Full Length Test
Instrumentation Engineering

Answer Keys and Explanations

1. [Ans. A]

$$V_2 = 4\left[I_2 + I_1 - \frac{I_2}{2}\right] \Rightarrow I_2 = -2I_1 + \frac{1}{2}V_2$$

$$I_1 = \frac{I_2}{2} + \frac{(V_1 - V_2) - V_2}{2} = -I_1 + \frac{V_2}{4} + \frac{V_1}{2} - V_2$$

$$\Rightarrow V_1 = 4I_1 + \frac{3}{2}V_2$$

$$\begin{bmatrix} 4 & 3/2 \\ -2 & 1/2 \end{bmatrix}$$

2. [Ans. C]

Maximum occurs at $\frac{n\pi}{\omega_d}$ where, n is odd

Hence first maximum occurs at $\frac{\pi}{\omega_d}$

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

$$s^2 + 6s + 25 = s^3 + 2\xi\omega_n s + \omega_n^2$$

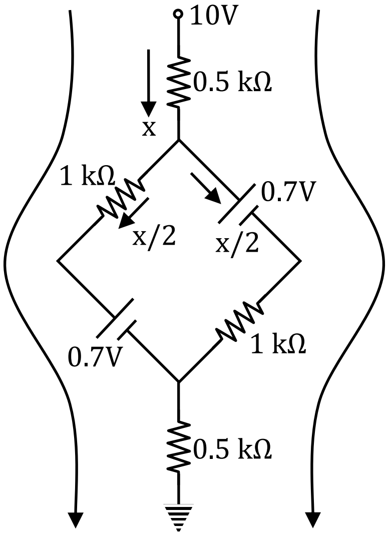
Comparing, $\omega_n = 5$ and $\xi = \frac{6}{2\omega_n} = 0.6$

$$\omega_n = 5$$

$$= \frac{\pi}{5\sqrt{1 - 0.36}}$$

$$= \frac{\pi}{4}$$

3. [Ans. *] Range: 3 to 3.2



$$KVL = 10 - 0.5 \times 10^3 x - 0.7 - 10^3(x/2) - 0.5 \times 10^3 x = 0$$

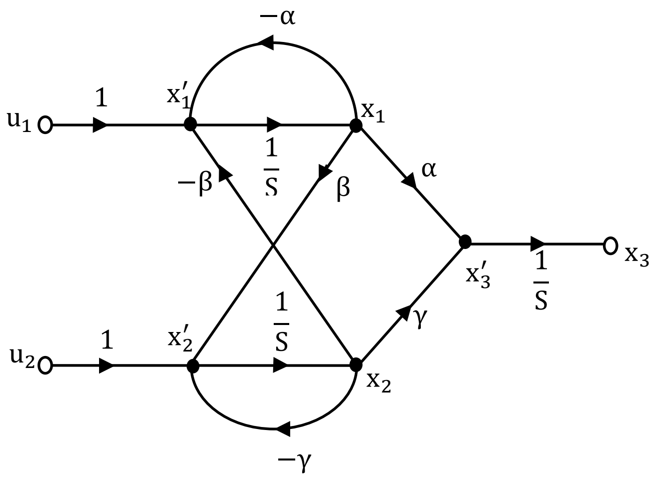
$$\Rightarrow 9.3 = 0.5 \times 10^3 x(1 + 1 + 1)$$

$$\Rightarrow 9.3 = 1.5 \times 10^3 x$$

$$x = \frac{9.3}{1.5 \times 10^3} = 6.2 \text{ mA}$$

$$I = \frac{x}{2} = \frac{6.2}{2} = 3.1 \text{ mA}$$

4. **[Ans. D]**



$\dot{x}_1 = -\alpha x_1 - \beta x_2 + u_1$
$\dot{x}_2 = \beta x_1 - \gamma x_2 + u_2$
$\dot{x}_3 = \alpha x_1 + \gamma x_2$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -\alpha & -\beta & 0 \\ \beta & -\gamma & 0 \\ \alpha & \gamma & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

One can denote any state by any name; changing $x_1 \to x_3, x_2 \to x_1$ and $x_3 \to x_2$

So, that answer is

$$\frac{d}{dt}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -\gamma & 0 & \beta \\ \gamma & 0 & \alpha \\ -\beta & 0 & -\alpha \end{bmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{bmatrix} 0 & 1 \\ 0 & 0 \\ 1 & 0 \end{bmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$$

5. **[Ans. C]**

By K.V.L

$2I_x = 2I_x + 2I_x + 2$

$2I_x = -2A$

$I_x = -1$

$V = 2i_x = -2V$

6. **[Ans. *] Range: 5.5 to 5.8**

$A_v = -\dfrac{\mu R_d}{R_D + r_d}$ $\qquad \omega_H = \dfrac{1}{C_M R_S}$

Where ,$C_M = C_{gs} + C_{gd}(1 + g_m R_L)$ and

$R = R_s$ and $R_L = r_d || R_d$

$$A_V = \frac{-2 \times 20 \times 20}{20 + 20} = -20$$

$R_L = 10k$

$C_M = 8 + 4(1 + 2 \times 10) = 92pF$

$R_s = 0.3\ k\Omega$

$C_M R_s = 92 \times 0.3 = 27.6 \times 10^{-9}$ sec

$$\omega_H = \frac{10^9}{27.6}$$

$$\therefore f_M = \frac{\omega_H}{2\pi} = 5.77\ MHz$$

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

$A_C \cos \omega_c t + 2\cos \omega_m t \times \cos \omega_c t$

$A_C \cos \omega_c t \left[1 + \frac{2}{A_C} \cos \omega_m t\right]$

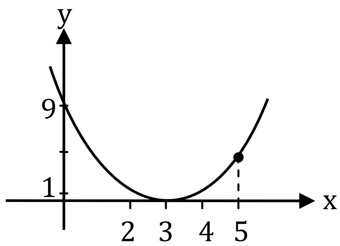
For envelope detection $\mu < 1 \Rightarrow \frac{2}{A_C} < 1 \Rightarrow A_C$ Should be atleast 2

