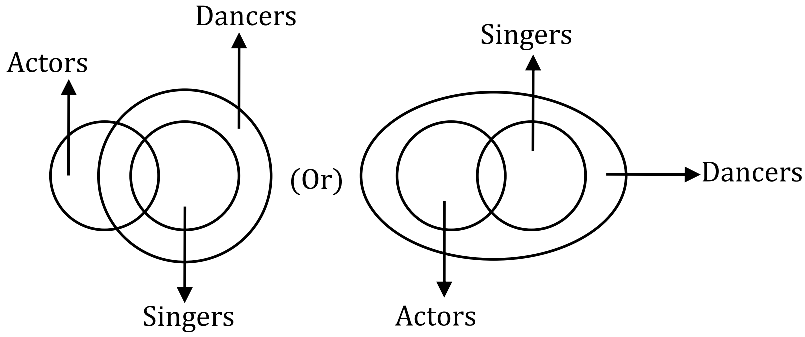
3. **[Ans. A]**
For this type of question take the LCM of speeds and assume the LCM as the distance
Then the time taken at speed of 60 km/hr $= \frac{300}{60} = 5$ hrs
Again the time taken at speed of 50 km/hr $= \frac{300}{50} = 6$ hrs
Thus we see that in place of 5 hrs trains take 6 hrs. Its means train takes 1 hr extra and this one hour is stopping period in the total time of 6 hrs. Thus in 6 hrs train halts for 1 hr. so in 1 hr train will stop for $1/6$ hours or 10 minutes.

4. **[Ans. *] Range: 10 to 10**
Let assume, Radha is at Point 'A'



Required distance $=$ AE $=$ AD $-$ DE
Since ABCD is a parallelogram
AD= BC
$\therefore$ AE $=$ BC $-$ DE
$= 14 - 4 = 10$

5. [Ans. A]



Only (1) Follows

6. [Ans. *] Range: 6 to 6

Given:

$R \rightarrow x + 10$ | x | | x + 5 | (5)$^+$
$L \rightarrow x + 6$ | x | | x + 5 | (1)$^+$
$B \rightarrow x + 5$ | x + | 25 | x + 5 |
$H \rightarrow x + 4$ | x | | x + 5 | (1)$^-$
$A \rightarrow x$ | x | | x + 5 | (5)$^-$

Thus total 6 coins have to be transferred.

7. [Ans. B]

The numbers are given in pair of 4 and 9.

The unit digit of each pair is 4, and there are 50 such pairs which are mutually multiplied together.

Unit digit $\underbrace{4 \times 9^2}_{4} \times \underbrace{4^3 \times 9^4}_{4} \times \underbrace{4^5 \times 9^6}_{4} \times \ldots . \underbrace{4^{99} \times 9^{100}}_{4}$

Again $4 \times 4 \times 4 \times 4 \ldots 4$(upto 50 times)

i.e., the unit digit of 4^{50}, which is 6

[Since unit digit of 4^{2n} is 6 for $n = 1, 2, 3, \ldots$etc]

8. [Ans. B]

16.66 18.75

17.5

(Boys) (Girls)

$\frac{50}{3}\times\frac{4}{4}$ $\frac{75}{4}\times\frac{3}{3}$ ... ... (Making Denominator equal)

$\Rightarrow$ $\frac{35}{2}\times\frac{6}{6}$

B G

200/12 225/12

$\Rightarrow$ 210/12

15/12 10/12

$\Rightarrow$ 3 : 2

$\therefore$ Boys $= 3x$; Girls $= 2x$

Given $3x - 2x = 8$

$\therefore x = 8$

Thus the number of Girls = 16 and number of Boys = 24

9. [Ans. D]

Let there be x voters and k votes goes to loser then

$0.8x - 120 = k + (k + 200)$ ... . ①

Also, $k + 200 = 0.41x$ ... . ②

From equation ① and ②

$0.8x - 120 = 0.41x - 200 + 0.41x$

$0.02x = 80$

$x = 4000$

$\therefore k = 0.41 \times 4000 - 200$

$\Rightarrow k = 1440$

And $(k + 200) = 1640$

Number of voters voted $= x - 0.2x$

$0.8x = 0.8 \times 4000 = 3200$

Therefore, percentage of votes for defeated candidates $= \frac{1440}{3200} \times 100 = 45\%$

10. [Ans. *] Range: 40 to 40

Given

$W_2 = 1.5\ W_1$ ... . (50% Increase in walk)

$D_1 = D_2$

$\because \dfrac{M_1 \times D_1}{W_1} = \dfrac{M_2 \times D_2}{W_2}$

$\therefore M_2 = 1.5\ M_1$

$\therefore$ If the efficiency of M_1 and M_2 is same, then 50% more work force is required.

But it is given the productivity of new labour is 25% more (i.e., 5/4 times efficient)

$\therefore$ Actual % increase in work force required $= \dfrac{50\%}{5/4} = 40\%$

Technical:

1. **[Ans. *] Range: 9 to 9**

The curve intersects the x-axis at $x = 1$

$\left((x-1)^{1/3} = 0 \Rightarrow x = 1\right)$

Given

$$\int_1^k (x-1)^{1/3}\,dx = 12$$

$$\left.\frac{(x-1)^{\frac{4}{3}}}{\frac{4}{3}}\right|_1^k = 12$$

$$\frac{(k-1)^{\frac{4}{3}}}{\frac{4}{3}} - 0 = 12$$

$\Rightarrow k = 9$

2. **[Ans. *] Range: 0.024 to 0.032**

Let H = Husband selection; W = Wife selection

Given $P(H) = \frac{1}{7} \Rightarrow P(H^C) = 1 - \frac{1}{7} = \frac{6}{7}$

$P(W) = \frac{1}{5} \Rightarrow P(W^C) = \frac{4}{5}$

Where H^C = Husband not selected

W^C = Wife not selected

Here, Husband selection and wife selection is independent events

P (Both of them selected) $= P(H \cap W)$

$$= P(H) \times P(W)$$

$$= \frac{1}{7} \times \frac{1}{5}$$

$$= \frac{1}{35} = 0.02857$$

3. **[Ans. C]**

$(4x^2D^2 - 24xD + 49)y = 0$

Given Differential Equation is a Cauchy-Euler Differential Equation convert the given Differential Equation into constant coefficient Differential Equation by using $x = e^z$

$D = \frac{d}{dx}; \theta = \frac{d}{dz}; x = e^z$

$x^2D^2 = \theta(\theta - 1)$, $xD = \theta$

$(4\theta(\theta - 1) - 24\theta + 49)y = 0$

$\Rightarrow 4\theta^2 - 4\theta - 24\theta + 49 = 0$

$\theta^2 - 7\theta + \frac{49}{4} = 0$

$\theta^2 - 2(3.5)\theta + (3.5)^2 = 0$

$\Rightarrow (\theta - 3.5)^2 = 0$

3.5 is a double root

$y_c = e^{3.5z}(C_1 + C_2z)$

$= x^{3.5}(C_1 + C_2 \ln(x))$

4. **[Ans. D]**

Two dimensional Laplace equation is given by

$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$

All the options (a, b, c) satisfy the Laplace equation.

