# Branch: Instrumentation Engineering - SOLUTIONS

**01. Ans: 24 (No range)**

**Sol:** Given that $F(x) = f(g(x))$

$\Rightarrow F^1(x) = f^1(g(x)).\ g^1(x)$ ($\because$ by chain rule)

$\Rightarrow F^1(5) = f^1(g(5)).\ g^1(5)$

$\Rightarrow F^1(5) = f^1(-2)\ .6$

$\therefore F^1(5) = (4)\ (6) = 24$

**02. Ans: (b)**

**Sol:** Strain gauge, LVDT and thermocouple may be classified as analogue transducers.

**03. Ans: (d)**

**Sol:**

i/p = $5\sin\omega t$ → [ ] → o/p = $10\cos\omega t$ $= 5A\sin(\omega t+\phi)$

$10\cos\omega t = 5A\sin(\omega t + \phi)$

$A = 2,\ \phi = 90^\circ$

If input = $10\cos\omega t$

output = $(10)\ (2)\cos(\omega t + 90^\circ)$

$= -20\sin\omega t$

**04. Ans: (d)**

**Sol:** We know that,

$P(A \cap B) \le \min$ of $\{P(A), P(B)\}$

$\Rightarrow P(A \cap B) \le 0.25$ ......... (1)

We have, $P(A \cup B) \le P(S)$

$\Rightarrow \{P(A) + P(B) - P(A \cap B)\} \le 1$

$\Rightarrow \{0.25 + 0.8 - P(A \cap B)\} \le 1$

$\Rightarrow 0.05 \le P(A \cap B)$ ........... (2)

From (1) and (2), we have

$0.05 \le P(A \cap B) \le 0.25$

**05. Ans:(C)**

**Sol:** $R_p = (10 - 1) \times 1\ M\Omega = 9\ M\Omega$

$$C_{eff} = \frac{45\,pF}{10} = 4.5\,pF$$

**06. Ans: (d)**

**Sol:**

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{3\times 10^3}{0.05}}$$

$f_n = 39$ (Hz)

**07. Ans: 388.488 (Range: 387 to 390)**

**Sol:** $i(t) = 4 + 3\cos(10t - 30°) + 4\sin(10t + 30°)$

$= 4 + 3\cos(10t - 30°) + 4\cos(10t + 30° - 90°)$

$= 4 + 3\cos(10t - 30°) + 4\cos(10t - 60°)$

$= 4 + 3\angle{-30°} + 4\angle{-60°}$

$= 4 + 3\cos 30° - j3\sin 30° + 4\cos 60° - j4\sin 60°$

$$= 4 + \left[\frac{4+3\sqrt{3}}{2} - j\frac{3+4\sqrt{3}}{2}\right]$$

$= 4 + 6.766\angle{-47.24°}$

$= 4 + 6.76\angle{-47.24}$

$i(t) = 4 + 6.76\cos(10t - 47.24)$

$$I_{rms} = \sqrt{4^2 + \left(\frac{6.76}{\sqrt{2}}\right)^2}$$

$$= \sqrt{38.84}$$

Power dissipated in $10\Omega$ is

$P = I_{rms}^2 \times R = \left(\sqrt{38.84}\right)^2 \times 10$

$= 38.84 \times 10$

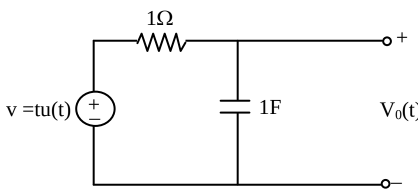
$P = 388.4$ watts

**08. Ans: (d)**

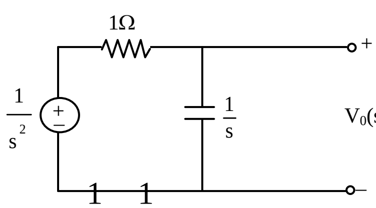
**Sol:** In case of Michelson interferometer if we use polychromatic light the pattern is not readable & no more useful, also color fringes overlap on each other.