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

$y = x^2 - 6x + 9 = (x-3)^2$

$y(2) = 1$

$y(5) = 4$



$\therefore$ Maximum value of y over the interval 2 to 5 will be at $x = 5$

9. **[Ans. B]**

The transform function will be of the form

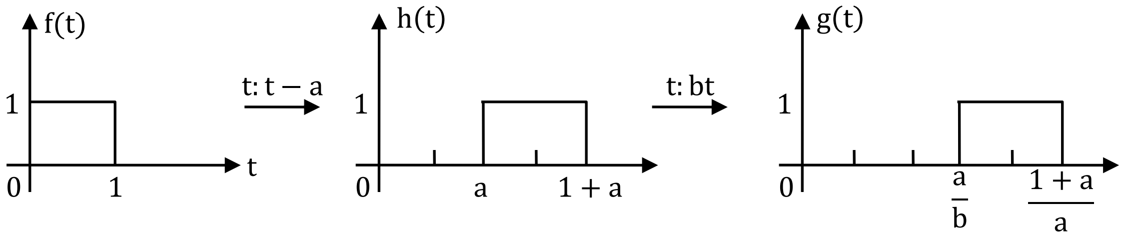
$$GH(s) = \frac{ks^2}{(s+P_1)(s+P_2)(s+P_3)}$$

$$\angle GH(s) = 180° - \tan^{-1}\frac{\omega}{P_1} - \tan^{-1}\frac{\omega}{P_2} - \tan^{-1}\frac{\omega}{P_3}$$

As ω varies from 0 to ∞

$\angle GH(s) =$ Decreasing from $180°$ to $-90°$

10. **[Ans. *] Range: 1 to 2**



$\frac{a}{b} = 3; \frac{1+a}{b} = 5$

$\frac{1+3}{b} = 5$

$\Rightarrow b = \frac{1}{2}$

$\Rightarrow a = \frac{3}{2} = 1.5$

11. [Ans. C]

$\dot{x}_1 = -4x_1 + x_2$

$\dot{x}_2 = x_3 + 2u$

$\dot{x}_3 - 3x_3 + u$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -4 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \\ 1 \end{bmatrix} u$$

$$\therefore A = \begin{bmatrix} -4 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & -3 \end{bmatrix}$$

12. [Ans. A]

$PQRS = I$

$P^{-1}\,PQRSS^{-1} = P^{-1}IS^{-1}$

$QR = P^{-1}S^{-1}$

$Q^{-1}QR = Q^{-1}P^{-1}S^{-1}$

$R = Q^{-1}P^{-1}S^{-1}$

$R^{-1} = (Q^{-1}P^{-1}S^{-1})^{-1}$

$\quad = SPQ$

13. [Ans. B]

In this given figure, 3 intersection points are given that shows, the system is stable for different value or region of k. So system is conditionally stable

14. [Ans. *] Range: 0.008 to 0.01

Open loop gain $= 1000 \pm 10$

$\qquad\qquad\qquad\quad A \qquad dA$

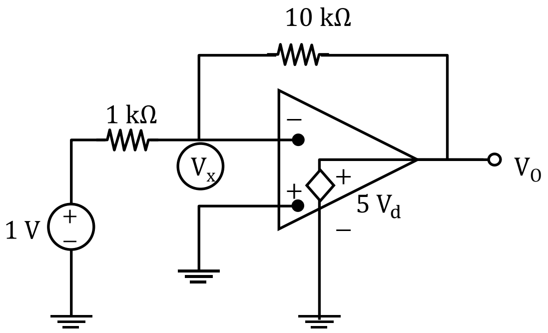
$$0.1\% = \frac{dA_f}{A_f} = \frac{0.1}{100}$$

$$\frac{dA_f}{A_f} = \frac{dA}{A}\left(\frac{1}{1 + A\beta}\right)$$

$$\Rightarrow \frac{0.1}{100} = \frac{10}{1000}\left(\frac{1}{1 + 1000\beta}\right)$$

$$\therefore \beta = \frac{0.9}{100} = 0.009$$

15. [Ans. *] Range: −3.2 to −3.1



Using KCL

$$\frac{V_x - 1}{1k} + \frac{V_x - V_O}{10k} = 0$$

$$\Rightarrow \frac{10V_x - 10 + V_x - V_O}{10k} = 0$$

$$\Rightarrow 11V_x = V_O + 10$$

$$\Rightarrow V_x = \frac{V_O + 10}{11}$$

$$0 - V_x = V_d$$

$$V_d = -V_x = -\left[\frac{V_O + 10}{11}\right]$$

$$V_O = 5\,V_d$$

$$V_O = -5\left[\frac{V_O + 10}{11}\right]$$

$$11V_O = -5V_O - 50 \Rightarrow V_O = -\frac{50}{16}V$$

$$V_O = -3.125V$$

16. [Ans. D]

$$\sigma \times \varepsilon_{absorbed} \times T^4 = \sigma \times \varepsilon_{actual} \times T^4$$

$$0.85 \times (1350 + 273.15)^4 = \varepsilon_{actual} \times T^4$$

$$T^4 = \left(\frac{0.85}{0.9}\right) \times (1350 + 273.15)^4$$

$$T_4 = 6.555 \times 10^{12}$$

$$T = 1600.08\text{ K}$$

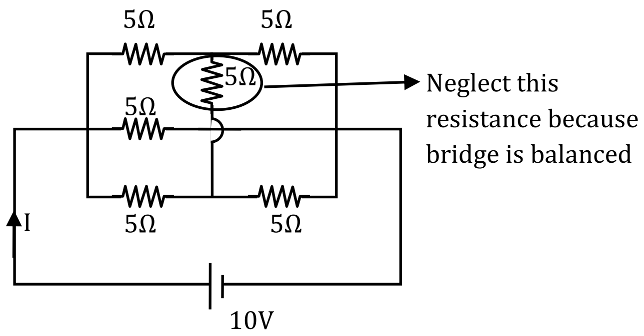
$$T = 1326.9°C$$

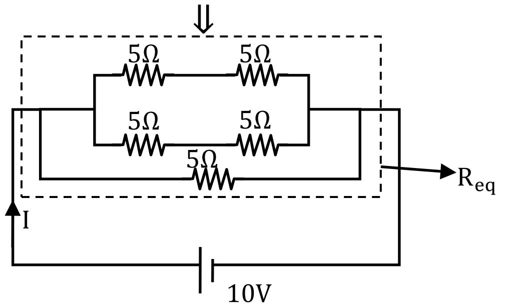
Error = Actual temperature − Measured temperature

