Branch: Instrumentation Engineering - SOLUTIONS

01. Ans: 59

Sol: Here, wavelength of light used,
$\lambda = 590.0$ nm

Distance between the two sources,
d = 3.0 mm

Distance between the source and screen,
d = 0.3m

Fringe width is given by

$$\beta = \frac{\lambda D}{d}$$

$$= \frac{590.0\times10^{-9}\times0.3}{3\times10^{-3}}$$

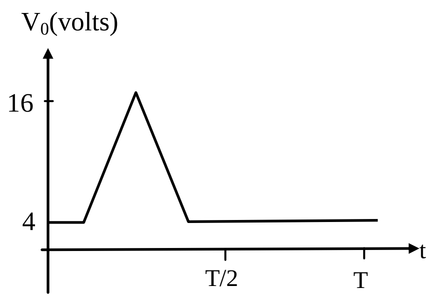
$$= 5.9\times10^{-5}\,\text{m}$$

$$= 59\ \mu\text{m}$$

02. Ans: (d)

Sol: For $V_i < 4V$, the diode is ON and the output $V_0 = 4V$

For $V_i > 4V$, the diode is OFF and the output $V_0 = V_i$.



03. Ans: 60

Sol: Since the water level x is proportional to the output voltage (V) therefore

$$\frac{x-0}{80-0} = \frac{V-0}{10\ -0} \Rightarrow$$

$$x = 8\ V$$
$$= 8\times7.5$$
$$= 60\ \text{mm}$$

04. Ans: (c)

Sol: Option (a):- Due to multiplication of input terms it is nonlinear, but it is TIV.
Option (b):-Due to multiplication of time variant term (n – 2) it is TV., but linear
Option (c): - It is linear and TIV.
Option (d):- $2^{x_1(n)+x_2(n)} \neq 2^{x_1(n)} + 2^{x_2(n)}$.
So, nonlinear and TIV system

05. Ans: 80 (no range)

Sol: Given that $\frac{\mu^2}{2+\mu^2} = \frac{1}{9}$

$$\Rightarrow 1-\frac{\mu^2}{2+\mu^2} = \frac{2}{2+\mu^2} = \frac{8}{9}$$

$$P_t = P_c\left(1+\frac{\mu^2}{2}\right) = P_c\left[\frac{2+\mu^2}{2}\right]$$

$$3600 = P_c\left(\frac{9}{8}\right)$$

$$P_c = 3200$$

$$\frac{A_c^2}{2} = 3200$$

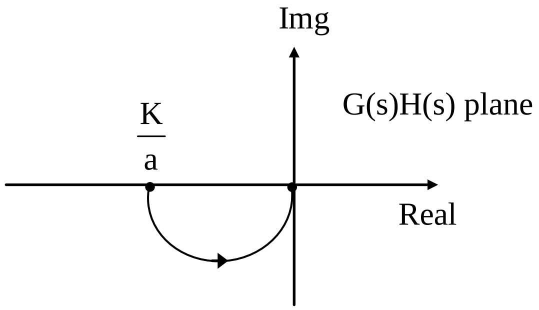
$$A_c = 80V$$

06. Ans: (c)

Sol: OLTF $= \dfrac{K}{s-a}$ (a > 0)

$$= \frac{K}{j\omega - a} = \frac{K}{\sqrt{\omega^2 + a^2}} \angle -\left(180^o - \tan^{-1}\frac{\omega}{a}\right)$$

The Polar plot is



07. Ans: (a)

Sol: The multiplexer output $I_0 = a$, $I_1 = \bar{a}_1$,

$I_2 = \bar{a}$, $I_3 = a$, $S_1 = b$, $S_0 = c$

$F = I_0\bar{S}_1\bar{S}_0 + I_1\bar{S}_1S_0 + I_2S_1\bar{S}_0 + I_3S_1S_0$

$F = a\bar{b}\bar{c} + \bar{a}\bar{b}c + \bar{a}b\bar{c} + abc$

$F = \sum m\,(1, 2, 4, 7)$

For a Full Adder circuit:-

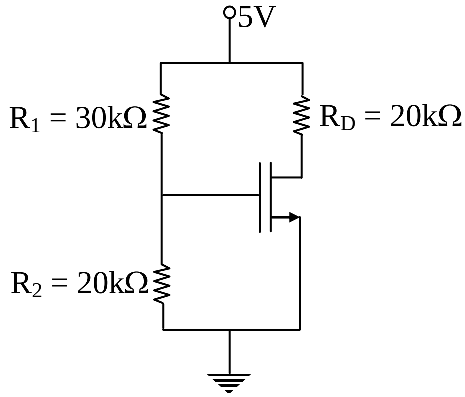
a b c	sum	carry
0 0 0	0	0
0 0 1	1	0
0 1 0	1	0
0 1 1	0	1
1 0 0	1	0
1 0 1	0	1
1 1 0	0	1
1 1 1	1	1

Sum $= \sum m(1, 2, 4, 7)$

The given multiplexer circuit is equivalent to sum equation of full adder.