**09. Ans: (b)**

**Sol:**




Converting into Laplace domain we get




$$V_0(s) = \frac{\frac{1}{s}\times\frac{1}{s^2}}{1+\frac{1}{s}} = \frac{1}{s^3\left(\frac{s+1}{s}\right)}$$

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

$$V_0(s) = \frac{A}{s}+\frac{B}{s^2}+\frac{C}{s+1}$$

$$B = \left.\frac{1}{s+1}\right|_{s=0} = 1$$

$$A = \left.\frac{dB}{ds}\right|_{s=0} = \left.\frac{(s+1)\times 0-1}{(s+1)^2}\right|_{s=0} = -1$$

$$C = \left.\frac{1}{s^2}\right|_{s=-1} = 1$$

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

Apply inverse Laplace transform on both sides

$V_0(t) = -u(t) + tu(t) + e^{-t}u(t)$

$V_0(t) = ((t-1) + e^{-t})u(t),\ t > 0$

**10. Ans: (d)**

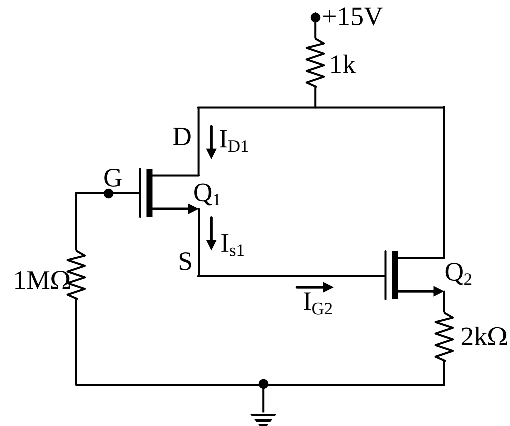
**Sol:** If $V_A > V_B$ all diodes are forward biased hence $R_{AB} = 0$. If $V_A < V_B$, $D_1$ $D_3$ RB & $D_2$ FB

$\therefore R_{AB} = 36\ \Omega + 18\ \Omega$

$= 54\ \Omega$

**11. Ans: –4 (No range)**

**Sol:**




**Step(1):** From the circuit,

$I_{S1} = I_{G2} = 0$ ____(1) [$\because I_G = 0$ in MOSFETs]

$\Rightarrow I_{D1} = I_{S1} = 0$ ____(2) [$\because I_D = I_S$ in MOSFETs

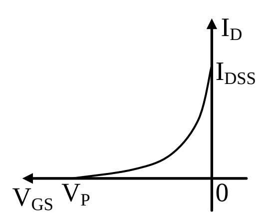
**Step(2):**Consider the transfer characteristics of a DMOSFET

Case (i): $I_D = I_{DSS}$ at $V_{GS} = 0$ ____(3)

Case (ii): $I_D = 0$ at $V_{GS} = V_P$ _____(4)

$\Rightarrow V_{GSQ1} = V_P = -4V$ ___(5)

$\because I_{D1} = 0$ in the ckt given



**12. Ans: (b)**

**Sol:** MOD-n ring counter is designed by using 'n' flipflops.
MOD-2n Johnson counter is designed by using 'n' flipflops.
So, MOD-8 ring counter requires 8 flipflops and MOD-8 Johnson counter requires 4 flipflops.

**13. Ans: 8.33 (Range: 8 to 8.6)**

**Sol:** According the concept of virtual ground
$V_1 = V_2$

$$\Rightarrow 5V = \frac{30kV_0}{30k + 20k}$$

$$\therefore\ V_0 = \frac{5V \times 50k}{30k} = 8.33V$$

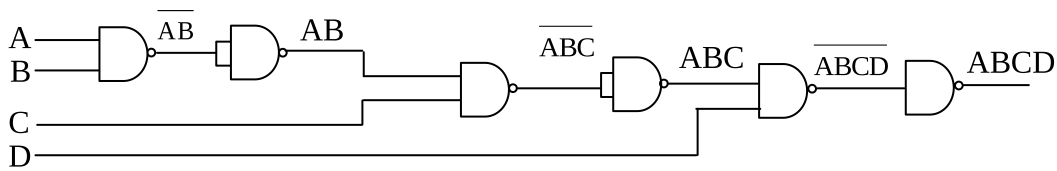
**14. Ans: (b)**

**Sol:** $\text{Energy}\,\alpha\,\dfrac{1}{\text{wave length}}$

$$E = \frac{hc}{\lambda}$$

**15. Ans: 6 (No range)**

**Sol:** $Y = ABCD = \overline{\overline{\overline{\overline{\overline{\overline{AB}}\,C}}\,D}}$




$\therefore$ 6 NAND gates are required.