= 1350 − 1326.9

= + 23.1 °C

17. [Ans. *] Range: 4 to 4





$R_{eq} = 5||(5+5)||(5+5) = 2.5\Omega$

$\therefore I = \dfrac{10}{2.5} = 4\text{ A}$

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

$y(t) = x(3t) + x(t) + x(0.5t)$

If $x(t)$ is band limited to 'f 'Hz. Then, $x(3t)$ is band limited to '3f ' Hz.

$\therefore$ Nyquist rate $= 2 \times 3f = 6f$

$\therefore a = 6$

19. [Ans. A]

PUSH H, PUSH, D will decrement SP by 4,

$(1000)_{16} - 4 = 0FFC$

H, D are register pairs HL, DE

The processor will execute the CALL indicated by next address 2050 loaded in PC.

POP H: Top of stack D will be popped

$\therefore SP = SP + 2$

$= 0FFC + 2 = 0FFE$

20. [Ans. D]

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

$P_1 - P_2 =$ Pressure drop, $Q =$ Volume flow rate

$L =$ Length of pipe

$R =$ Pipe radius, $\mu =$ dynomic viscosity

$$Q_A = \frac{\pi R_A^4 (P_1 - P_2)}{8\mu_A L} \quad \dots (1)$$

$$Q_B = \frac{\pi R_B^4 (P_1 - P_2)}{8\mu_B L} \quad \dots (2)$$

Equating (1) and (2)

$$\frac{\pi R_A^4 (P_1 - P_2)}{8\mu_A L} = \frac{\pi R_B^4 (P_1 - P_2)}{8\mu_B L}$$

$$\Rightarrow \frac{R_A^4}{R_B^4} = \frac{\mu_A}{\mu_B}$$

$$\Rightarrow \left(\frac{R_A}{R_B}\right)^4 = \frac{1}{\mu_B/\mu_A} = \frac{1}{16}$$

$$\Rightarrow \left(\frac{R_A}{R_B}\right) = \frac{1}{\sqrt[4]{16}} = \frac{1}{2}$$

$$\Rightarrow R_A = \frac{1}{2} R_B$$

$$\Rightarrow \frac{D_A}{2} = \frac{1}{2}\frac{D_B}{2}$$

$$\Rightarrow \frac{D_A}{D_B} = \frac{1}{2} = \frac{1}{\sqrt{4}}$$

21. [Ans. D]

$f_m = 5\text{kHz} - 500\text{Hz}$

$\quad = 4.5\text{kHz}$

$BW = 2f_m$

$\Rightarrow 2 \times 4.5 = 9\text{kHz}$

22. [Ans. A]

Green's theorem and stokes theorem convert line integral to surface integral and vice versa. Whereas Gauss's Divergence theorem converts from surface to volume and vice versa.

23. [Ans. C]

Energy imparted $= \dfrac{1.24 \times 10^{-6}}{0.2537 \times 10^{-6}} = 4.89\ \text{eV}$

The balance energy $= 4.89 - 4.30 = 0.59\ \text{eV}$ is available for acceleration of electrons

$\therefore$ Kinetic energy of electrons $= \dfrac{1}{2}mV^2 = e(\text{balance energy})$

$\therefore$ Velocity of electrons, $V = \sqrt{2 \times 0.59 \times 0.176 \times 10^{12}} = 0.456 \times 10^6 \text{m/s}$

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

The gain of -40dB/dec line is obtained from the frequency $\omega = \mu$ at which intersects the 0 dB line.

Thus,

$\sqrt{K} = \mu$

Given $K = 25(\text{gain})$

So, $\mu = \sqrt{25}$

$\quad = 5\ \text{rad/sec}$

25. [Ans. D]

Given $(D^2 + 5D + 6) = \sin 2x,\ y_p = \dfrac{1}{D^2 + 5D + 6}\sin 2x,\ D^2 = -2^2 = -4$

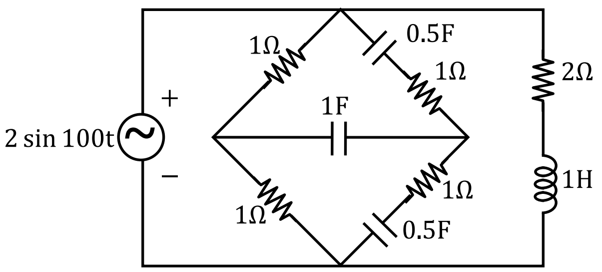
$$= \frac{1}{-4 + 5D + 6}\sin 2x = \frac{1}{5D + 2}\sin 2x$$

$$= \frac{5D - 2}{25D^2 - 4}\sin 2x = \frac{5 \times D(\sin 2x) - 2\sin 2x}{25 \times -4 - 4}$$

$$= \frac{10\cos 2x - 2\sin 2x}{-104}$$

26. [Ans. B]

This circuit is drawn again for better understanding. The simplified diagram is shown below



Now from the figure it is clear that the 1 Farad capacitor is connected in a bridge network which is completely balanced. Therefore voltage on the both side of the capacitor will be same and make zero drop across the capacitor

Hence current flowing through it will be zero.