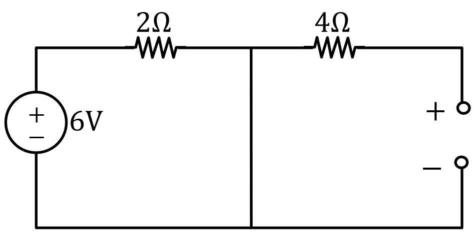
5. **[Ans. *] Range: 0.5 to 0.5**

$p\left(\frac{1}{2} < x < \frac{3}{2}\right) = F\left(\frac{3}{2}\right) - F\left(\frac{1}{2}\right)$

$= \left(\frac{1}{2} + \frac{{}^3/_2 - 1}{4}\right) - \frac{\frac{1}{2}}{4} = 0.5$

6. **[Ans. *]Range: 0 to 0**

At steady state, $t \to \infty$

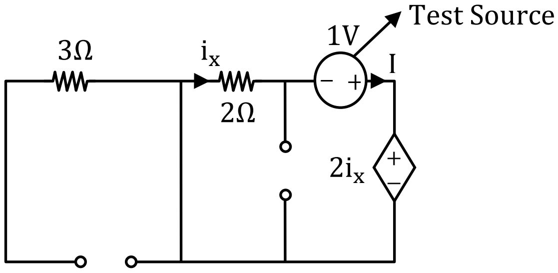


$V_c(\infty) = 0V$

7. **[Ans. *]Range: 3.9 to 4.1**

Dependent source is present so test source method will be applicable.

(i) Remove all the independent sources by their internal impedance.



$i_x = I$

$-1 + 2I + 2I = 0$

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

$R_{th} = \frac{1}{I} = 4\Omega$

For maximum power $R_L = R_{th} = 4\Omega$

8. **[Ans. C]**

⇒ Slope is not same in 1^{st} and 3^{rd} quadrants, so this is non-linear component.

⇒ This graph is not symmetric neither in 1^{st} and 3^{rd} quadrant or 2^{nd} and 4^{th} quadrant, so it is unilateral.

⇒ Slope is negative (offered resistance in 2^{nd} quadrant) so active component.

9. **[Ans. B]**

Change in resistance @ 25°C,

$\Delta R = 1040 - 1000 = 40\Omega$

Now gage factor is defined as:

$$\lambda = \frac{\text{fractional change in resistance}}{\text{fractional change in length}}$$

Or

$$\lambda = \frac{\Delta R/R}{\Delta L/L}$$

$$\therefore \frac{\Delta L}{L} = \frac{\Delta R/R}{\lambda}$$

$$= \frac{40}{1000 \times 2.5}$$

$$= 0.016 \text{ m/m}$$

$$\frac{\Delta L}{L} = 16 \text{ mm/m}$$

10. **[Ans. *]Range: 100 to 100**

LVDT is used for dynamic displacement measurement. The maximum measurable frequency of dynamic input can be $\frac{1}{10}$th of the supply frequency

i. e., $f_s \geq 10\, f_m$

where f_c = supply frequency

f_m = measuring input frequency

$\therefore f_m \leq \frac{1}{10} f_s$

$\therefore$ In the given problem

$$f_m = \frac{1000}{10} = 100 \text{ Hz}$$

11. **[Ans. *]Range: 250 to 250**

Resistance of the gauge in Bridgeman gauge is given by

$R = R_o(1 + b\,\Delta P)$

R_o = Resistance @ ambient pressure

b = Pressure coefficient of resistance

ΔP = Pressure

As per given data:

$R = 1k[1 + 25 \times 10^{-12} \times 10^{10}]$

$R = 1250\Omega$

Change in resistance $\Delta R = 1250 - 1000$

$= 250\Omega$

$\Delta R = 250\Omega$

12. **[Ans. C]**

flow rate $Q\ \alpha \sqrt{\Delta P}$

ΔP = diffrential pressure

$$\frac{Q_1}{Q_2} = \sqrt{\frac{\Delta P_1}{\Delta P_2}}$$

Given $Q_1 = 1\text{ m}^3/\text{s}$, $Q_2 = \frac{1}{2} Q_1 = 0.5\text{m}^3/\text{s}$

$\Delta P_1 = 40$ kPa

$$\frac{1}{0.5} = \sqrt{\frac{40}{\Delta P_2}}$$

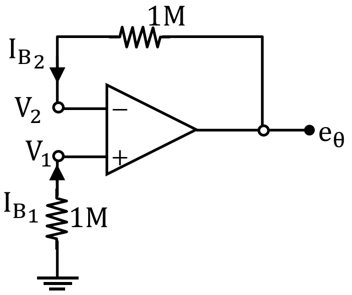
$$2 = \sqrt{\frac{40}{\Delta P_2}}$$

$\Rightarrow \Delta P_2 = 10$ kPa

Change in pressure = 40 kPa − 10 kPa

= 30 kPa

13. **[Ans. C]**



$V_1 = -I_{B_1} \times 1M, V_2 = V_1 = -I_{B_1} \times 1M$ (due to virtual ground)