**16. Ans: (a)**

**Sol:** $|adjA| = |A|^{n-1}$

$\Rightarrow 1(12 - 12) - 11(4 - 6) + 3(4 - 6) = |A|^2$

$\Rightarrow 22 - 6 = |A|^2$

$\therefore |A| = \pm 4$

**17. Ans: 55 (Range: 54.90 to 55)**

**Sol:** Compensator $D(s) = \dfrac{0.4s+1}{0.04s+1} = \dfrac{1+aTs}{1+Ts}$

aT = 0.4
T = 0.04
$\therefore$ a = 10
Maximum phase angle,

$$\phi_m = \sin^{-1}\left(\frac{a-1}{a+1}\right) = 55°$$

**18. Ans: (c)**

**Sol:** Given $y(n) - \dfrac{1}{4}y(n-1) = x(n)$

Apply z transform

$$Y(z) - \frac{1}{4}z^{-1}Y(z) = X(z)$$

$$Y(z) = \frac{X(z)}{1 - \frac{1}{4}z^{-1}}$$

$x(n) = \delta(n-1)$

$$X(z) = z^{-1}$$

$$Y(z) = \frac{z^{-1}}{1 - \frac{1}{4}z^{-1}}$$

Apply inverse z transform

$$\left(\frac{1}{4}\right)^n u(n) \leftrightarrow \frac{1}{1-\frac{1}{4}z^{-1}}$$

From time shifting property

$$\left(\frac{1}{4}\right)^{n-1} u(n-1) \leftrightarrow \frac{z^{-1}}{1-\frac{1}{4}z^{-1}}$$

So, $y(n) = \left(\frac{1}{4}\right)^{n-1} u(n-1)$

**19. Ans: 4 ( no range)**

**Sol:** $\frac{1}{T_S} = 8000$

So, $T_S$ = 125μ sec

The separation between samples is 5μsec

As the sample is represented by a pulse of 1μsec duration. The separation between two successive pulses is 4 μsec.

**20. Ans: (d)**

**Sol:** $(1+t)\frac{dy}{dt} = 4y$

$$\int \frac{1}{y}dy = \int \frac{4}{1+t}dt$$

log y = 4 log (1 + t) + log(c)

$y = c(1 + t)^4$

$y(0) = 1 \Rightarrow 1 = c(1 + 0)^4 \Rightarrow c = 1$

$\Rightarrow y = (1 + t)^4$

**21. Ans: (c)**

**Sol:** $H_1(z) = \frac{z^2 + 1.5z - 1}{z^2}$ and

$H_2(z) = z^2 + 1.5z - 1$

∴ The zeros of the functions will be identical but not the poles.

**22. Ans: (d)**

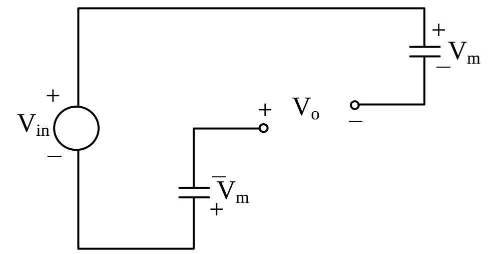
**Sol:** $\frac{E}{R} = \frac{1}{1-\left[-\frac{4}{s+1}-\frac{4}{s+1}\right]} = \frac{s+1}{s+9}$

**23. Ans: (d)**

**Sol:** During positive cycle $D_3$ is FB, $D_4$ is RB. Hence $C_1$ gets charged to $V_m$

During Negative cycle $D_1$ is FB, $D_2$ is RB. Hence $C_2$ gets charged to $-V_m$

After the capacitors are charged, the diodes will remain reverse biased




KVL

$-V_{in} + V_m - V_o - V_m = 0$

$V_o = -V_{in}$

**24. Ans: 1 (No range)**

**Sol:** If rank of A is 2, then |A| = 0

$\Rightarrow x^3 - 1$

$(x - 1)(x^2 + x + 1) = 0$

$\Rightarrow x = 1, \ \frac{-1 \pm \sqrt{3}i}{2}$

$\therefore x = 1$

**25. Ans: (d)**

**Sol:** The percent error is

$$e_p = \frac{r-b}{b_{max} - b_{min}} \times 100$$

$$= \frac{384-379}{440-300} \times 100$$

= 3.6%

**26. Ans: (d)**

**Sol:** Given curve 'C' is a closed curve.

So, we have to evaluate the integral by using Green's theorem.