27. **[Ans. D]**

For a single tone SSB-SC signal the waveform after carrier reinsertion becomes

$$s'(t) = s(t) + c(L) = \cos(\omega_c t + \omega_m t) + A\cos\omega_c t$$
$$= (A + \cos\omega_m t)\cos\omega_c t - \sin\omega_c t \sin\omega_m t$$

The output of the demodulation is given by [the envelope will be]

$$V(t) = \sqrt{[A + \cos\omega_m t]^2 + [\sin\omega_m t]^2}$$
$$= \sqrt{A^2 + 1 + 2A\cos\omega_m t}$$
$$= \sqrt{A^2+1}\left[1 + \frac{2A}{1+A^2}\cos\omega_m t\right]^{1/2}$$
$$= \sqrt{A^2+1}\left[1 + \frac{A}{A^2+1}\cos\omega_m t\right] \text{ [Binomial expansion]}$$
$$= \sqrt{A^2+1} + \frac{A}{\sqrt{A^2+1}}\cos\omega_m t$$

Neglecting d.c component the normalized power of detected signal will be

$$P_d = \frac{1}{2}\left[\frac{A^2}{A^2+1}\right]$$

Given, $P_d = 90\% \times 0.5$

$$\frac{1}{2}\left[\frac{A^2}{A^2+1}\right] = 90\% \times 0.5$$

$$\Rightarrow \frac{A^2}{1+A^2} = 0.9$$

$$\Rightarrow A = 3$$

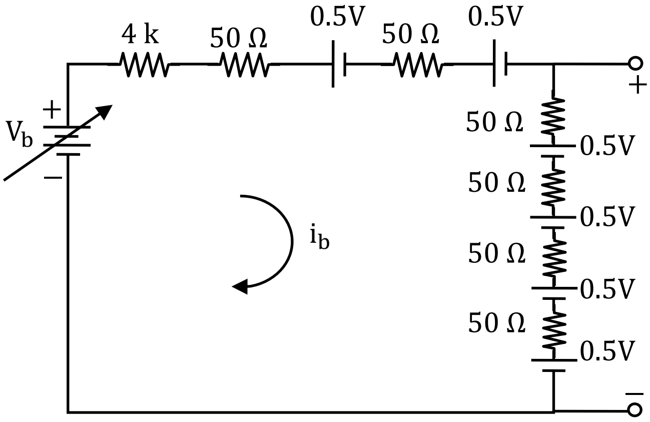
28. **[Ans. B]**

x(t) at max be '∞' and at minimum be '−∞' but |x(t)| at max be '∞' and at minimum be '0' and $e^{-\infty} = 0$ and $e^{0} = 1$

$\therefore e^{-5|x(t)|} \in [0, 1]$

∴It is strictly bounded

29. [Ans. *]Range 4.50 to 5.00



$$i_b = \frac{V_b - 3}{4.3k}$$

and $V_0 = i_b \times 200 + 2$

$$V_0 = \left(\frac{V_b - 3}{4.3k}\right) \times 200 + 2$$

for $V_{b1} = 4\text{ V}$

$$V_{01} = \frac{1}{4.3} \times 0.2 + 2$$

$V_{01} = 2.046\text{ V}$

and for $V_{b2} = 6\text{ V}$

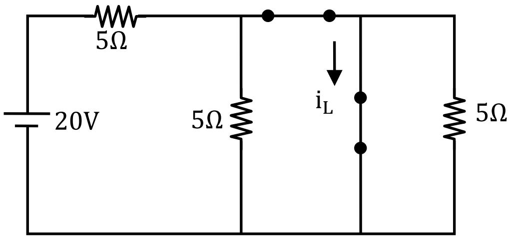
$$V_{02} = \frac{6 - 3}{4.3} \times 0.2 + 2$$

$V_{02} = 2.139\text{ V}$

$$\text{Regulation} = \frac{V_{02} - V_{01}}{V_{01}} \times 100\%$$

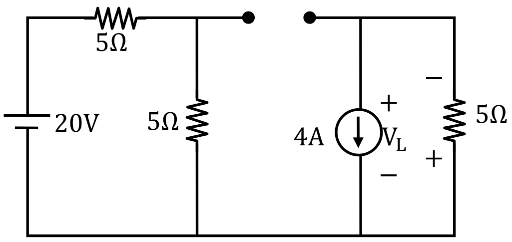
Regulation $= 4.545\%$

30. [Ans. *] Range: -20 to -20



$$i_L(0^-) = i_L(0^+) = \frac{20}{5} = 4\text{A}$$

At $t = 0^+$



$V_L(0^+) = -5 \times 4 = -20\text{V}$

31. [Ans. A]

Given,

$C(t) = K[1 - 1.66e^{-8t}\sin(6t + 37^{o})]$

Standard response for second order system with i/p Au(t) is

$$C(t) = A\left[1 - \frac{e^{-\zeta\omega_n t}}{\sqrt{1-\zeta^2}}\sin(\omega_d t + \phi)\right]$$

On comparison we get

$$\frac{1}{\sqrt{1-\zeta^2}} = 1.66$$

$\zeta\omega_n = 8$

$\omega_n\sqrt{1-\zeta^2} = 6$

On solving we get; $\omega_n = 9.96 \cong 10$ rad/sec; $\zeta = 0.8$

32. [Ans. *] Range: 58 to 59

$Z_L = j\omega L = j \times 500 \times 0.02 = j10\Omega$

$V_L = I_L \times Z_L = 2.5\angle 40° \times 10\angle 90° = 25\angle 130°$

The current through 25Ω is $1\angle 130°$Amp

The current through unknown element and 10Ω is $2.54\ \angle 40° + 1\ \angle 130°$

$= 2.69\angle 61.80°$

$\therefore V_s = 10(2.69\angle 61.8°) + 25\angle -30° + 25\angle 130°$

$= 35.44\angle 58.93°$

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

By KCL at output node

$I_x + I_2 = 2I_x$

$I_2 = I_x$

$V_x = 4I_2 + V_2 \ldots\ldots\ldots$ (1)

$$\frac{V_1 - V_x}{4} = \frac{V_x}{4} + I_2 \ldots\ldots\ldots (2)$$

$V_1 - V_x = V_x + 4I_2$

So,

$V_1 = 2V_x + 4I_2$

$V_1 = 2(4I_2 + V_2) + 4I_2$

$\quad = 8I_2 + 4I_2 + 2V_2$

$V_1 = 2V_2 + 12I_2$

$S = 2, \qquad M = 12$

$M \times S = 24$

34. [Ans. A]