08. Ans: 0.3

Sol:



$$V_G = V_{GS} = \left(\frac{R_2}{R_1 + R_2}\right)V_{DD}$$

$$V_{GS} = \left(\frac{20k}{30k + 20k}\right)5 = 2V$$

Assume transistor is in saturation

$$I_D = \frac{1}{2}k_n\left(V_{GS} - V_{TN}\right)^2$$

$$= \frac{1}{2}(0.2m)(2-1)^2 = 0.1mA$$

$V_{DS} = V_{DD} - I_D R_D = 5 - (0.1m)(20k) = 3V$

$V_{DS} > V_{GS} - V_{TN} \rightarrow$ transistor is in saturation

$P_D = I_D V_{DS} = (0.1m)(3) = 0.3mW$

09. Ans: (d)

Sol: The sensor's sensitivity error in percentage is

$$\frac{9.5mV/V/mmHg - 10mV/V/mmHg}{10mV/V/mmHg} \times 100\%$$

$$= -5\%$$

10. Ans: (c)

Sol: $\because \underset{x\to 0}{Lt}\dfrac{\tan(ax)}{x} = a$

Now, $\underset{x\to 0}{Lt}\dfrac{\tan(4x)}{4x} = \dfrac{1}{4}\underset{x\to 0}{Lt}\dfrac{\tan(4x)}{x}$

$\therefore \underset{x\to 0}{Lt}\dfrac{\tan(4x)}{4x} = \dfrac{1}{4}(4) = 1$

11. Ans: 0.836 (Range: 0.8 to 0.85)

Sol: $i_2 = \frac{24}{4}\left(1 - e^{-4t/8}\right)$

$= 6(1 - e^{-0.5t})$

At t = 0.3

$i_2 = 0.836$ A

12. Ans: (a)

Sol: 20 V displayed on a 3 and half digital display

1 digital = 0.1V

Voltage error = ± (0.6% of the reading + 1d)

= ± (0.6% of 20V + 0.1V)

= ± 0.12 + 0.1 V

= ± 0.22V

$\text{Error} = \frac{\pm 0.22\text{V}}{20\text{V}} \times 100\%$

= ± 1.1 %

13. Ans: (c)

Sol: $\frac{(s+2)(s+3)}{s} = \frac{s^2+5s+6}{s} = 5 + \frac{6}{s} + s$

$= K_P + \frac{K_I}{s} + K_D s$

$K_p = 5, K_I = 6, K_D = 1$

14. Ans: (c)

Sol: Given $\frac{d^2y(t)}{dt^2} + \frac{dy(t)}{dt} - 2y(t) = x(t)$.

Apply L.T

$s^2Y(s) + sY(s) - 2Y(s) = X(s)$

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

$= \frac{-1/3}{s+2} + \frac{1/3}{s-1}$

Given that system is stable. So, ROC must include jω axis.

So, ROC $-2 < \sigma < 1$.

$h(t) = \frac{-1}{3}e^{-2t}u(t) - \frac{1}{3}e^{t}u(-t)$

15. Ans: 60

Sol:

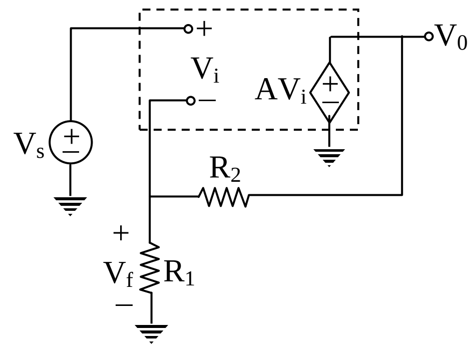


Fig. Non inverting op-amp circuit with op-amp replaced by its equivalent circuit

$\beta = \frac{V_f}{V_0} = \frac{R_1}{R_1 + R_2} = \frac{1k}{1k + 9k} = 0.1$

The de-sensitivity factor is 1 + Aβ

$= 1 + (10^4 \times 0.1) \cong 10^3$

$= 20\log 10^3$ dB

= 60dB

16. Ans: 10 (no range)

Sol: Resolution = ΔV_i = 5mV

Maximum Analog input = $V_{i(max)}$ = 5V

$\Delta V_i = \frac{1}{2^n - 1} \times 5$

$2^n - 1 = 1000$

$2^n = 1001$

$n \approx 10$

17. Ans: (c)

Sol: $\text{T.F} = \frac{Y(s)}{U(s)} = C\,(sI - A)^{-1}B,$

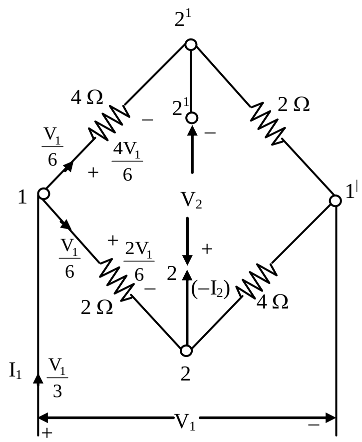
$u(t) = \delta(t) \xrightarrow{LT} U(s) = 1$

$Y(s) = C(sI - A)^{-1}\,B$

$y(t) = C\,e^{At}\,B$, as $e^{At} \xrightarrow{LT} (sI - A)^{-1}$

18. Ans: (c)

Sol: The circuit is redrawn as a planar circuit for convenience.



We have $V_1 = A\,V_2 + B\,(-I_2)$

$I_1 = C\,V_2 + D\,(-I_2)$

With port 2 open; between 1 & 1′ there is a 6 Ω path (1– 2′ –1′) and another 6 Ω path (1 – 2 – 1′).

$\therefore$ Effective resistance between 1 and 1′ = 3 Ω

$I_1 = V_1/3$

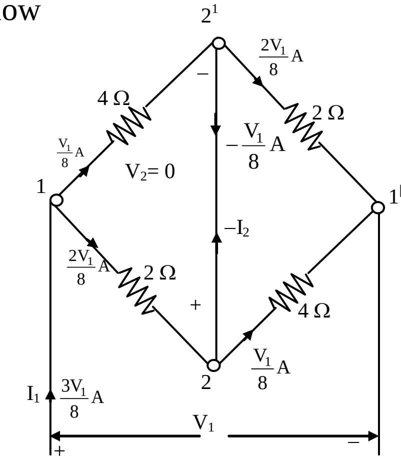
With port 2 open; $I_2 = 0$. Currents and voltage drops across different resistors are shown in above figure.