Drop in feedback resistor $1M = I_{B_2} \times 1M$

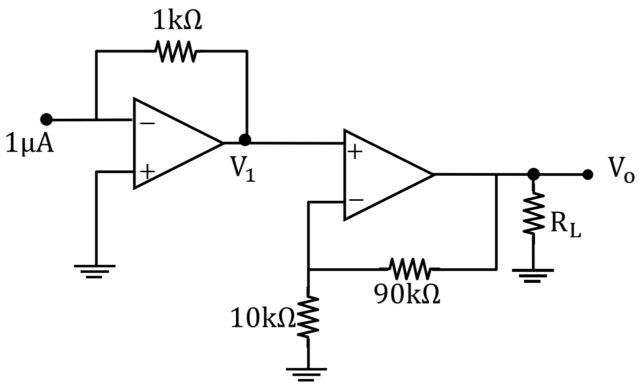
$e_\theta = V_2 + I_{B_2} \times 1M$

$e_\theta = -I_{B_1} \times 1M + I_{B_2} \times 1M$

$e_\theta = (I_{B_2} - I_{B_1}) \times 1M$

Where $(I_{B_2} - I_{B_1})$ is offset current

14. **[Ans. *]Range: -10 to -10**

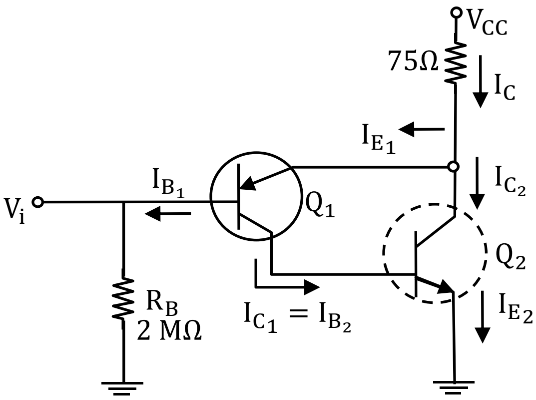


$V_1 = \frac{10}{10+90} V_o = \frac{V_o}{10}$

$V_1 = -1 \times 10^3 \times 1 \times 10^{-6} = -10^{-3}$

$\therefore V_o = -10\ mV$

15. **[Ans. A]**



$I_{E_1} + I_{C_2} = I_C$

$\approx I_{C_1} + I_{C_2}$

$= I_{B_2} + I_{C_2}$

$\approx I_{C_2}$

$\therefore V_{CC} - I_C R_C - V_{EB_1} - I_{B_1} R_B = 0$

$\Rightarrow V_{CC} - I_{C_2} R_C - V_{EB_1} - I_{B_1} R_B = 0$

$\Rightarrow V_{CC} - \beta_2 I_{B_2} R_C - V_{EB_1} - I_{B_1} R_B = 0$

$\Rightarrow V_{CC} - \beta_2 I_{C_1} R_C - V_{EB_1} - I_{B_1} R_B = 0$

$\Rightarrow V_{CC} - \beta_1 \beta_2 I_{B_1} R_C - V_{EB_1} - I_{B_1} R_B = 0$

$$\Rightarrow I_{B_1} = \frac{V_{CC} - V_{EB_1}}{R_B + \beta_1 \beta_2 R_C}$$

$$= \frac{18 - 0.7}{2\text{M}\Omega + (140)(180)(75)}$$

$$= \frac{17.3}{3.89 \times 10^6} = 4.45\ \mu\text{A}$$

16. **[Ans. C]**

From diagram,

$$\frac{y(s)}{x(s)} = \frac{\frac{1}{s} + \frac{1}{s^2}}{1 + \frac{5}{s} + \frac{6}{s^2}}$$

$$\frac{y(s)}{x(s)} = \frac{\frac{s+1}{s^2}}{\frac{s^2+5s+6}{s^2}}$$

$$\frac{y(s)}{x(s)} = \frac{s+1}{s^2 + 5s + 6}$$

$$\frac{y(s)}{x(s)} = \frac{(s+1)}{(s+2)(s+3)} \qquad x(s) = \frac{1}{s} \rightarrow \text{Unit step}$$

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

$$y(s) = \frac{1/6}{s} + \frac{1/2}{s+2} - \frac{2/3}{s+3}$$

$y(t) = \left(\frac{1}{6} + \frac{1}{2}e^{-2t} - \frac{2}{3}e^{-3t}\right) u(t)$

17. **[Ans. B]**

M_1, M_2 are NMOS

M_3, M_4 are PMOS

V_1	V_2	M_1 (NMOS)	M_2 (NMOS)	M_3 (PMOS)	M_4 (PMOS)	V_0
0	0	OFF	OFF	ON	ON	0
0	1	OFF	ON	ON	OFF	1
1	0	ON	OFF	OFF	ON	1
1	1	ON	ON	OFF	OFF	1

∴ Positive OR

(or) Negative AND

18. **[Ans. *]Range: 1 to 1**

$$y(n) - \frac{1}{4}y(n-1) - \frac{1}{8}y(n-2) = x(n) + 3x(n-1) + 2x(n-2)$$

Total Z transforms on both side

$$y(z) - \frac{1}{4}z^{-1}y(z) - \frac{1}{8}z^{-2}y(z) = x(z) + 3z^{-1}x(z) + 2z^{-2}x(z)$$

$$\frac{y(z)}{x(z)} = \frac{1 + 3z^{-1} + 2z^{-2}}{1 - \frac{1}{4}z^{-1} - \frac{1}{8}z^{-2}}$$

$$-\frac{1}{8}z^{-2} - \frac{1}{4}z^{-1} + 1 \,\overline{\big)\, 2z^{-2} + 3z^{-1} + 1}\; (16)$$

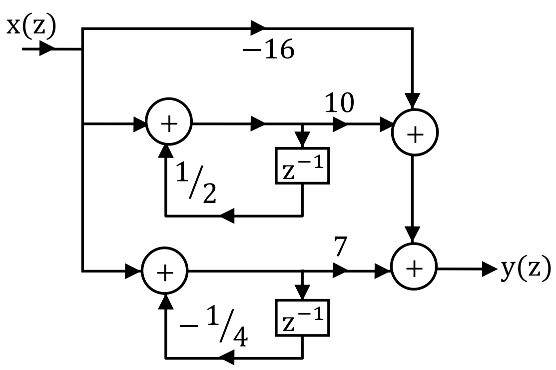
$$\frac{2z^{-2} + 3z^{-1} + 1}{\underline{2z^{-1} - 4z^{-1} + 16}}$$

$$7z^{-1} - 15$$

$$H(z) = -16 + \frac{17 - z^{-1}}{(1 - {}^{1}/_{2}\,z^{-1})(1 + {}^{1}/_{4}\,z^{-1})}$$

$$= -16 + \frac{10}{1 - {}^{1}/_{2}\,z^{-1}} + \frac{7}{1 + {}^{1}/_{4}\,z^{-1}}$$

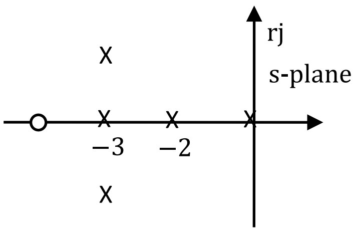
$a + b + c = -16 + 10 + 7 = 1$



19. **[Ans. B]**
From Diagram,
$h(n) = 8\,\delta(n) - 4\,\delta(n-1) + 0 + 4\,\delta(n-3) - 8\,\delta(n-4)$
$H(z) = 8 - 4z^{-1} + 4z^{-3} - 8z^{-4}$
To check filter $\left(z = e^{j\omega}\right)$
$H\left(e^{j\omega}\right) = 8 - 4\,e^{-j\omega} + 4\,e^{-3j\omega} - 8\,e^{-4j\omega}$
$\begin{bmatrix} \omega = 0(\text{Low frequency}) \Rightarrow 8 - 4 + 4 - 8 = 0 \\ \omega = \pi(\text{High frequency}) \Rightarrow 8 + 4 - 4 - 8 = 0 \end{bmatrix}$
So, it is a band pass filter.