By Green's theorem, we have

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

Now, $\oint_C [(x-y)dx + (x+3y)\,dy]$

$$= \iint_R \left[\frac{\partial}{\partial x}[x+3y] - \frac{\partial}{\partial y}(x-y)\right] dx\ dy$$

$$= \iint_R [1-(-1)]\, dx\, dy$$

$$= 2\iint_R 1\,dx\,dy$$

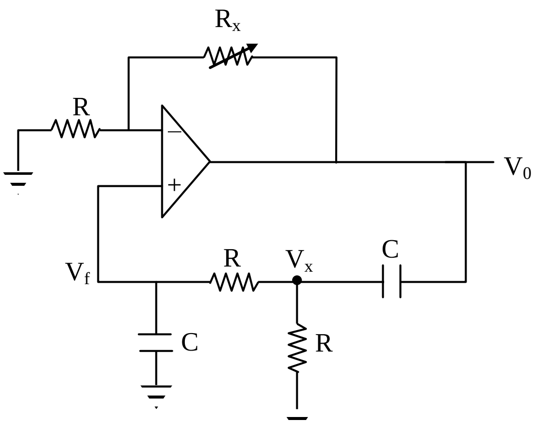
= 2(Area of the circle 'C')

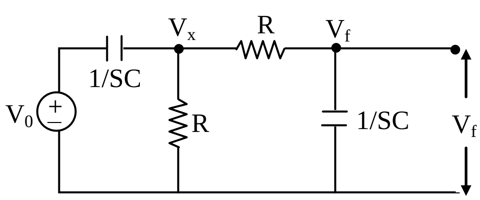
$= 2(\pi r^2)_{r=4}$

$= 32\pi$

**27. Ans: (c)**

**Sol:**



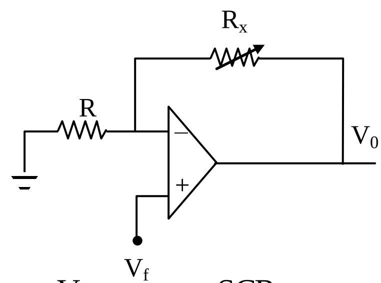




Feedback Network

$$\frac{V_0 - V_x}{\frac{1}{SC}} = \frac{V_x}{R} + \frac{V_x - V_f}{R} \quad \text{……. (1)}$$

and $\dfrac{V_x - V_f}{R} = \dfrac{V_f}{\frac{1}{SC}}$ …… (2)

$\therefore V_x = (1+SRC)\, V_f$ --------(3)




$$\Rightarrow \beta = \frac{V_f}{V_0} = \frac{SCR}{S^2C^2R^2 + 3SCR + 1}$$

[$\because$ from equation (1), (2) & (3)]

$$\therefore \beta = \frac{1}{3 + j\left[\omega CR - \frac{1}{\omega CR}\right]}$$

$$\frac{V_0}{V_f} = 1 + \frac{R_x}{R}$$

Since for sustained oscillations $\beta A = 1$

$$\Rightarrow A = \frac{1}{\beta}$$

$$\therefore 1 + \frac{R_x}{R} = 3 + j\left[\omega CR - \frac{1}{\omega CR}\right]$$

Equating img., parts

$$\Rightarrow \omega CR - \frac{1}{\omega CR} = 0$$

$$\Rightarrow f = \frac{1}{2\pi RC}\,\text{Hz}$$

$$\&\ 1 + \frac{R_x}{R} = 3$$

$\therefore R_x = 2R$

**28. Ans: 560**

**Sol:** Applied pressure $P = 0.8\times10^6$ ($N/m^2$)

Bellows deflection for given pressure

$\Delta x = 0.125$mm

LVDT sensitivity $\Rightarrow S = 40\left(\frac{V}{mm}\right)$

Sensitivity of the LVDT in $\left(\frac{V}{N/m^2}\right) = S\Delta x \frac{1}{P}$

$$= 40(V/mm) \times 0.125(mm) \times \frac{1}{0.8\times10^6 (N/m2)}$$

$$= 6.25\times10^{-6}\frac{V}{(N/m^2)}$$

Sensitivity of the LVDT

$$\left(\frac{\mu V}{N/m^2}\right) = 6.25\left(\frac{\mu V}{N/m^2}\right)$$

Pressure output of LVDT for

$$3.5V \text{ is} = \frac{3.5}{6.25\times10^{-6}} = 0.56\times10^6 = 560 \text{ KN}/m^2$$