By KVL; $\frac{4V_1}{6} = \frac{2V_1}{6} + V_2$

$$V_2 = \frac{V_1}{3} \qquad \left.\frac{V_1}{V_2}\right|_{I_2=0} = A = 3$$

Also, $$\left.\frac{I_1}{V_2}\right|_{I_2=0} = C = \frac{\frac{V_1}{3}}{\frac{V_1}{3}} = 1\,℧$$

With port 2 shorted, the figure is redrawn below



Between 1 and 1′; we have (4 Ω // 2 Ω) in series with (4 Ω // 2 Ω) = $\frac{8}{3}\,\Omega$

$I_1 = \frac{3V_1}{8}\,A$. From figure, where currents are marked, $(-I_2) = \frac{V_1}{8}\,A$

$$B = \left.\frac{V_1}{(-I_2)}\right|_{V_2=0} = \frac{V_1}{\frac{V_1}{8}} = 8\ \Omega$$

$$D = \left.\frac{I_1}{-I_2}\right|_{V_2=0} = \frac{\frac{3V_1}{8}}{\left(\frac{V_1}{8}\right)} = 3$$

19. Ans: -3.467 (-3.46 to -3.48)

Sol: 1.50cm core displacement produces 5.2 V, hence –1.0cm core movement produces a voltage $V = \frac{(-1.0)\times(-5.2)}{(-1.5)} = -3.467\,V$

20. Ans: 0.0625 (no range)

Sol: $G(z) = z^{-3}.\frac{1}{1-\frac{1}{4}z^{-1}}$

Let, $x(n) \leftrightarrow X(z) = \dfrac{1}{1-\frac{1}{4}.z^{-1}}$

$\therefore\ x(n) = \left(\frac{1}{4}\right)^n u(n)$

By Time shifting property,

$x(n-3) \xleftrightarrow{ZT} z^{-3}X(z)$

$\left(\frac{1}{4}\right)^{n-3} u(n-3) \xleftrightarrow{Z.T.} z^{-3}.\dfrac{1}{1-\frac{1}{4}.z^{-1}} = G(z)$

$\therefore\ z^{-1}\{G(z)\} = g(n) = \left(\frac{1}{4}\right)^{n-3} u(n-3)$

Put n = 5

$g(5) = \left(\frac{1}{4}\right)^{5-3} = \left(\frac{1}{4}\right)^2$

$g(5) = \frac{1}{16} = 0.0625$

21. Ans: 3

Sol: N = 100,

B = 0.2 T

D = 1cm

ℓ = 1.5cm

I = 1 mA

T_D = B I N (D ℓ)

= 0.2 T × 1.5 × 10^{-2} × 1 mA × 100 × 1 × 10^{-2}

= 3 × 10^{-6} Nm

= 3 μNm

22. Ans: 1.19 range (1.0 to 1.3)

Sol: For first wire, resistivity of conducting material is

$$\rho = \frac{RA}{\ell} = \frac{0.56\times2\times10^{-6}}{50} = 2.24\times10^{-8}\,\Omega-m$$

$\therefore$ Cross-sectional area of second wire is

$$A = \frac{\rho\ell}{R} = \frac{(2.24\times10^{-8})(100)}{2} = 1.12\times10^{-6}\,m^2$$

$$\text{Diameter(d)} = 2\sqrt{\frac{A}{\pi}} = 2\sqrt{\frac{1.12\times10^{-6}}{\pi}}$$

= 1.19 × 10^{-3} m

23. Ans: 1.56 (Range: 1.52 to 1.60)

Sol: SNR at input:

$$SNR = \frac{(3\times10^{-6}V)^2}{(1\times10^{-6}V)^2} = 9$$

SNR at output:

$$SNR = \frac{(3\times20\times10^{-6}V)^2}{[(1\times20+5)\times10^{-6}V]^2} = 5.76$$

Note: The amplifier also amplifies the input noise.

The noise factor therefore is

$$F_n = \frac{\text{SNR at input}}{\text{SNR at output}} = \frac{9}{5.76} = 1.56$$

24. Ans: (c)

Sol: HOLD has highest priority among all other signals.

HOLD > TRAP(RST 4.5) > RST 7.5 > RST 6.5

25. Ans: 0.25

Sol: Given

$$\int_0^x f(t)\,dt = -2 + \frac{x^2}{2} + 4x\sin(2x) + 2\cos(2x)$$

Differentiating both sides of above w.r.t 'x', we get

$$\frac{d}{dx}\left[\int_0^x f(t)\,dt\right] = -0 + \frac{2x}{2} + 4\sin(2x)$$
$$+8x\cos(2x) - 4\sin(2x)$$

$$\Rightarrow \left(\frac{d}{dx}(x)\right)[f(x)] - \left(\frac{d}{dx}(0)\right).[f(0)] = x + 8x\ \cos(2x)$$

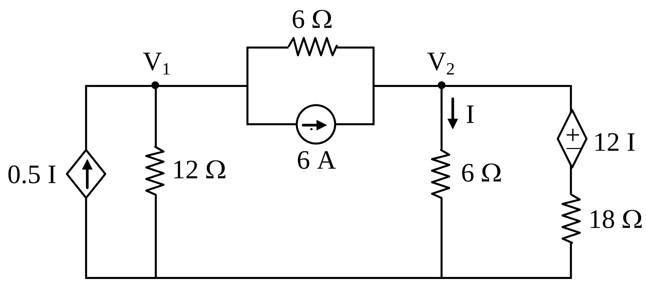
$\Rightarrow$ f(x) = x + 8x.cos(2x)

$$\therefore\ \frac{1}{\pi}f\left(\frac{\pi}{4}\right) = \frac{1}{\pi}\left[\frac{\pi}{4} + 8\left(\frac{\pi}{4}\right).\cos\left(\frac{2\pi}{4}\right)\right]$$

$$= \frac{1}{4} = 0.25$$

26. Ans: 3 (range 2.9 t0 3.1)

Sol:



Here,

$I = \frac{V_2}{6}$

Dependent current source supplies current of 0.5I

i.e., $0.5\left(\frac{V_2}{6}\right) = \frac{V_2}{12}$

dependent voltage source supplies voltage of 12I

i.e., $12\left(\frac{V_2}{6}\right) = 2V_2$

Apply KCL at Node (1)

$-\frac{V_2}{12} + \frac{V_1}{12} + \frac{V_1 - V_2}{6} = -6$

$\Rightarrow 3V_1 - 3V_2 = -72$ ………(1)

Apply KCL at Node (2),

$\frac{V_2 - V_1}{6} + \frac{V_2}{6} + \frac{V_2 - 2V_2}{18} = 6$

$-3V_1 + 5V_2 = 108$ ………(2)

Adding (1) & (2), we get

$V_2 = 18$ V

$I = \frac{V_2}{6} = \frac{18}{6} = 3A$

27. Ans: 2 no range

Sol: Given that $f(x, y) = x^2 + 2y^2$ .... (1)

with $y - x^2 + 1 = 0$ .... (2)

From (2), we write $y = x^2 - 1$ .... (3)

Put (3) in (1), we get

$f(x, y) = x^2 + 2y^2 = x^2 + 2(x^2 - 1)^2$

$= x^2 + 2[x^4 - 2x^2 + 1]$

Let $g(x) = 2x^4 - 3x^2 + 2$

Then $g'(x) = 8x^3 - 6x$ and $g''(x) = 24x^2 - 6$

Consider $g'(x) = 0$

$\Rightarrow 8x^3 - 6x = 0$

$\therefore x = 0, \frac{\sqrt{3}}{2}, \frac{-\sqrt{3}}{2}$ are stationary points.

At $x = 0$, $g''(0) = -6 < 0$

At $x = \pm\frac{\sqrt{3}}{2}$, $g''\left(\pm\frac{\sqrt{3}}{2}\right) = 12 > 0$

$\therefore$ x = 0 is a local point of maxima.

Hence, the maximum value of the function f(x, y) at x = 0 is

$f(x, y) = f(x, x^2 - 1) = f(0, -1)$

$= 0 + 2[0 - 0 + 1]$

$= 2$

28. Ans: (a)

Sol: $F_1(A,B,C) = \sum m\,(1,3,4,6)$

$F_2(A,B,C) = \sum m\,(0,2,5,7)$

$F = \overline{F_1.F_2} \rightarrow F = \overline{0} = 1$

29. Ans: –1.32 (Range: –1.33 to –1.30)

Sol: From given data, both MOSFET's are identical.

$\therefore I_{D1} = I_{D2}$ & KCL at Node V_3

$\Rightarrow I_{D1} + I_{D2} = 200\mu$

$\therefore I_{D1} = I_{D2} = 100\mu$

$\therefore V_1 = 5 - I_{D1}(40k) = 1V$

$V_2 = 5 - I_{D2}(40k) = 1V$

Now, let M_1, M_2 are in saturation

$\therefore V_{D1} = V_1 = 1V$, $V_{G1} = 0V$, $V_{S1} = V_3$, $V_{GS1} = 0 - V_3$

$\therefore I_{D_1} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_1 \times \left[V_{GS_1} - V_{T_1}\right]^2$

$\Rightarrow 100\mu = \frac{1}{2} \times 100\mu \times 20\left[-V_3 - 1\right]^2$

$\therefore V_3 = -1.32V$

Now test for Assumption $\rightarrow$

$V_{DS_1} = V_1 - V_3 = 1 - [-1.32] = 2.32V$

$V_{GS_1} - V_T = -V_3 - 1 = 1.32 - 1 = 0.32V$

$\therefore\ V_{DS_1} > V_{GS_1} - V_T \Rightarrow$ Saturation

$\Rightarrow$ True Assumption

$\Rightarrow V_3 = -1.32V$ is Correct

30. Ans: 20.765 (Range: 20.50 to 20.90)

Sol: To turn on the LED, the transistor must be ON, which requires a base Voltage V_{BE} greater or equal to 0.7 V:

$V_{BE} = V_B - V_E \geq 0.7V \Rightarrow V_B \geq 0.7$ V(since $V_E = 0V$, grounded)

$I_C = 100 I_B$

$$\Rightarrow \frac{V_{CC} - V_{LED} - V_{CE}}{R_{CB}} = 100\left(\frac{V_{in} - V_B}{R_{CdS}} - \frac{V_B - 0}{R_B}\right)$$

$$\frac{10V - 2V - 0.2V}{220\Omega} = 100\left(\frac{10V - 0.7V}{R_{CdS}} - \frac{0.7V}{7.5\times10^3\Omega}\right)$$

$$\Rightarrow R_{CdS} = 20.765k\Omega$$

Thus, the maximum resistance of the photo resistor R_{CdS} must be 20.765 kΩ for the LED to be ON.