20. **[Ans. A]**
The best possible frequencies will be the one for which transmitted symbols are orthogonal and phase continuity is maintained as well. Let the two frequencies be f_{c_1} and f_{c_2} for orthogonality
$f_{c_2} - f_{c_1} = n\frac{R_b}{2}$ where n is integer
And for phase continuity f_{c_1} and f_{c_2} should be integer times R_b

21. **[Ans. B]**



$N = P - Z$
$N = 4 - 1$
$N = 3$
$\phi = \frac{(2g+1)180}{P-2}$
$g = 0, 1, 2$
$\phi \Rightarrow 60°, 180°, 300°$
$\phi = 60°, 180°, -60°$
Centroid $C = \frac{\varepsilon_P - \varepsilon_Z}{P - Z}$
$= \frac{-3 + 5j - 3 - 5j - 2 - 0 - (-4)}{4 - 1}$
$\Rightarrow\ -\frac{4}{3}$
$\Rightarrow\ -1.33$

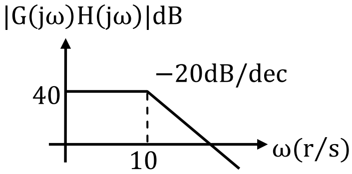
22. **[Ans. A]**

At balance condition

$$R_x = \frac{R_2 R_3}{R_4} = \frac{1000 \times 1000}{1000} = 1000\Omega$$

$$L'_x = R_2\, R_3\, C_4 = 1000 \times 1000 \times 0.5\ \mu F$$
$$= 0.5\ H$$

23. **[Ans. C]**



$$G(s)H(s) \Rightarrow \frac{k}{\left(1 + \frac{s}{10}\right)}$$

$Y = mx + c$

$40 = 0 \times \log(10) + c$

$c = 40$

$c = 20\log k$

$40 = 20 \log k$

$\log k = 2$

$k = 100$

$$G(s)H(s) = \frac{1000}{(s + 10)}$$

24. **[Ans.] Range: 500 to 500**

$$\text{Number of modes} = \frac{\text{Bandwidth}}{\text{Frequency separation}} = \frac{\text{Bandwidth}}{\Delta\nu}$$

$$\therefore 5 = \frac{1500 \times 10^6}{\Delta\nu}$$

$\Rightarrow \Delta\nu = 300 \times 10^6$ Hz

Now frequency separation is also given by

$\Delta\nu = \frac{C}{2nL}$; Where C = Light velocity

L = Length of cavity

n = Refractive index = 1

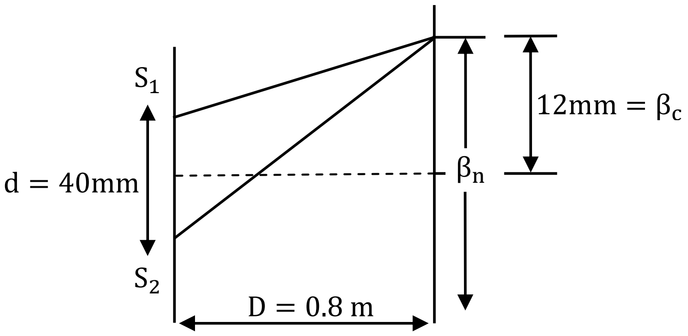
$$\Rightarrow L = \frac{C}{2\Delta\nu}$$

$$L = \frac{3 \times 10^8}{2 \times 3 \times 10^8} = 0.5\ m = 500\ mm$$

Cavity length = 500 mm

25. **[Ans. *]Range: 100 to 100**

Given,



Fringe width is given as,

$$\beta_n = \frac{n \cdot \lambda \cdot D}{d}$$

$$\Rightarrow \lambda = \frac{\beta_n \cdot d}{n \cdot D}$$

$$= \frac{12 \times 40 \times 10^{-6}}{6 \times 0.8}$$

$$= 100 \times 10^{-6}$$

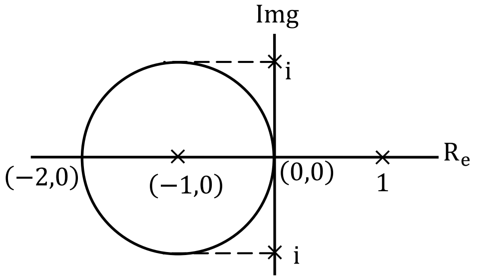
$$\lambda = 100 \mu m$$

Wavelength $= 100\ \mu m$

26. **[Ans. B]**

$$\oint \frac{z^2}{z^4 - 1}\, dz$$

$|z + 1| = 1 \rightarrow$ centre $(-1,0)$, radius $= 1$



$$\Rightarrow \oint \frac{z^2}{(z^2)^2 - 1^2}\, dz$$

$$\Rightarrow \oint \frac{z^2}{(z^2+1)(z^2-1)}$$

$$\Rightarrow \oint \frac{z^2}{(z^2-i^2)(z^2-1^2)}$$

$(\because i^2 = -1)$

$$\Rightarrow \oint \frac{z^2}{(z-i)(z+i)(z-1)(z+1)}$$

Poles $\Rightarrow z = -i, +i, -1, +1$

Only one pole $z = -1$ lies inside the curve so, by Cauchy's theorem

$$\Rightarrow \oint_c \frac{f(z)}{z-a} = 2\pi i\, f(a)$$

$$\oint \frac{z^2}{\frac{(z^2+1)(z-1)}{z+1}}\, dz = 2\pi i\, f(a)$$

Where $f(z) = \dfrac{z^2}{(z^2+1)(z-1)}$, $a = -1$

$$\Rightarrow 2\pi i\left(\frac{(-1)^2}{((-1)^2+1)(-1-1)}\right)$$

$$\Rightarrow 2\pi i\left(\frac{1}{(1+1)(-1-1)}\right) = \frac{2\pi i}{2\times(-2)} = -\frac{\pi i}{2}$$

27. **[Ans. D]**

Given $f(x) = x^3 + 2x - 7$ and $x_0 = 0$

$f'(x) = 3x^2 + 2$

Newton Raphson formula is

$$x_{(n+1)} = x_n - \frac{f(x_n)}{f'(x_3)}$$

Putting n =0

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)} = 1 - \frac{f(1)}{f'(1)}$$

$$= 1 - \frac{(-4)}{5}$$

$$= 1 + \frac{4}{5}$$

$x_1 = 1.8$

28. **[Ans. D]**

1. We know that a linear system of equation is consistent when rank (A/b) = Rank(A) option C is correct
2. [0 0 0 … 0|α]
   $\Rightarrow 0x_1 + 0x_2 + \ldots 0x_n = \alpha$
   There is no $(x_1, x_2, \ldots x_n)$ satisfying
   $0x_1 + 0x_2 + \ldots 0x_n = \alpha$
   Option A is correct
3. 'B' does not contain a pivot. Hence b is a non-basic column in [A/b]
   Hence Option D is correct

29. **[Ans. B]**

Inductor current is given by

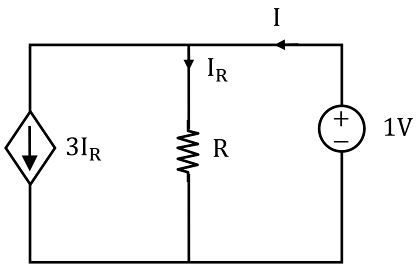
$i_L(t) = i_L(\infty) - [i_L(\infty) - i_L(0^+)]e^{-(R_{eq}\,t)/L}$