**29. Ans: 0.2**

**Sol:** Given that $\frac{dy}{dx} = x^3 - 2y$ $\quad\left(\because \frac{dy}{dx} = f(x, y)\right)$

with y(0) = 0.25 $\quad$ ($\because$ $y(x_0) = y_0$)

Let $x_0 = 0$, $y_0 = 0.25$ & $h = 0.1$

Then $x_1 = x_0 + h = 0.1$

The formula for Euler's forward method is

$y(x_1) \simeq y_1 = y_0 + h\, f(x_0, y_0)$

$\Rightarrow y(0.1) \simeq y_1 = 0.25 + (0.1)\left(x_0^3 - 2y_0\right)$

$\Rightarrow y(0.1) \simeq y_1 = 0.25 + (0.1)\,[0 - 2(0.25)]$

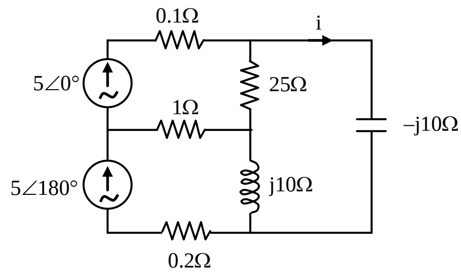
$\therefore y(0.1) \simeq y_1 = 0.25 - (0.1)(0.5)$

$= 0.25 - 0.05$

$= 0.2$

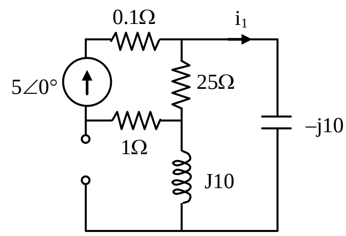
**30. Ans: (b)**

**Sol:**

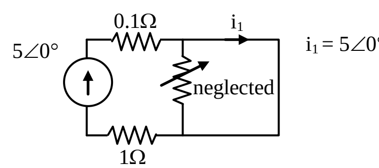



By super position principle $i = i_1 + i_{11}$

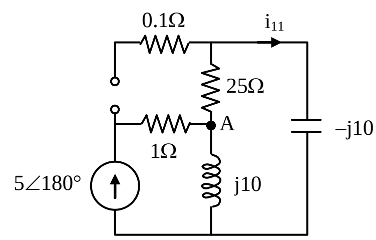
Current $i_1$: $5\angle0°$ source acting alone




$-j10 + j10 = 0\ \Omega$ (short circuit)




Current $i_{11}$: $5\angle180°$ source acting alone




By current division rule at node A

$$i_{11} = 5\angle180° \times \frac{j10}{25 + j10 - j10}$$

$= 2j\angle180°$

$= -2j$

$\therefore I = i_1 + i_{11} = 5 - 2j$ A

**31. Ans: 3750**

**Sol:** Give data:

$\lambda = 9000A^\circ$

$\Delta = 2\%$

$\mu_{core} = 1.6 = n_1$

$\pi = 3$

$V = 8$

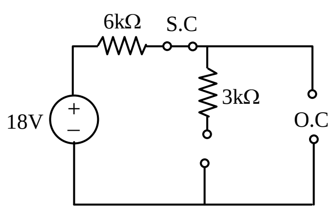
$$V = \frac{2\pi r}{\lambda} n_1 \sqrt{2\Delta}$$

$$8 = \frac{2\times 3\times r}{9000\times 10^{-10}}\times 1.6\sqrt{2\times\frac{2}{100}}$$

$r = 3750nm$

**32. Ans: –60 (No Range)**

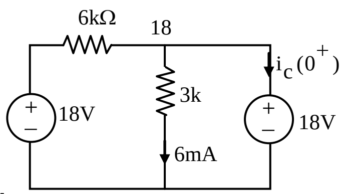
**Sol:** At time $t = 0^-$ switch is in open condition