31. Ans: (b)

Sol: Given that $A = (a_{ij})_{n\times n}$,

where $a_{ij} = \begin{cases} (n+1)^2 - i, & \forall\ i = j \\ 0, & \forall\ i \neq j \end{cases}$

$$\Rightarrow A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

$$= \begin{bmatrix} 15 & 0 & 0 \\ 0 & 14 & 0 \\ 0 & 0 & 13 \end{bmatrix}_{3\times3} \quad \text{for } n = 3$$

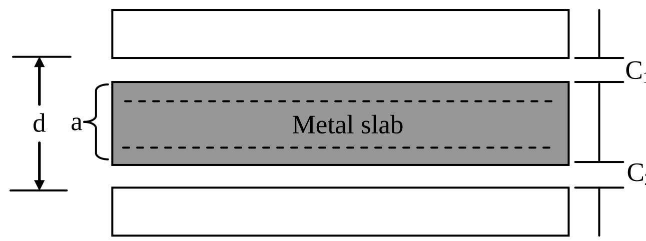
$\Rightarrow A_{3\times3}$ is a diagonal matrix & its eigen values are its diagonal elements 15, 14, 13.

If $\lambda_1, \lambda_2, \lambda_3$ are the eigen values of $A_{3\times3}$ matrix then the eigen values of matrix $A^2_{3\times3}$ are λ_1^2, λ_2^2 *and* λ_3^2.

$\therefore$ The eigen values of a required matrix A^2 are $(15)^2$, $(14)^2$ and $(13)^2$ (i.e., 225, 196, 169)

32. Ans: (a)

Sol: This three-plate capacitor forms the two equal capacitors ($C_1 = C_2$) in series shown in figure., each with a separation of (d – a)/2.



$$C = \frac{C_1 C_1}{C_1 + C_1}$$

$$= \frac{C_1}{2}$$

$$= \frac{1}{2}\frac{\varepsilon_0 A}{(d-a)/2}$$

$$= \frac{\varepsilon_0 A}{d-a}$$

$$= \frac{\varepsilon_0 A}{d}\frac{d}{d-a}$$

$$C = \frac{d}{d-a}C_0$$

33. Ans: (d)

Sol: Initial energy (W_i)

$$= \frac{1}{2}C_1V^2 = \frac{1}{2}\times100\times10^{-6}\times100\times100$$

$= 0.5J$

When connected in parallel, the initial charge $Q_i = C_1V$

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

$= 10$ mC

is redistributed in parallel combination of $C = C_1 + C_2$

$= (100+400)\mu F$

$\therefore$ Common voltage becomes

$$V = \frac{Q}{C} = \frac{10\times10^{-3}}{500\times10^{-6}} = 20\,V$$

$$W_1 = \frac{1}{2}C_1V^2 = \frac{1}{2}\times100\times10^{-6}\times(20)^2 = 0.02J$$

$$W_2 = \frac{1}{2}C_2V^2 = \frac{1}{2}\times400\times10^{-6}\times(20)^2 = 0.08J$$

Final energy (W_f) = $W_1 + W_2$ = 0.1J

Energy dissipated = $W_i - W_f$ = 0.5 – 0.1

= 0.4J

34. Ans: (a)

Sol: Data: NA = 0.16

n_1 = 1.45

d = 60 cm = 0.6 m

$\lambda_0 = 0.9\ \mu m = 9\times10^{-7}$ m

The normalized frequency is known as V-number

$$V = \frac{\pi d}{\lambda_0}\sqrt{n_1^2 - n_2^2}$$

$$= \frac{3.143\times60\ m}{9\times10^{-7}\ m}\times0.16 = 3.35\times10^5$$

35. Ans: (d)

Sol: % Efficiency of AM System,

$$\%\eta = \frac{K_a^2 P_m}{1+K_a^2.P_m}\times100\%$$

$$= \frac{0.1^2\times100}{1+0.1^2.\times100}\times100\ \%$$

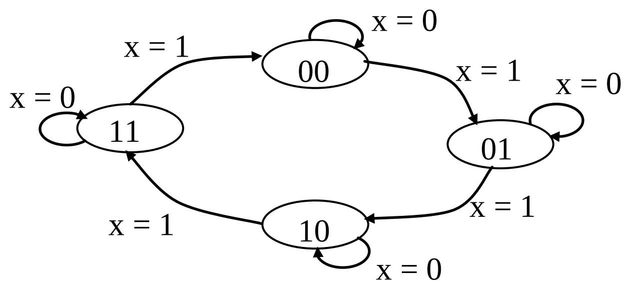
$$= \frac{1}{1+1}\times100\,\%$$

= 50%

36. Ans: (c)

Sol:

P.S	i/p	FF i/ps	N.S
$Q_1\,Q_2$	x	$J_1\ K_1\ \ J_2\ K_2$	Q_1Q_2
0 0	0	0 0 0 0	0 0
0 0	1	0 0 1 1	0 1
0 1	0	0 0 0 0	0 1
0 1	1	1 1 1 1	1 0
1 0	0	0 0 0 0	1 0
1 0	1	0 0 1 1	1 1
1 1	0	0 0 0 0	1 1
1 1	1	1 1 1 1	0 0