A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
0	0	1	X	X	X	X	X	X	X	X	X	X	X	X	X

Only option 'A' is valid

35. [Ans. *] Range: 2.3 to 2.4

$f(x) = x^3 - 3x - 5 \Rightarrow f'(x) = 3x^2 - 3$

By Newton-Raphson method $x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$

$$\Rightarrow x_{n+1} = x_n - \frac{(x_n^3 - 3x_n - 5)}{3x_n^2 - 3} = \frac{2x_n^3 + 5}{3(x_n^2 - 1)}$$

Given $x_0 = 2$

$$\Rightarrow x_1 = \frac{2(2)^3 + 5}{3(2^2 - 1)} = \frac{21}{9} = 2.3333$$

36. [Ans. D]

$x^2 - x + I = 0$, Multiplying both sides by x^{-1}

$x - I + x^{-1} = 0$

$$\therefore x^{-1} = I - x = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} b^2 & 1 \\ (b^2 + b - 1) & (1 - b) \end{bmatrix} = \begin{bmatrix} (1 - b^2) & -1 \\ (1 - b - b^2) & b \end{bmatrix}$$

37. [Ans. *] Range: 51 to 52

Areal spread $= \pi(\theta p)^2$

$$\theta = \frac{1.22\lambda}{\alpha} = \frac{1.22 \times 720 \times 10^{-9}}{5 \times 10^{-3}} = 175.68 \times 10^{-6}$$

$$\begin{aligned} \therefore \text{Areal spread } &= 3.14 \times (175.68 \times 10^{-6} \times 0.1)^2 \\ &= 969.11 \times 10^{-12} \\ &= 9.691 \times 10^{-10}\ \text{m}^2 \end{aligned}$$

$$\begin{aligned} \therefore \text{Intensity } &= \frac{50 \times 10^{-3}}{9.69 \times 10^{-10}} \\ &= 51.59 \times 10^6 \\ &= 51.59\ \text{MW/m}^2 \end{aligned}$$

38. [Ans. *] Range: 76 to 77

$$R_4 = \frac{R_1 R_2}{R_3} = \frac{500 \times 615}{100} = 3{,}075\Omega$$

$$\frac{\delta R_4}{R_4} = \pm\left[\frac{\delta R_1}{R_1} + \frac{\delta R_2}{R_2} + \frac{\delta R_3}{R_3}\right] \times 100 = \pm(1 + 1 + 0.5) = \pm 2.5\%$$

$$\text{Limiting error} = 3075 \times \frac{2.5}{100} = 76.875\ \Omega$$

39. [Ans. *] Range: 2.5 to 3.0

For $V_0 = 0V$ current through the 3kΩ resistance connected in the collector terminal of pnp transistor is

$$\frac{0V-(-6V)}{3k\Omega} = 2\text{ mA}$$

Therefore, emitter potential of the pnp transistor

$$V_{Epnp} = 6V - \text{Voltage drop across } 1.5\text{ k}\Omega \text{ Resistor}$$
$$= 6V - 2mA \times 1.5\text{ k}\Omega$$
$$= 3V$$

$$V_{B_{pnp}} = V_{E_{pnp}} - 0.6V = 3V - 0.6V = 2.4V$$

current through 1.8kΩ resistor

$$\frac{6V - V_{B_{pnp}}}{1.8k\Omega} = \frac{6V-2.4V}{1.8k\Omega} = 2mA$$

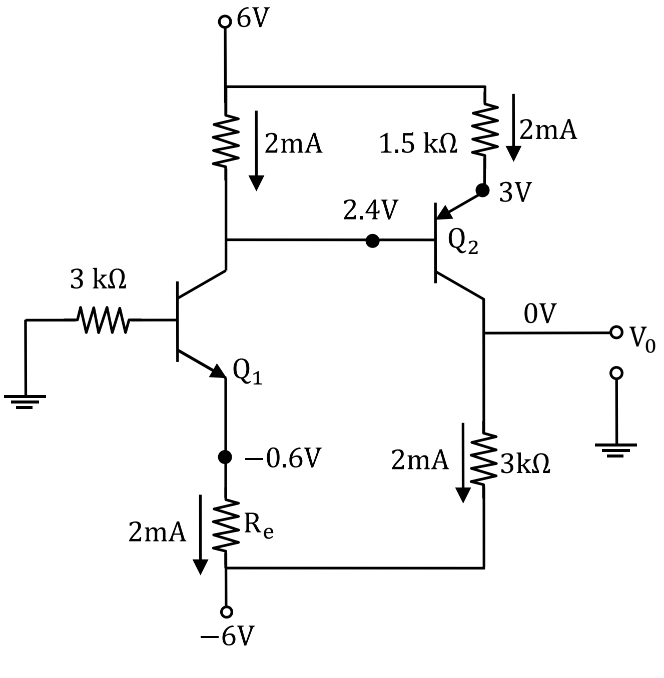
Now for $V_S = 0V$ Base of npn transistor is grounded i.e at 0V

Therefore $V_{E_{npn}} = 0V - 0.6V = -0.6V$

Voltage drop across $R_e = -0.6V - (-6V) = 5.4V$

Current through $R_e = 2mA$

$\therefore$ Required value of $R_e = \dfrac{5.4V}{2mA} = 2.7k\Omega$



40. [Ans. *]Range: 3.7 to 4

For proper functioning the clock period should be equal to or greater than all t_{pd}'s