Any independent source is not present

So, $i(\infty) = 0$

$i_L(t) = i(0^+)\,e^{-(R_{eq}\,t)/L}$

R_{eq} calculation across 'L'



$I_R = \frac{1}{R}$

$I = I_R + 3I_R$

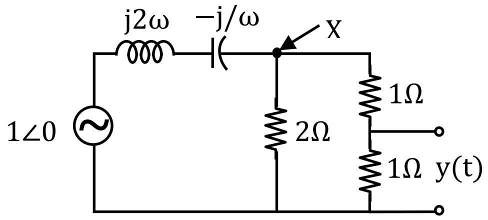
$I = 4I_R$

$R_{eq} = \frac{1}{I} = \frac{1}{4I_R} = \frac{R}{4}$

$R_{eq} = \frac{R}{4}$

$i_L(t) = 1e^{-Rt/4L}$

30. **[Ans. *]Range: 0.9 to 1.1**



$$y(t) = \frac{V_x}{2}$$

$$\frac{V_x - 1\angle 0}{j2\omega - \frac{j}{\omega}} + \frac{V_x}{2} + \frac{V_x}{2} = 0$$

$$V_x\left[\frac{\omega}{j2\omega^2 - j} + \frac{1}{2} + \frac{1}{2}\right] = \frac{\omega\, 1\angle 0}{j2\omega^2 - j}$$

$$V_x = \frac{\frac{1\angle 90}{(1-2\omega^2)}}{1 + \frac{j\omega}{1-2\omega^2}}$$

$$V_x = \frac{1\angle 90}{1 - 2\omega^2 + j\omega}$$

$$V_x = \frac{1}{\sqrt{(1-2\omega^2)^2 + \omega^2}}\angle 90 - \tan^{-1}\left(\frac{\omega}{1-2\omega^2}\right)$$

$$y(t) = \frac{V_x}{2} = \frac{1}{2\sqrt{(1-2\omega^2)^2 + \omega^2}}\angle 90 - \tan^{-1}\left(\frac{\omega^2}{1-2\omega^2}\right)$$

$$\phi = -45 = 90 - \tan^{-1}\left(\frac{\omega}{1-2\omega^2}\right)$$

$$\tan 135 = \frac{\omega^2}{1-2\omega^2}$$

$$\Rightarrow 1 - 2\omega^2 - \omega = 0$$

ω =1 rad/sec

31. **[Ans.*]Range: 3 to 3**

At balance $Z_1 = \frac{Z_2 . Z_3}{Z_4}$

The total uncertainty or standard deviation in

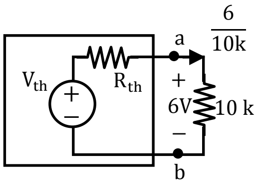
$$\sigma_{Z_1} = \sqrt{\left(\frac{\partial Z_1}{\partial Z_2}\right)^2 \sigma_{Z_2}^2 + \left(\frac{\partial Z_1}{\partial Z_3}\right)^2 \sigma_{Z_3}^2 + \left(\frac{\partial Z_1}{\partial Z_4}\right)^2 \sigma_{Z_4}^2}$$

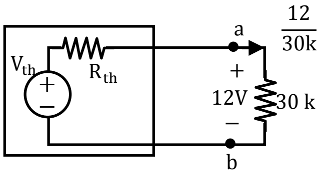
$$\sigma_{Z_1} = \sqrt{\left(\frac{Z_3}{Z_2}\right)^2 * (0.01Z_2)^2 + \left(\frac{Z_2}{Z_4}\right)^4 * (0.02Z_3)^2 + \left(\frac{-Z_2Z_3}{Z_4^2}\right)^2 (0.02)}$$

$$\sigma_{Z_1} = \sqrt{\left(\frac{Z_1}{Z_2}\right)^2 * (0.01Z_2)^2 + \left(\frac{Z_1}{Z_3}\right)^2 * (0.02Z_3)^2 * \left(\frac{-Z_1}{Z_4}\right)^2 * (0.02)}$$

$$\therefore \frac{\sigma_{Z_1}}{Z_1} \times 100 = \sqrt{1^2 + 2^2 + 2^2} = \sqrt{9}\,\% = 3\,\%$$

32. **[Ans. *] Range: 9.5 to 9.7**





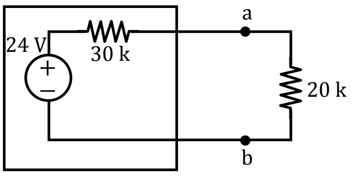
$$V_{th} = R_{th}\frac{6}{10k} + 6V \ldots\ldots\ldots.(1)$$

$$V_{th} = R_{th}\frac{12}{30k} + 12\ V \ldots\ldots\ldots.(2)$$

By solving (1) and (2)

$V_{th} = 24\ V$

$R_{th} = 30k\Omega$



$$V_{ab} = \frac{20k \times 24}{50\ k}$$

$V_{ab} = 9.6\ V$

33. **[Ans. *]Range: 1.45 to 1.50**

for $x = 50, R_T = R\exp(-b/x)$

$$\therefore R_T = 100\text{k}\ \exp\left(-\frac{100}{50}\right)$$

$R_T = 13.53\ \text{k}\Omega$

$$V_o = -\left(\frac{R_T}{R_1}\right) \times V_{in}$$

$$= -\left(\frac{13.53}{1}\right) \times 1$$

$= -13.53$ Volts

$$\text{For } x = 60, R_T = 100\text{k}\exp\left(-\frac{100}{60}\right)$$

$= 18.887\text{k}\Omega$

$$V_o = -\left(\frac{R_T}{R_1}\right) \times V_{in}$$

$= -18.88$ volts, but opamp will be saturated to -15V hence $V_o = -15$V

Change $= 1500 - 13.53$

$= 1.47$ Volts

34. **[Ans. C]**

Change in thickness= $\Delta t = 1 - 0.75 = 0.25$cm

$$\therefore \text{Strain developed} = \frac{\Delta t}{t} = \frac{0.25}{1\text{cm}} = 0.25[\text{Strain is dimensional}]$$

Then the applied stress;

Stress = Strain × Young's Modulus

$= 0.25 \times 200 \times 10^6 = 50\ \text{MN/m}^2$

∴ The voltage sensitivity constant is given by

$$g = \frac{\text{Electric field generated}}{\text{stress applied}} = \frac{10 \times 100}{50 \times 10^6} = \frac{20}{10^6}\ \text{V-m/N}$$

$g = 0.00002$ V-m/N

35. **[Ans. *] Range: 2 to 2**

The intensity of the gamma rays detected is given by:

$I = I_o e^{-\mu h}$__________ (i)

Where μ= absorption coefficient

ρ = liquid density

H=height (level)