Circuit is behaving as upcounter when x = 1

37. Ans: 10

Sol: Put s = z –1

$$CE = 1+\frac{k}{(z-1)(z-1+3)(z-1+4)} = 0$$

$z^3 + 4z^2 + z + k - 6 = 0$

z^3	1	1
z^2	4	k – 6
z^1	$\frac{10-k}{4}$	
z^0	k – 6	

10 – k = 0

k = 10

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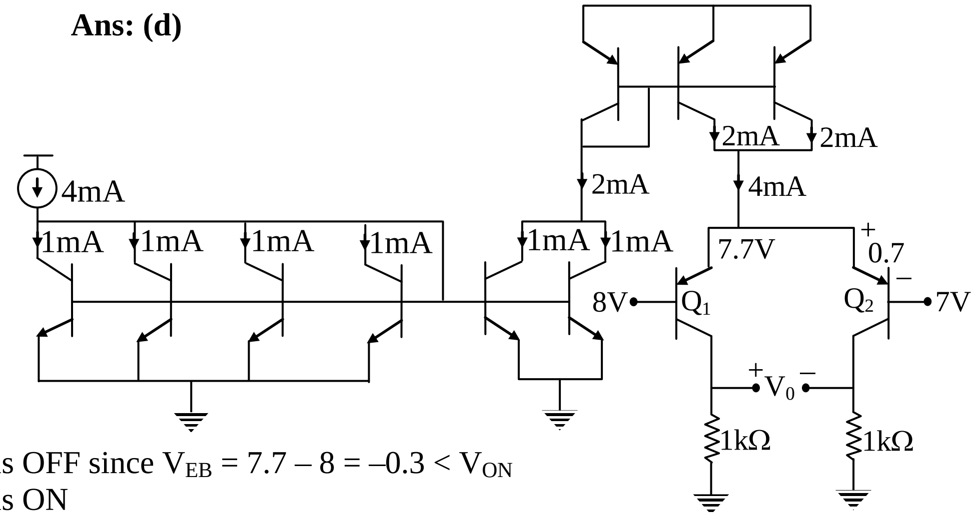
38. Ans: (d)

Sol:



Q_1 is OFF since $V_{EB} = 7.7 - 8 = -0.3 < V_{ON}$

Q_2 is ON

4mA current is passed through Q_2 transistor and $V_0 = 0 - (4mA \times 1k) = -4V$.

39. Ans: 91 (range: 88 to 93)

Sol: Total energy = $E_{x(t)} = \int_0^{\infty} e^{-2t}dt = \frac{1}{2}$

Given, $x(t) = e^{-t}u(t)$

$$X(\omega) = \frac{1}{1+j\omega}$$

$$|X(\omega)|^2 = \frac{1}{1+\omega^2}$$

Using parseval's theorem Energy contained

in $|\omega| \leq 7$ rad/sec $= \frac{1}{2\pi}\int_{-7}^{7}|X(\omega)|^2 d\omega$

$$= \frac{1}{2\pi}\int_{-7}^{7}\frac{1}{1+\omega^2}d\omega$$

$$= \frac{1}{2\pi}\tan^{-1}(\omega)\Big|_{-7}^{7}$$

$$= \frac{2}{2\pi}\tan^{-1}(7)$$

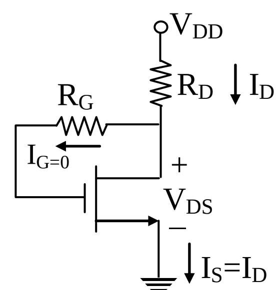
$= 0.4548$

Percentage of energy

$$= \frac{0.4548}{0.5} = 0.9096 \times 100 = 90.96\% \approx 91\%$$

40. Ans: (a)

Sol: DC analysis



$V_{GS} = V_{DS} = V_{DD} - I_D R_D$

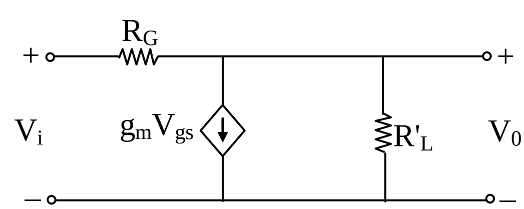
$$I_D = \frac{1}{2}K_n(V_{GS} - V_{TH})^2$$

Solve quadratic equation in I_D

$I_D = 1.06mA$

$V_{DS} = V_{GS} = 4.4V$

AC Analysis



$R_L' = R_L \| R_D \| r_0$

$A_V = -g_m R_L'$

$$g_m = \mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS} - V_{TH}) = 0.725 mA/V$$

$$r_0 = \frac{V_A}{I_D} = \frac{50}{1.06} = 47k\Omega$$

$R'_L = 4.52k\Omega$

$\therefore A_V = -g_m R'_L = -0.725 \times 4.52$

$= -3.27 \approx -3.3$

41. Ans: 3.2 (3.1 to 3.3)

Sol: $Y_{eq} = \frac{1}{2+j4} + \frac{1}{R} = \left(\frac{1}{10} + \frac{1}{R} - \frac{j}{5}\right)\mho$

For 0.9 lagging, angle of admittance must be $\cos^{-1}(0.9) = -25.84°$

Thus, $\frac{1/5}{1/10 + 1/R} = \tan 25.84 = 0.482$

$\Rightarrow R = 3.2\ \Omega$

42. Ans: 1 (Range: 0.98 to 1.2)

Sol: $R_\theta = 1.68\ e^{\left[3050\left(\frac{1}{\theta} - \frac{1}{298}\right)\right]}(k\Omega)$

$\theta = 50\ °C = 323\ K$

$R_{50°C} = 1.68\ e^{\left[3050\left(\frac{1}{323} - \frac{1}{298}\right)\right]}(k\Omega)$

$= 0.761\ (k\Omega)$

$$V_{OUT} = \left(\frac{1.22\ K}{1.22 K + 0.761 K} - \frac{0.29\ K}{0.29 K + 1K}\right) \times 2.56$$

$V_{OUT} \cong 1\ V$

43. Ans: (c)

Sol:

	MVI B, 0AH	7T
LOOP:	MVI C, 50H	7T
	DCR C	4T
	DCR B	4T
	JNZ LOOP	10T/7T

B register initialized with 0AH i.e., 10d.

Effect on zero flag due to "DCR B" instruction will be verified by "JNZ LOOP" instruction in iteration.

Therefore LOOP gets executed for 10 times.