MOD – 12 ⇒ 4 FF's

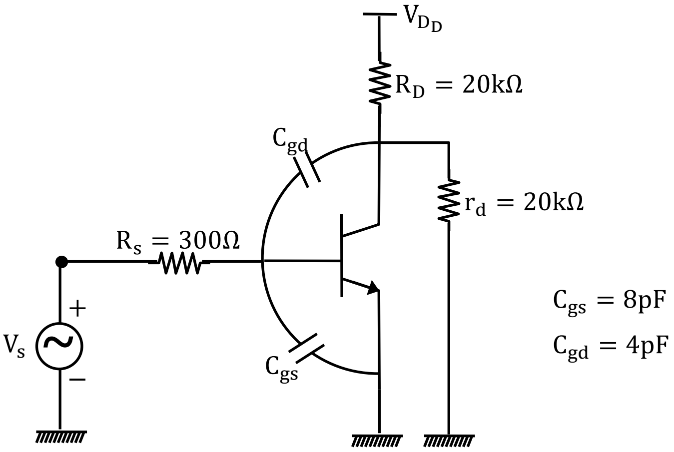
$\therefore 4 \times 60 = 240$ ns

t_{pd} of NAND = 25 ns

$\therefore$ Total t_{pd} = 265 ns

$\therefore f_e = \dfrac{1}{265}$ Hz = 3.774 MHz

41. [Ans. D]



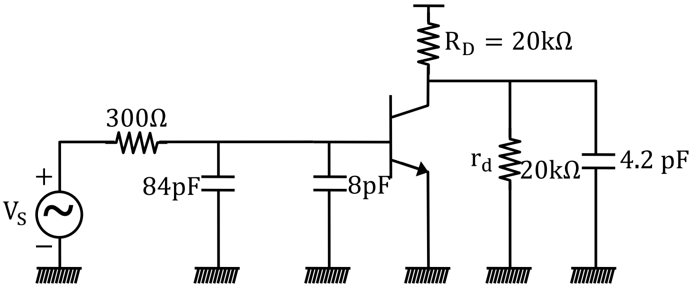
The midband gain of the circuit is

$A_V = -g_m(r_d||R_D)$

$= -2 \times 10^{-3}(20k\Omega||20k\Omega)$

$= -20$

Splitting the C_{gd} using Millers theorem we have



$C_{in} = C_{gd}(1 - Av)$

$= 4(1 + 20)$

$= 84 \text{ pF}$

$C_{out} = C_{gd}\left(1 - \frac{1}{Av}\right)$

$= 4\left(1 + \frac{1}{20}\right) = 4.2 \text{ pF}$

Cut off frequency at input side

$f_{in_{cutoff}} = \frac{1}{2\pi R_s(C_{in} + C_{gs})}$

$= \frac{1}{2\pi \times 300 \times 92 \times 10^{-12}} = 5.76 \text{ MHz}$

Cut off frequency at output side

$f_{out_{cutoff}} = \frac{1}{2\pi\, C_{out}(R_D||r_d)}$

$= \frac{1}{2\pi(4.2 \times 10^{-12}) \times 10^{1} \times 10^{3}} = 3.7 \text{ MHz}$

As the upper cutoff frequency is defined by the minimum of the input and output cutoff, thus 3.7 MHz is the correct answer.

42. [Ans. C]

For $V_i < 0$, both diode D_1 and zener diode are forward biased

$$-i_1 = \frac{0 - V_i}{10}, \text{At } V_i = -10\text{ V}, i_1 = -1\text{ mA}$$

for $V_i > 3$,

$$i_1 = \frac{V_i - 3}{20}, \text{At } V_i = 10\text{ V}, i_1 = 0.35\text{ mA}$$

43. [Ans. *] Range: 1.9 to 2

$$P_1 = 2 \times 3 \times 4; P_2 = 1 \times 5 \times 1 = 5$$

$$L_1 = -2, L_2 = -3, L_3 = -4, L_4 = -5$$

$$L_1 L_3 = 8, \Delta = 1 - (-2 - 3 - 4 - 5) + 8 = 23$$

$$\Delta_1 = 1, \Delta_2 = 1 - (-3) = 4$$

$$\frac{C}{R} = \frac{24 + 5 \times 4}{23} = \frac{44}{23} = 1.913$$

44. [Ans. *] Range:1 to 2

R_0 facing R_E is given by $\frac{R_s + r_\pi}{\beta_0 + 1}$

$$g_m . r_\pi = \beta_0;\ g_m = \frac{0.25}{25}\ \left[g_m = \frac{I_c}{V_T}\right]$$

$$r_\pi = 150 \times \frac{25}{0.25} = 15\text{k}\Omega$$

$$R_0 = \frac{3 + 15}{151} = 119.2\Omega$$

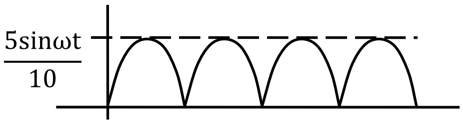
$$R_0' = R_0 || R_E = 110\Omega$$

$$\Rightarrow \frac{R_0 R_E}{R_0 + R_E} = 110 \text{ with } R_0 = 119.2\Omega$$

$$\Rightarrow R_E = 1.42\text{k}\Omega$$

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

Ammeter input is



$$\therefore I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{0.5}{\sqrt{2}}$$

$$\therefore E = I_{rms}^2 . R . t$$

$$= \left(\frac{0.5}{\sqrt{2}}\right)^2 \times 10 \times 20$$

$$= 25\text{ J}$$

46. [Ans. *] Range: 7.9 to 8.1

To solve this problem we could compute the analytical expression for the inverse Z-T , and then we could evaluate that expression at k=3. An alternative method to recall that

$F(z) = f[0] + f[1]z^{-1} + f[2]z^{-2} + f[3]z^{-3} + f[4]z^{-4} + \cdots \dots \dots$

i.e., f[k] can be computed by expanding the fraction in power of z^{-1}. This can be done by dividing n(z) by d(z) upto the term z^{-3}, its coefficient is equal to f[3]

$z^7 + 2z^6 + z^5 + z^4 + 0.5) \quad 2z^6 - z^5 + 3z^3 + 2z^2 \quad (2z^{-1} - 5z^{-2} + 8z^{-3}$

$2z^6 + 4z^5 + 2z^4 + 2z^3 + z^{-1}$

$-5z^5 - 2z^4 + z^3 + 2z^2 - z^{-1}$

$-5z^5 - 10z^4 - 5z^3 - 5z^2 - 2.5z^{-2}$

$8z^4 + 6z^3 + 7z^2 - z^{-1} + 2.5z^{-2}$

$8z^4$

So, coefficient is 8

47. [Ans. C]

$u = \log\dfrac{x^4 + y^4}{x + y}$, Here 'u' is not a homogeneous function.