So, L is short circuit, C is open circuit $i_L(0^-) = 0$

$V_C(0^+) = V_C(0^-) = 18V$

At $t = 0^+$ switch is closed




$$I_C(0^+) = C\frac{dv(0^+)}{dt}$$

$$\frac{dv(0^+)}{dt} = \frac{i_C(0^+)}{C}$$

$$i_C(0^+) = -6\times 10^{-3}A$$

$$\frac{dv(0^+)}{dt} = \frac{-6\times 10^{-3}}{100\times 10^{-6}}$$

$$\frac{dv(0^+)}{dt} = -60V/sec$$

**33. Ans: 16 (Range: 15.9 to 16.2)**

**Sol:** $G(s)\,H(s) = \frac{10}{(s+2)^4}$

$$\angle G(j\omega)\,H(j\omega) = \angle\frac{10}{(j\omega+2)^4}$$

$$\text{Gain margin(GM)} = 20\log\frac{1}{|G(j\omega)H(j\omega)|_{\omega=\omega_{PC}}}$$

$$\angle G(j\omega)H(j\omega)\big|_{\omega=\omega_{PC}} = -180^o$$

$$\angle\frac{10}{(j\omega+2)^4}\bigg|_{\omega=\omega_{pc}} = -180^o$$

$$-4\tan^{-1}\frac{\omega_{pc}}{2} = -180^o$$

$\Rightarrow \omega_{PC} = 2$

$$|G(j\omega)H(j\omega)|_{\omega=\omega_{PC}} = \left|\frac{10}{(j(2)+2)^4}\right|$$

$$= \frac{10}{\left(\sqrt{2^2+2^2}\right)^4} = \frac{10}{64}$$

$$\text{Gain margin} = 20\log\frac{64}{10}$$

$= 20[\log 64 - \log 10]$

$= 20\,[6\,(0.3) - 1]$

$= 16$ (Range: 15.9 to 16.2)

**34. Ans: 1.69 (Range: 1.45 to 1.85)**

**Sol:** The value of K can be determined from the following equation:

$$K = \frac{I_{D(on)}}{\left(V_{GS(on)} - V_{GS(th)}\right)^2}$$

$$= \frac{10mA}{(10V-1.5V)^2} = 1.38\times 10^{-1} mA/V^2$$

$[\because V_{GS\,(on)} = 10V]$

From the circuit, the source voltage is seen to be 0V.

Therefore, $V_{GS} = V_G - V_S = V_G - 0 = V_G$.

The value of $V_G$ ( $= V_{GS}$) is given by:

$$V_G\,(\text{or } V_{GS}) = \frac{V_{DD}}{R_1+R_2}\times R_2$$

$$= \frac{10V}{(1+1)M\Omega}\times 1M\Omega = 5V$$

$I_D = K\,(V_{GS} - V_{GS\,(th)})^2$

$= (1.38\times10^{-1}\text{mA/V}^2)\,(5V - 1.5V)^2$

$= 1.69\text{mA}$

**35. Ans: 0.0045 (Range: 0.004 to 0.005)**

**Sol:** Let X = number of accidents between 5 P.M and 6 P.M.

For Poisson distribution,

$\lambda = np = (1000)\,(0.0001) = 0.1$

$P(X = x) = \dfrac{e^{-\lambda}.\lambda^x}{\angle x}$ (x = 0, 1, 2,……..)