The only instruction outside the LOOP is MVI B, 0AH which gets executed for only 1 time.

All the instructions inside the loop gets executed for 10 times.

$\therefore$ Total T – states

= 1×7T + 10 × [7T + 4T + 4T + 10T] – 3T

= 7T + 10 × 25T – 3T = 4T+250T

= 254T

44. Ans: (b)

Sol: If $R_L = 15\ k\Omega$, voltage across Zener diode is $24 \times \frac{15\times10^3}{(15+5)\times10^3} = 24 \times \frac{15}{20} = 18\ V$

$$I_S = \frac{24-18}{5\times10^3} = 1.2\ mA$$

Power through $R_S = I_S^2 R_S = (1.2\times10^{-3})^2 \times 5\times10^3$

= 7.2 mW

45. Ans: 50 (no range)

Sol: $C = 5000 \log_2\left[1 + \frac{1.023}{2\times5000\times10^{-7}}\right] = 50 kbps$

46. Ans: 20

Sol: $P = I^2R$

$P = (10\ mA)^2 \times 820\Omega$

= 82 mW

error in R = ± 10%

error in I = ± 2% of 25 mA

= ± 0.5 mA

$= \frac{\pm 0.5 mA}{10 mA} \times 100\%$

= ± 5%

% error in I^2 = 2 (±5%)

= ± 10%

% error in P=(% error in I^2) + (% error in R)

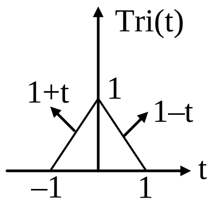
= ± (10% + 10%)

= ± 20%

47. Ans: 0.67 (range: 0.6 to 0.7)

Sol: $Tri(t) \leftrightarrow Sinc^2(f)$

$x(t) = Tri(t)$, $X(f) = Sinc^2(f)$



Using parseval's theorem

$$\int_{-\infty}^{\infty}|x(t)|^2 dt = \int_{-\infty}^{\infty}|X(f)|^2 df$$

$$\int_{-\infty}^{\infty} \text{Sinc}^2(f).\text{Sinc}^2(f)df = \int_{-\infty}^{\infty} \text{Tri}(t).\text{Tri}(t)dt$$

$$\int_{-\infty}^{\infty} \text{Sinc}^4(f)df = \int_{-\infty}^{\infty} \text{Tri}(t).\text{Tri}(t)dt$$

$$= \int_{-1}^{0}(t+1)^2 dt + \int_{0}^{1}(1-t)^2 dt$$

$$= \frac{1}{3}+\frac{1}{3} = \frac{2}{3} = 0.67$$

48. Ans: 0.11 Range: 0.1 to 0.2

Sol: Total possible outcomes for both faces even = (2, 2), (2, 4), (2, 6), (4, 2), (4, 4), (4, 6), (6, 2), (6, 4), (6, 6) = 9

Total favorable outcome for sum smaller than 6 = (2, 2)

P (sum is less than 6 given both faces are even) = $\frac{1}{9}$ = 0.11

49. Ans: (d)

Sol: i) The process transconductance parameter,

$k_n' = \mu_n C_{ox}$

$= 450 \times 10^{-4} \times 8.6 \times 10^{-15} \times 10^{12} A/V^2$

$= 387 \mu A/V^2$

ii) The transistor transductance parameter, k_n

$$= k_n'\left(\frac{W}{L}\right) = 387\left(\frac{2}{0.18}\right) = \frac{4.3mA}{V^2}$$

50. Ans: 4 (no range)

Sol: Bitrate, $R_b = 40000 \times 5 = 200$kbps

For M-ary PSK signalling bandwidth

$$= \frac{R_b(1+\alpha)}{\log_2 M}$$

$$130k \geq \frac{(1+\alpha)R_b}{\log_2 M}$$

$$\log_2 M \geq \frac{1.3 \times 200k}{130k}$$

$$\log_2 M \geq 2$$

$$M = 4$$

51. Ans: (a)

Sol: $\text{CLTF} = \frac{G(s)}{1+G(s)}$

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

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

By comparing with standard form of second order characteristic equation

$2\zeta\omega_n = (k + 1)$ and $\omega_n = \sqrt{4k}$

$2\omega_n = k + 1 \quad \because \zeta = 1$

$2 \times \sqrt{4k} = k+1 \Rightarrow 16k = k^2 + 2k + 1$

$\Rightarrow k^2 - 14k + 1 = 0 \Rightarrow k = 0.071$ & 13.92

52. Ans: (a)

Sol: $H(s) = \frac{1}{(s+0.1)^2+4}$

The relationship between s and z in backward difference method is $s = \frac{1-z^{-1}}{T_s}$

Given $f_s = 10$ Hz $\Rightarrow T_s = \frac{1}{10} = 0.1$sec

$$H(z) = \frac{1}{\left[\frac{1-z^{-1}}{0.1}+0.1\right]^2+4}$$

$$H(z)=\frac{1}{\left(\frac{1-z^{-1}+0.01}{0.1}\right)^2+4}$$

$$H(z)=\frac{1}{100\left(1.01-z^{-1}\right)^2+4}$$

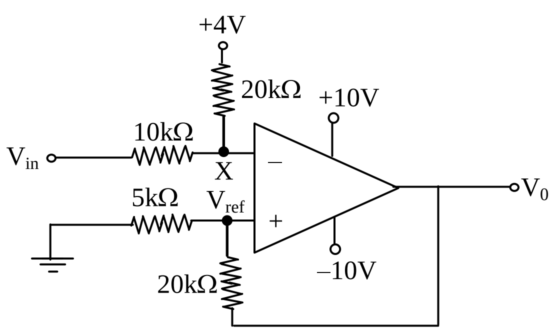
$$H(z)=\frac{\frac{1}{100}}{1.02-2.02z^{-1}+z^{-2}+\left(\frac{4}{100}\right)}$$