$\therefore e^u = \dfrac{x^4 + y^4}{x + y}$, which is a homogeneous function of order '3'

$$\therefore x\frac{\partial(e^u)}{\partial x} + y\frac{\partial}{\partial y}(e^u) = 3e^u$$

$\left[\text{As } x\dfrac{\partial f}{\partial x} + y\dfrac{\partial f}{\partial y} = nf, \text{Where n is the order of homogenous function}\right]$

$$\Rightarrow x.e^u\frac{\partial u}{\partial x} + ye^u\frac{\partial u}{\partial y} = 3e^u$$

$$\Rightarrow x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = 3$$

48. [Ans. C]

$$R_A = R_o \exp \beta_A \left(\frac{1}{T} - \frac{1}{T_o}\right)$$

$$R_B = R_o \exp \beta_B \left(\frac{1}{T} - \frac{1}{T_o}\right)$$

$$\therefore \frac{R_A}{R_B} = \frac{\exp \beta_A \left(\frac{1}{T} - \frac{1}{T_o}\right)}{\exp \beta_B \left(\frac{1}{T} - \frac{1}{T_o}\right)}$$

$$0.5 = \exp(\beta_A - \beta_B)\left(\frac{1}{T} - \frac{1}{T_o}\right)$$

$$(\beta_A - \beta_B) = \frac{\ln(0.5)}{\left(\frac{1}{T_o} - \frac{1}{T}\right)}$$

$$= \frac{\ln(0.5)}{\left(\frac{1}{298} - \frac{1}{398}\right)}$$

$$= 822.10 \approx 822$$

Difference in material constants is 822

49. [Ans. C]

$R_{35} = R_{25}\,[1{+}\propto(35-25)]$

$R_{35} = 100\,[1-0.05\,(35-25)]$

$R_{35} = 50\Omega$

50. [Ans. C]

$E_L = \frac{Z_L}{Z_T} \times E_o$

$Z_L = \frac{R_L}{1 + j\omega R_L C_L}$

$Z_T = \frac{1}{j\omega C_x} + \frac{R_L}{1 + j\omega R_L C_L}$

$\therefore E_L = \frac{j\omega C_x R_L}{1 + j\omega(C_x + C_L)R_L}$

$|E_L| = \left(\frac{\omega C - x\,R_L}{\sqrt{1 + \omega^2(C_x + C_L)^2 R_L^2}}\right) E_o$

For higher frequencies

$\omega^2(C_x + C_L)^2 > 1$

$\therefore |E_L| = \frac{E_o C_x}{C_x + C_L}$

$|E_L| = \frac{C_x}{C_x + C_L} E_o$

51. [Ans. A]

$M = \frac{1}{\sqrt{1 + (1/\omega\tau)^2}}$

$T_0 = \text{Time constant} = RC$

$T_{01} = RC_1 = 1 \times 10^6 \left(C_{P_1} + C_a\right) = 10^6 \times 1050\text{ pF}$

$= 1.05\text{ m sec}$

$T_{02} = RC_2 = 1 \times 10^6 \left(C_{P_2} + C_a\right) = 10^6 \times 1550\text{ pF}$

$= 1.55\text{ m sec and } \omega = 25\text{ rad/sec}$

$\therefore M_1 = \frac{1}{\sqrt{1 + \left(\frac{1}{25 \times 1.05 \times 10^{-3}}\right)^2}} = 26.24 \times 10^{-3}$

And $M_2 = \frac{1}{\sqrt{1 + \left(\frac{1}{25 \times 1.55 \times 10^{-3}}\right)^2}} = 38.72 \times 10^{-3}$

Percentage error $= \frac{M_2 - M_1}{M_1} \times 100$

$= 47.56\%$

52. [Ans. *] Range: 4.6 to 5

Current through diode D_1

$$I_{D_1} = I_s\left[1 - \exp\left(-\frac{eV_{D_1}}{kT}\right)\right] \approx I_s[\text{as } D_1 \text{reverse biased}]$$

Current through diode D_2

$$I_{D_2} = I_s\left[\exp\left(\frac{eV_{D_2}}{kT}\right) - 1\right]$$

As the diodes are connected in series equating the current we have,

$$I_{D_1} = I_{D_2}$$

$$\text{or, } I_s = I_s\left[\exp\left(\frac{eV_{D_2}}{kT}\right) - 1\right]$$

$$\text{or } \exp\left(\frac{eV_{D_2}}{kT}\right) = 2$$

$$\therefore V_{D_2} = \frac{kT}{e}\ln 2 = V_T \ln 2$$

$$V_{D_1} + V_{D_2} = 5V$$

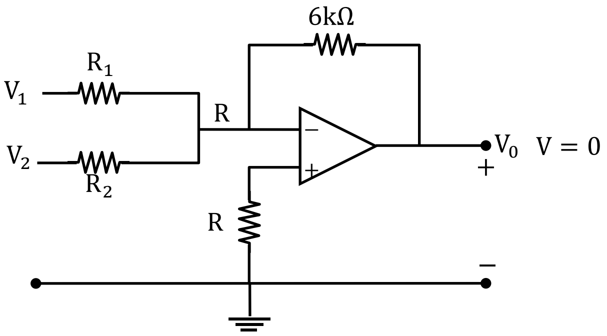
$$\text{or, } V_{D_1} = 5V - V_T \ln 2$$

$$\therefore V_{D_1} - V_{D_2} = (5V - V_T \ln 2) - V_T \ln 2$$

$$= 5 - 2V_T \ln 2$$

$$= 4.965V$$

53. [Ans. *] Range: 1000 to 1000



At V

$$\frac{V - V_1}{R_1} + \frac{V - V_2}{R_2} + \frac{V - V_0}{6} = 0$$

$$\Rightarrow -\frac{V_1}{R_1} - \frac{V_2}{R_2} = \frac{V_0}{6}$$

$$\Rightarrow V_0 = \frac{-6}{R_1}V_1 - \frac{6}{R_2}V_2$$

Given $V_0 = -2V_1 - 3V_2$ $\therefore R_1 = 3k\Omega; R_2 = 2k\Omega$

The value of R is parallel combination of resistors.