Required Probability = $P(X \geq 2)$

$= 1 - P(X < 2)$

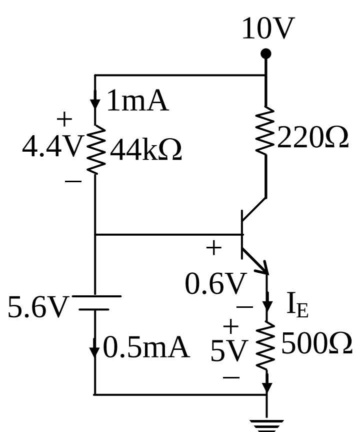
$= 1 - \{P(X = 0) + P(X = 1)\}$

$= 1 - e^{-0.1}\,(1 + 0.1)$

$= 0.0045$

**36. Ans: 0.95 (No range)**

**Sol:** Zener diode is in breakdown, replace it with a voltage source of value $V_Z$ = 5.6V & $V_{BE}$ = 0.6V




Applying KCL at Base, we get

$-1\text{mA} + 0.5\text{mA} + I_B = 0$

$I_B = 0.5\text{mA}$

$I_E = \dfrac{5}{500\Omega} = 10\text{mA}$

$I_E = (\beta+1)\,I_B$

$\beta+1 = \dfrac{I_E}{I_B}$

$\beta+1 = \dfrac{10}{0.5}$

$\beta + 1 = 20$

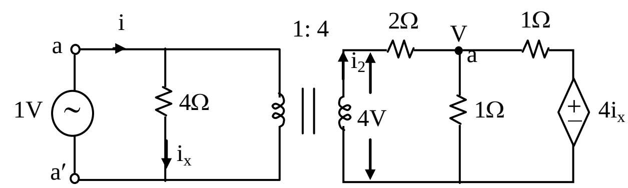
$\beta = 19$

$\alpha = \dfrac{\beta}{1+\beta} = \dfrac{19}{20} = 0.95$

**37. Ans: 171 (Range: 165 to 175)**

**Sol:** Now 1V is applied at primary side a-a′

$R = \dfrac{1}{i}$




By transformation ratio

$K = \dfrac{4}{1} = 4$

$\dfrac{V_2}{V_1} = k = 4$

$V_2 = 4V$

$i_x = \dfrac{1}{4}A$

Apply KCL at node-a,

$$\frac{V-4}{2} + \frac{V}{1} + \frac{V-4i_x}{1} = 0$$

$V - 4 + 2V + 2V - 8i_x = 0$

$5V = 4 + 8i_x = 4 + 8\dfrac{1}{4} = 6$

$V = \dfrac{6}{5}V$

$i_2$ is current flows through secondary winding then

$$i_2 = \frac{4-\frac{6}{5}}{2} = \frac{14}{10} = 1.4\,A$$

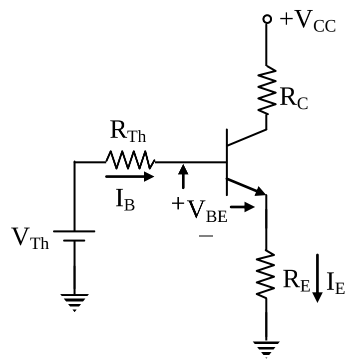
This $i_2$ transferred to primary then $i_2' = 1.4\times 4$

$\therefore$ $i = i_x + i_2' = \frac{1}{4} + 1.4\times 4 = 5.85$ A

$\therefore$ $R = \frac{1}{i} = \frac{1}{5.85} = 171$ m$\Omega$

**38. 4.92 (Range: 4.8 to 5.1)**

**Sol:**




fig(a): Thevenin equivalent of the given circuit

**Step (1):**

KVL for the input loop of circuit shown in fig (a)

$V_{Th} - I_B R_{Th} - V_{BE} - I_E R_E = 0$ ------- (1)

$I_E = \dfrac{V_{Th} - V_{BE}}{R_E + \frac{R_{Th}}{1+\beta}}$ ---- (2) $\left[\because I_B = \frac{I_E}{1+\beta}\right]$

$V_{Th} = \dfrac{V_{CC}R_2}{R_1 + R_2}$

$R_{Th} = R_1 // R_2$

**Step (2):**

But $I_E R_E = \dfrac{V_{CC}}{3} = \left[\dfrac{V_{Th} - V_{BE}}{R_E + \frac{R_{Th}}{1+\beta}}\right] R_E$ ----- (3)

($\because$ Given that voltage drop across $R_E = \frac{V_{CC}}{3}$)

$$\left\{\frac{(V_{Th} - V_{BE})}{R_E\left[1 + \left(\frac{R_{Th}}{R_E}\right)\left(\frac{1}{1+\beta}\right)\right]}\right\} R_E = \frac{V_{CC}}{3} \text{ ----- (4)}$$

$$V_{Th} = \frac{V_{CC}}{3}\left[1 + \left(5.73\times\frac{1}{101}\right)\right] + V_{BE} \text{ ----- (5)}$$

$V_{Th} = 4.92693$V -------- (6)

**39. Ans: (b)**

**Sol:** Given $v = y + e^{-x}\cos y$

$\Rightarrow v_x = -e^{-x}\cos(y)$ and $v_y = 1 - e^{-x}\sin(y)$

Consider $du = (u_x)\,dx + (u_y)\,dy$

$= (v_y)\,dx + (-v_x)\,dy$

$\Rightarrow du = (1 - e^{-x}\sin y)\,dx + (e^{-x}\cos y)\,dy$

$\Rightarrow \int du = \int (1 - e^{-x}\sin y)\,dx + \int 0\,dy + k$

$\Rightarrow u = x + e^{-x}\sin y + k$

Now the required analytic function f(z) is given by $f(z) = u + iv$

$\Rightarrow f(z) = (x + e^{-x}\sin y + k)$

$+ i\,(y + e^{-x}\cos y)$

$\therefore$ $f(z) = z + ie^{-z} + k$

**40. Ans: (b)**

**Sol:** For break point,

$\dfrac{dk}{ds} = 0$

$\dfrac{d}{ds}\left(\dfrac{1}{G(s)H(s)}\right) = 0$

$\dfrac{d}{ds}(s(s+6)(s^2+4s+13)) = 0$

$(s^2+6s)[2s+4] + (s^2+4s+13)[2s+6] = 0$

$2s^3+16s^2+24s+2s^3+6s^2+8s^2+24s+26s+78 = 0$

$4s^3 + 30s^2 + 74s + 78 = 0$

$f(s) = 2s^3 + 15s^2 + 37s + 39 = 0$ -------(1)