I= Intensity after height h

$I_o =$ Intensity before liquid

In the problem statement the product μρ is given by default. Hence,

$I_A = I_o e^{-\mu_1 h_1} = I_o e^{-7.7h_1}$

and

$I_B = I_o e^{-\mu_2 h_2} = I_o e^{-15.4h_2}$

$\therefore \frac{I_A}{I_B} = \frac{I_o e^{-7.7h_1}}{I_o e^{-15.4h_2}}$

Now given $I_A = I_B$

$\therefore 1 = e^{-7.7h_1 + 15.4h_2}$

$\Rightarrow 7.7h_1 = 15.4h_2$

$\Rightarrow \frac{h_1}{h_2} = \frac{15.4}{7.7} = 2 \rightarrow$ [ans]

Alternatively:

From equation (i) it is clear that

$\mu \propto \frac{1}{h} \therefore \frac{\mu_1}{\mu_2} = \frac{h_2}{h_1}$

or, $\frac{h_1}{h_2} = \frac{\mu_2}{\mu_1}$

hence, $\frac{h_1}{h_2} = 2$

36. **[Ans. *] Range: 1042 to 1044**

In the viscosity measurement the flow rate is approximated as;

$$Q = \frac{\pi R^4 (P_1 - P_2)}{8\mu L}$$

R=radius of pipe, $(P_1 - P_2) = \text{Differential Pressure}$

$L = \text{Length of pipe}, \mu = \text{viscosity}$

Hence as per given data:

$$\mu = \frac{\pi R^4 (P_1 - P_2)}{8 \times Q \times L} = \frac{\pi \times (5 \times 10^{-2})^4 \times 50 \times 10^3}{8 \times 1 \times 1}$$

$\mu = 0.122 \text{ Pa} - \text{sec}$

Now flow velocity; $v = \frac{Q}{A} = \frac{Q}{\frac{\pi}{4}D^2}$

$$= \frac{1}{\frac{\pi}{4} \times (10 \times 10^{-2})^2} = \frac{400}{r}$$

$= 127.32 \text{ m/sec}$

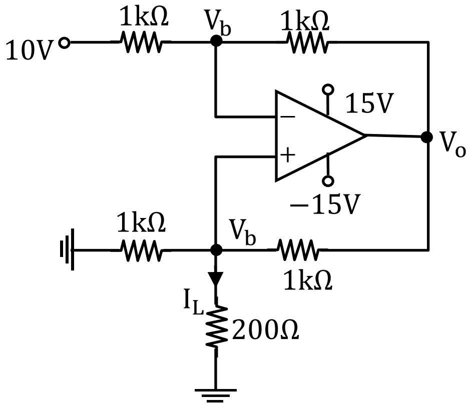
Hence finally Reynold's Number:

$$R_e = \frac{\rho \cdot D \cdot v}{\mu}, \rho = \text{density}$$

$$= \frac{10 \times 10 \times 10^{-2} \times 127.32}{0.122}$$

$R_e = 1043.63$

37. **[Ans. B]**



$$\frac{10 - V_b}{1} = \frac{V_b - V_o}{1} \Rightarrow 2V_b = V_o + 10 \cdots\cdots (1)$$

KCL

$$\frac{V_b}{2} + \frac{V_b}{1} + \frac{V_b - V_o}{1} = 0$$

$\Rightarrow 5V_b + V_b + V_b - V_o = 0 \Rightarrow 7V_b - V_o \cdots\cdots (2)$

Solve (1)and(2)

$V_b = -2V$

$$I_L = \frac{V_b}{200} = -10 \text{ mA}$$

38. **[Ans. B]**

$$V_{i_{min}} = \frac{(R_L + R)V_z}{R_L} = \frac{(1200 + 320)20}{1200} = 25.33V$$

$$I_L = \frac{V_L}{R_L} = \frac{V_z}{R_L} = \frac{20V}{1.2k} = 16.67\text{ mA}$$

$$I_{R_{max}} = I_{z_m} + I_L = 60 + 16.67 = 76.67\text{ mA}$$

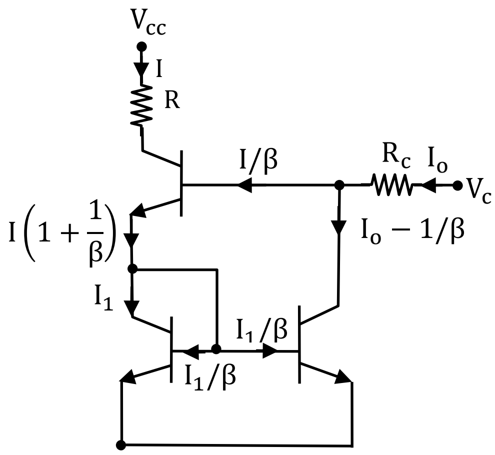
$$V_{i_{max}} = I_{R_{max}} R + V_z$$

$$= 76.67 \times 320 + 20$$

$$= 24.53 + 20$$

$$= 44.53V$$

39. **[Ans. *]Range: 1.78 to 1.80**



$$I\left(1 + \frac{1}{\beta}\right) = I_1 + \frac{2I_1}{\beta} = I_1\left(1 + \frac{2}{\beta}\right)$$

$$I_1 = \frac{(\beta + 1)/\beta}{(\beta + 2)/\beta} I \Rightarrow I_1 = \frac{\beta + 1}{\beta + 2} I$$

$$I_o - \frac{I}{\beta} = \beta \frac{I_1}{\beta} = I_1$$

$$\Rightarrow I_o - \frac{I}{\beta} = \frac{\beta + 1}{\beta + 2} I$$

$$\Rightarrow I = I_o\left[\frac{\beta(\beta + 2)}{\beta^2 + 2\beta + 2}\right]$$

$$V_c = R_c I_o + V_{BE} + V_{BE} \Rightarrow 5 = 2 \times 10^3 I_o + 2 \times 0.7$$

$$\Rightarrow I_o = 1.8\text{ mA}$$

$$I = 1.8\left[\frac{100(100 + 2)}{100^2 + 2 \times 100 + 2}\right]$$

$$\Rightarrow I = \frac{1.8 \times 100 \times 102}{10202}$$

$$= 1.79965\text{ mA}$$

40. **[Ans. A]**

$$V_{UT} = -(-V_{sat})\frac{R}{dR} = -(-5)\frac{1}{10} = 0.5V$$

$$V_{LT} = -V_{sat}\frac{R}{dR} = -10\frac{1}{10} = -1V$$

41. **[Ans. *] Range: 9 to 9**

Given minimum analog input (to be converted accurately)

=10mV

Maximum step size ≅ 10 mV

Maximum voltage ≃(step size) (number of steps)

$5 = 10 \times 10^{-3} \times (2^n - 1)$

$\Rightarrow n = 9.$

42. **[Ans. C]**

O/P NAND gate is 0 if $A_7$to A_3 and $I_0/\overline{M} = 1$

A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0	
1	1	1	1	1	0	0	0	-Starting address
1	1	1	1	1	1	1	1	-Final address