$$H(z)=\frac{\frac{1}{100}}{1.06-2.02z^{-1}+z^{-2}}$$

$$H(z)=\frac{9.43\times10^{-3}}{1-1.91z^{-1}+0.94z^{-2}}$$

53. Ans: 6

Sol: Consider node 'X' at inverting input terminal



Apply Nodal analysis technique at node 'X':

$$\frac{V_X-V_{in}}{10k}+\frac{V_X-4}{20k}=0$$

$$\Rightarrow V_X=\frac{2V_{in}+4}{3}$$

Reference voltage at non-inverting terminal,

If $V_0 = +10V$,

$$V_{ref}=V_0\times\frac{5k}{5k+20k}=10\times\frac{1}{5}=2V$$

If $V_0 = -10V$,

$$V_{ref}=V_0\times\frac{5k}{5k+20k}=-10\times\frac{1}{5}=-2V$$

For $V_X > 2V$, $V_0 = -V_{sat}$

i.e., $\frac{4+2V_{in}}{3}>2$

$\Rightarrow V_{in} > \frac{6-4}{2} = 1V$

$\Rightarrow$ i.e 'V_0' is changing $+V_{sat}$ to $-V_{sat}$

When $V_{in} > 1V$

$\therefore V_{UTP} = 1V$

For $V_X < -2V$, $V_0 = +V_{sat}$

i.e., $\frac{4+2V_{in}}{3}<-2$

$\Rightarrow V_{in} < \frac{-6-4}{2} = -5$

$\Rightarrow$ i.e 'V_0' is changing $-V_{sat}$ to $+V_{sat}$

When $V_{in} < -5V$

$\therefore V_{LTP} = -5V$

$\therefore V_H = V_{UTP} - V_{LTP} = 1 - (-5) = 6V$

54. Ans: 0

Sol: $$TF=K\frac{\left(1+\frac{s}{0.5}\right)^2}{\left(1+\frac{s}{10}\right)^3}$$

It is type 0 system

Velocity error coefficient K_v

$= \lim_{s\to0} s\,G(s)H(s)$

$= 0$

55 Ans: 1.52 no range

Sol: Consider

$$\int_C \bar{f}.\,d\bar{r} = \int_{(0,0)}^{(1,1)} \left[\sqrt{x}\ dx + \left(x + y^3\right)dy\right] \text{....... (1)}$$

Given that C: $x = t^2$, $y = t^3$, $0 \le t \le 1$
$\Rightarrow dx = 2t\ dt,\ dy = 3t^2\ dt$ ...... (2)

Using (2), (1) becomes

$$\int_C \bar{f}.\,d\bar{r} = \int_{t=0}^{1} \left[(t)(2t)\,dt + \left(t^2 + t^9\right)\left(3t^2\right)dt\right]$$

$$\Rightarrow \int_C \bar{f}.\,d\bar{r} = \int_{t=0}^{1} \left[2t^2 + 3t^4 + 3t^{11}\right]dt$$

$$\Rightarrow \int_C \bar{f}.\,d\bar{r} = \left(\frac{2t^3}{3} + \frac{3t^5}{5} + \frac{3t^{12}}{12}\right)_0^1$$

$$\therefore \int_C \bar{f}.\,d\bar{r} = \left(\frac{2}{3} + \frac{3}{5} + \frac{3}{12}\right) = 1.52$$

56. Ans: (b)
Sol: (so) is wrong because they mean the same.

57. Ans: (c)

58. Ans: (a)

59. Ans: (d)
Sol: Capacity of the tank = (12×13.5)= 162 litres
Capacity of each bucket = 9 litres.
Number of buckets needed = 162/9 =18

60. Ans: (d)
Sol: Volume of Cuboid
= length × breadth × height

Number of cuboids

$$= \frac{(\text{Volume of cuboids})\text{ formed from}}{(\text{Volume of cuboids})\text{ taken}}$$

$$= \frac{18 \times 15 \times 12}{5 \times 3 \times 2} = 108$$

61. Ans: (b)
Sol: **At the most case:** Let the numbers be {–45, 1, 1, 1, ……, 1}.
Average is 0. So, at the most 44 numbers may be > 0.
At the least case: Let the numbers be {45, –1, –1, –1, …., –1}.
Average is 0. So, at the least 1 number may be > 0.

62. Ans: (b)
Sol: Perimeter = Distance covered in 8 min.

$$= 12000 \times \frac{8}{60}\text{ m} = 1600\text{ m.}$$

Let length = 3*x* metres and breadth
= 2*x* metres.

Then, 2(3*x* + 2*x*) = 1600 or *x* = 160.

∴ Length = 480 m and Breadth = 320 m

∴ Area = (480 x 320) m^2 = 153600 m^2

63. Ans: (b)
Sol: Consider CP as 100%.
Loss 15% ⇒ So, SP = 85%
Gain 15 % ⇒ So, New SP = 115%
Given 115% – 85% = 30% = 450

$$\frac{100}{30} \times 450 = 1500$$

64. Ans: (a)
Sol: GDP at the beginning of 2013 is equal to the GDP at the end of 2012
⇒ GDP growth rate in 2012 = 7%

GDP at the end of 2011 = GDP at the beginning of 2012 = \$1 trillion

∴ GDP at the beginning of 2013

$$= \frac{100 + 7}{100} \times 1\text{ trillion}$$

$$= \frac{107}{100} = \$1.07\text{ trillion}$$

65. Ans: (a)