$$R = (R_1||R_2)||R_F$$

$$= (3k\Omega \,||\, 2k\Omega) \,||\, 6k\Omega$$

$$= (1.2k||6k)\Omega$$

$$= 1k\Omega$$

$$= 1000\Omega$$

$\therefore$ R is called offset minimizing resistor

54. [Ans. B]

For 12 mA control signal, the stem length will be at 5 cm

For equal percentage valve, Range ability $R = Q_{max}/Q_{min}$

$= 100/10 = 10$

Flow rate $= Q_{min} \times (R)^{s/s_{max}}$

$= 10\,(10)^{5/10}$

$= 31.6\,m^3/sec$

55. [Ans. *] Range: 1.40 to 1.40

Characteristic equation

$$1 + \frac{k}{s(s+1)(s+5)} = 0$$

$\Rightarrow s^3 + 6s^2 + 5s + k = 0$ ……①

Put $s = j\omega$ in equation ①

$\Rightarrow (j\omega)^3 + 6(j\omega)^2 + 5(j\omega) + k = 0$

$\Rightarrow j(5\omega - \omega^3) + (k_p - 6\omega^2) = 0$

$5\omega - \omega^3 = 0$

$\Rightarrow \omega = \sqrt{5} = \omega_0$

$$P_\omega = \frac{2\pi}{\omega_0}$$

$= 2.80$

Integral time $T_i = \frac{P_\omega}{2} = \frac{2.80}{2} = 1.40$ sec

Required solution is 1.40 sec

56. [Ans. D]

They will chime together after the time in minutes equal to LCM of 18, 24, 32.

$18 = 2 \times 3 \times 3$

$24 = 2 \times 2 \times 2 \times 3$

$32 = 2 \times 2 \times 2 \times 2 \times 2$

$\therefore$ LCM $= 2 \times 2 \times 2 \times 3 \times 3 \times 2 \times 2 = 288$

288 min = 4 hrs 48 min.

57. [Ans. C]

According to the statement, 80% of the total runs were made by spinners. So, conclusion I does not follow. Nothing about the opening batsmen is mentioned in the statement. So, conclusion II also does not follow

58. [Ans. D]

1 km = 1000 meter

1 min = 60 second

$$\text{Average speed } = \frac{\text{Total distance}}{\text{Total time}}$$

Total distance = 12 km = 12000 meter

Total time = 6 + 6 +12 minute = 24 × 60 = 1440 seconds

$$\text{Average speed } = \frac{12000}{1440} = 8.33 \text{ m/s}$$

59. [Ans. A]

60. [Ans. C]

CEPQS - E cannot go with S.

AEPQS - C and P have to be together. E cannot go with S.

ACPRS -It satisfies all the conditions and also there are two boys in the team.

BDPRS - C and P have to be together.

Hence, C

61. [Ans. A]

$$\text{Number of males in U.P } = \left[\frac{3}{5} \text{ of } (15\% \text{ of N})\right] = \frac{3}{5} \times \frac{15}{100} \times \text{N} = \frac{9\text{N}}{100}$$

$$\text{Total population, N } = 3276000$$

$$\text{Number of males in M.P } = \left[\frac{3}{4} \text{ of } (20\% \text{ of N})\right] = \frac{3}{4} \times \frac{20}{100} \times \text{N} = \frac{15\text{N}}{100}$$

$$\text{Number of males in Goa } \left[\frac{3}{8} \text{ of } (12\% \text{ of N})\right] = \frac{3}{8} \times \frac{12}{100} \times \text{N} = \frac{4.5\text{N}}{100}$$

$$\text{Total males in these 3 states } = \frac{(9 + 15 + 4.5)\text{N}}{100} = \frac{28.5\text{N}}{100}$$

$$\text{Required \% } = \left(\frac{28.5 \times \frac{\text{N}}{100} \times 100}{\text{N}}\right)\% = 28.5\%$$

62. [Ans. C]

A cube is cut into 125 smaller cubes.

∴ Length of cube $=\sqrt[3]{125}$

∴ l = 5 unit

Let upper face be coloured red.

Then bottom face will be coloured green, two adjacent faces are coloured yellow and blue respectively.

Two faces are uncoloured.

Number of cubes uncoloured on all faces $= (n-2)^3 = (5-2)^3 = 27$

Now there are two surfaces which are not coloured.

∴ There will be 9 cubes at centre on both the uncoloured surfaces each.

3 cubes at the common edge of both uncoloured surfaces.

∴ Total number of uncoloured cubes = 27 + 9 + 9 + 3 = 48

63. [Ans. C]

64. [Ans. B]

The passage clearly states the unawareness of teachers regarding population education. Thus, the teachers should be given a proper orientation on the same.

65. [Ans. C]

In statement I nothing is given about c. Hence it is not enough to answer the question.

In statement II nothing is mentioned about a. Hence this statement alone cannot answer the question.

Combining both the statements we get

a : b : c = 3 : 15 : 10

∴ a : c = 3 :10

$$\frac{a}{c} = \frac{3}{10}$$

$$\frac{a+c}{c} = \frac{3+10}{10} = \frac{13}{10}$$

∴ Question can be answered using both the statements.

Hence, C.