43. **[Ans. A]**

(Digital value) ×resolution $> V_A + V_T$

(Digital value)× 40mV > 6.001V=6001mV

Digital value > 150.025

$151_{10} = 10010111_2$

44. **[Ans. *]Range: 15 to 17**

Time taken for '1' complex multiplication 'T' = 1 μsec

For DFT given $N = 4096 = 2^{12}$

Total complex multiplication: $N^2 = 2^{24}$

Total time in T_1 DFT $= N^2 \times T$

$= 2^{24} \times 10^{-6}$

$(2^4)1 \approx 16$ sec

Total complex multiplication $= \frac{N}{2}\log_2 N$

$= \frac{2^{12}}{2}\log_2 2^{12}$

$= (2^{12}) \times 6(1)$

Total time in FFT $T_2 = \left(\frac{N}{2}\log_2 N\right) \times T$

$= 2^{12} \times 6 \times 10^{-6}$

$= (24)$m sec

$T_1 - T_2 = 16 - 0.024 \approx 16$ sec

45. **[Ans. *]Range: 0.14 to 0.17**

$$4\frac{d^2y(t)}{dt^2}+6\frac{dy(t)}{dt}-4y(t)=\delta(t)$$

Take Laplace transform both side

$$4s^2y(s)+6sy(s)-4y(s)=1$$

$$y(s)[4s^2+6s-4]=1$$

$$y(s)=\frac{1}{4s^2+6s+4}$$

$$=\frac{1}{4s^2+8s-2s-4}$$

$$=\frac{1}{4s(s+2)-2(s+2)}$$

$$=\frac{1}{(s+2)(4s-2)}$$

$$=\frac{1/4}{(s+2)\left(s-\frac{1}{2}\right)}$$

$$y(t)=\frac{-1/10}{(s+2)}+\frac{1/10}{\left(s-{}^{1}/_{2}\right)}$$

$$y(t)=\left(-\frac{1}{10}e^{-2t}+\frac{1}{10}e^{+{}^{1}/_{2}t}\right)u(t)$$

$$y(t)|_{t=1}=-\frac{(0.1353)}{10}+\frac{1.648}{10}$$

$$=0.1513$$

46. **[Ans. B]**

From Diagram

$h(n) = [h_1(n) + h_2(n)] * h_3(n)$

$$[h_1(n) + h_2(n)] = \{\underset{\uparrow}{1}, 2, 3\} + \{0, \underset{\uparrow}{-2}, 1\}$$

$[h_1(n) + h_2(n)] = \{1, 0, 4\}$

$$[h_1(n) + h_2(n)] * h_3(n) = \{\underset{\uparrow}{1}, 0, 4\} * \{\underset{\uparrow}{1}, 1, -2\}$$

$$\begin{array}{cc|ccc} & & \downarrow & & \\ & & 1 & 1 & -2 \\ \hline \rightarrow & 1 & 1 & 1 & -2 \\ & 0 & 0 & 0 & 0 \\ & 4 & 4 & 4 & -8 \end{array}$$

$$h(n) = \{\underset{\uparrow}{1}, 1, 2, 4, -8\}$$

$$x(n) = \{\underset{\uparrow}{1}, 2\}$$

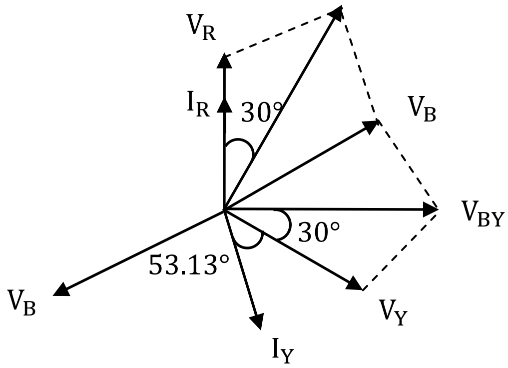
$y(n) = x(n) * h(n)$

$$y(n) = \begin{array}{cc|ccccc} & & & \downarrow & & & \\ & & & 1 & 2 & 4 & -8 \\ \hline \rightarrow & 1 & 1 & 1 & 2 & 4 & -8 \\ & 2 & 2 & 2 & 4 & 8 & -16 \end{array}$$

$$y(n) = \{\underset{\uparrow}{1}, 3, 4, 8, 0, -16\}$$

$y(z) = 1 + 3z^{-1} + 4z^{-2} + 8z^{-3} - 16z^{-5}$

47. **[Ans. B]**



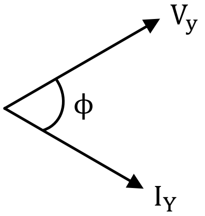
$$I_{ph} = \frac{V_{ph}}{Z} = \frac{V_L}{\sqrt{3}.Z}$$

The reading of wattmeter -1 is

$$P_1 = V_{pc}.I_{cc}\cos\ (V_{pc}, I_{cc})$$
$$= V_{RB}.I_R\cos(V_{RB}, I_R)$$
$$= V_L.I_L\cos 30°$$
$$= \left(\sqrt{3}\ .V_{ph}I_{ph}\cos 30°\right)$$
$$= \left(\sqrt{3}\ V_{ph}\right)\left(\frac{V_L}{\sqrt{3}.Z}\right)\cos 30°$$
$$= 110 \times \frac{110}{\sqrt{3}\times 5} \times \cos\ 30° = 1210\text{ W}$$

$P_1 = 1210$ W

The reading of wattmeter -2 is



$Z_3 = 3 + j4$

$$\phi = \tan^{-1}\left(\frac{4}{3}\right) \Rightarrow 53.13°$$

$$P_2 = V_{pc}I_{cc}\cos\ (V_{pc}, I_{cc})$$
$$= V_{YB}.I_Y\cos\ (V_{YB}, I_Y)$$
$$= V_L.I_L\cos(53.13° + 30°)$$
$$= \left(\sqrt{3}\ .V_{ph}\right)\left(I_{ph}\right)\cos\ (83.13°)$$
$$= 110 * \frac{110}{\sqrt{3}\times 5} \times \cos 83.13° = 167.12\text{ W}$$

$P_2 = 167.12$ W

48. **[Ans. *]Range: 1.25 to 1.25**

The natural frequency of oscillations is given by:

$$w_n = \sqrt{\frac{k}{M}}, \qquad [k = \text{stiffness N/m}, M = \text{kg(mass)}]$$

$$\therefore w_n = \sqrt{\frac{1000}{10}} = \sqrt{100} = 10 \text{ rad/sec}$$

Now damped frequency of oscillations is given by:

$$w_d = w_n\sqrt{1-\xi^2}, \qquad \xi = \text{damping ratio}$$

$$\therefore w_d = 10\sqrt{1-0.62} = 8 \text{ rad/sec}$$

$$\therefore \text{The required ratio} = \frac{w_n}{w_d}$$

$$= \frac{10}{8} = 1.25$$

49. **[Ans. B]**

$$G(s) = \frac{16}{(S+1)^6}$$

$$G(j\omega) = \frac{16}{(j\omega+1)^6} \cdots\cdots (i)$$

$$|G(j\omega)| = \frac{16}{\left(\sqrt{1+\omega^2}\right)^6} \cdots\cdots (ii)$$

$$\angle G(j\omega) = -6\tan^{-1}[\omega] \cdots\cdots (iii)$$

$$\text{at } \omega_{PC} :\rightarrow \angle G(j\omega) = -6\tan^{-1}[\omega] = -180$$

$$\tan^{-1}[\omega] = 30$$

$$\omega = \frac{1}{\sqrt{3}} \quad \text{rad/s}$$

$$|G(j\omega)|_{\omega=\omega_{PC}} = X$$

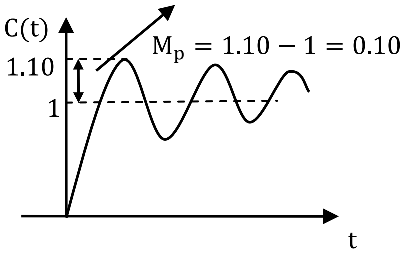
$$|G(j\omega)| = \frac{16}{\left[\sqrt{1+\left(\frac{1}{\sqrt{3}}\right)^2}\right]^6}$$

$$|G(j\omega)| = \frac{16}{\left(\frac{2}{\sqrt{3}}\right)^6} = \frac{16\times 27}{64}$$

$$X \Rightarrow 6.75$$

$$G.m = \frac{1}{X} = 0.148$$

50. **[Ans. *]Range: 1.67 to 1.71**



$M_P = e^{-\xi\pi/\sqrt{1-\xi^2}} = 0.10$

$\xi = 0.59$

$\omega_d = 3.23\,\text{rad/s}$

$\omega_d = \omega_n\sqrt{1-\xi^2}$

$3.23 = \omega_n\sqrt{1-(0.59)^2}$

$\omega_n = 4\,\text{rad/s}$

settling time $t_s = \dfrac{4}{\xi\omega_n}$

$t_s = \dfrac{4}{0.59 \times 4}$

$t_s = 1.69$

51. **[Ans. A]**

From Diagram

Calculation of ω

$5.105\ \text{dB} - 0 = -20[\log(\omega) - \log(90)]$

$5.105 = -20\log(\omega) + 20\log 90$

$5.105 = -20\log(\omega) + 39.08$

$\omega \simeq 50\ \text{r/s}$

Calculation of k:

$y - 5.105 = -40[\log(20) - \log(50)]$

$y - 5.105 = -52.04 + 67.95$

$y = 21.02\ \text{dB}$

$y = mx + c$

$21.02 = -20\log(20) + c$

$21.02 = -26.02 + c$

$c = 47.021$

$c = 20\log k$

$47.04 = 20\log k$

$\Rightarrow k = 224.96$

52. **[Ans. A]**

Angular spread is given by,

$\Delta\theta = \frac{1.22\lambda}{D}$ where, λ = wavelength, D = aperture

$\therefore \Delta\theta = \frac{1.22 \times 720 \times 10^{-9}}{4 \times 10^{-3}} = 219.6 \times 10^{-6}$

Average spread $= A_r = \pi(r \cdot \Delta\theta)^2$

r = Focal length = 10 cm = 0.1 cm

$\therefore A_r = \pi(0.1 \times 219.6 \times 10^{-6})^2$

$= 1.514 \times 10^{-9} m^2$

Hence Intensity of image $= \frac{\text{Power}}{\text{Average Spread}}$

$= \frac{50mW}{1.514 \times 10^{-9}}$

$= \frac{50 \times 10^{-3}}{1.514 \times 10^{-9}}$

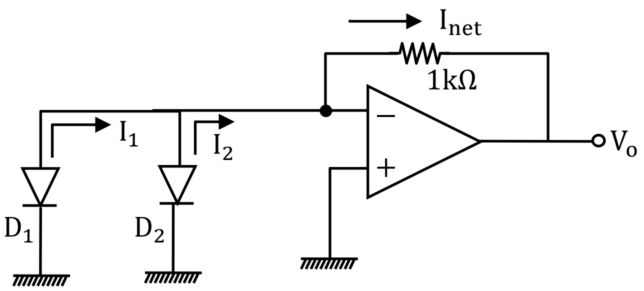
$= 33.0198 \times 10^6$

$\cong 33.02\ MW/m^2$

53. **[Ans. *]Range: 2 to 2**

The currents supplied by the diodes will be the reverse current. Now given output voltage is $V_o = 5V$ hence

$V_o = -I_{net} \times R \Rightarrow I_{net} = \frac{V_o}{R} = \frac{5}{1\ k\Omega} = 5mA$



Clearly applying KCL at inverting terminal,

$I_1 + I_2 = I_{net}$ {Since diodes are in parallel}

$I_2 = I_{net} - I_1 = 5\ mA - 3.9\ mA = 1.1\ mA$

Now given responsivity $R = 0.55\ A/w$

$\therefore$ Power incident on $D_2 = \frac{1.1\ mA}{0.55}$

Power on $D_2 = 2\ mW$

54. **[Ans. *]Range: 34 to 36**

The number of modes through graded index fiber is given as:

$$N = \frac{V^2}{4}, V = \frac{2\pi r}{\lambda}\sqrt{n_{1^2} - n_{2^2}}$$

So as per given data,

N=1170

$$N = \frac{V^2}{4}$$

$$\Rightarrow V^2 = 4 \times N = 4 \times 1170$$

$$\Rightarrow V = 2\sqrt{1170} \cong 68.410$$

$$\therefore V = \frac{2\pi r}{\lambda}\sqrt{n_{1^2} - n_{2^2}}$$

$$\text{Or, } V = \frac{2\pi r}{\lambda} n_1\sqrt{2\Delta}$$

Now, $n_1 = 1.48$, $r = ?$, $\lambda = 0.85\ \mu m$ and $\Delta = 1.6\% = 0.016$

$$\therefore 68.410 = \frac{2\pi \times r}{0.85 \times 10^{-6}} \times 1.48\sqrt{2 \times 0.016}$$

$$\Rightarrow r = 34.95\ \mu m = 35\ \mu m$$

55. **[Ans. C]**

$$V_o(s) = -\frac{R_f}{R_1} V_i(s) + \left(\frac{1/CS}{R + CS}\right)\left(1 + \frac{R_f}{R_1}\right) V_i(s)$$

$$= -\frac{R_1}{R_1} V_i(s) + \left(\frac{1}{RCS + 1}\right)\left(1 + \frac{R_1}{R_1}\right) V_i(s)$$

$$= V_i(s)\left[-1 + \frac{2}{1} + RCS\right]$$

$$= V_i(s)\left[1 - \frac{RCS}{1 + RCS}\right]$$

$$\Rightarrow \frac{V_o(j\omega)}{V_i(j\omega)} = \frac{1 - j\omega RC}{1 + j\omega RC}$$