$f(-5) = -21$

f (–4) = 3
f (–3) = 9
As there is a sign change in between –5, –4, one root is on real axis, which is in between –5, –4. Three real axis break points is not possible.

**41. Ans: (b)**

**Sol:** $f(t) = \left(-\frac{t}{T}+1\right)\left[u(t)-u(t-T)\right]$

$f(t) = \left(-\frac{t}{T}\right)\left[u(t)-u(t-T)\right]+\left[u(t)-u(t-T)\right]$

$\left[u(t)-u(t-T)\right] \leftrightarrow \frac{1}{s}-\frac{e^{-sT}}{s}$

From differentiation in s-domain property

$$\left(-\frac{t}{T}\right)\left[u(t)-u(t-T)\right] \leftrightarrow \frac{1}{T}\frac{d}{ds}\left(\frac{1}{s}-\frac{e^{-sT}}{s}\right) = \frac{1}{T}\left[\frac{-1}{s^2}-\frac{\left(se^{-sT}(-T)-e^{-sT}\right)}{s^2}\right]$$

$$\left(-\frac{t}{T}\right)\left[u(t)-u(t-T)\right] \leftrightarrow \frac{1}{T}\left[\frac{-1}{s^2}+T\frac{e^{-sT}}{s}+\frac{e^{-sT}}{s^2}\right] = \frac{e^{-sT}}{s}+\frac{e^{-sT}}{Ts^2}-\frac{1}{s^2T}$$

$$F(s) = \frac{1}{s}-\frac{e^{-sT}}{s}+\frac{e^{-sT}}{s}+\frac{e^{-sT}}{Ts^2}-\frac{1}{s^2T} = \frac{1}{s}+\frac{e^{-sT}}{Ts^2}-\frac{1}{s^2T} = \frac{1}{s^2T}\left[sT-1+e^{-sT}\right]$$

**42. Ans: 3 (No range)**

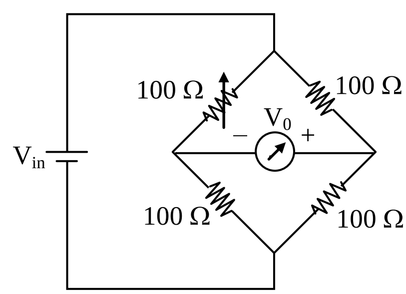
**Sol:** $J_0 = \overline{Q}_1$; $K_0 = 1$; $J_1 = Q_0$; $K_1 = 1$

| $J_0$ $K_0$ | $J_1$ $K_1$ | $Q_0$ $Q_1$ |
|---|---|---|
| | | 0 0 |
| 1 1 | 0 1 | 1 0 |
| 1 1 | 1 1 | 0 1 |
| 0 1 | 0 1 | 0 0 |
| 1 1 | 0 1 | 1 0 |

→ It is a mod-3 counter.

**43. Ans: (c)**

**Sol:** $V_{in} = 15 \times 10^{-3}[100+100]$
$V_{in} = 3$ Volts




% change in "$R_s$" is 5% $\Rightarrow 100\times\frac{5}{100} = 5\Omega$

$R_s = 105\ \Omega$

$V_0 = \frac{3\times100}{200}-\frac{3\times100}{205} = 300\left[\frac{1}{200}-\frac{1}{205}\right]$
$= 0.03658 = 36.58$ mV

**44. Ans: (c)**

**Sol:** By giving different sets of input values and Q(t) (present state) we have to determine next state Q(t+1)

| X | Y | Q(t) | S | R | Q(t+1) |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 1 | × |
| 1 | 1 | 1 | 1 | 1 | × |

K-map for Q (t + 1)

| X \ YQ(t) | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 1 | 1 | | |
| 1 | | 1 | × | × |

$$\therefore\ Q(t+1)=\overline{X}\,\overline{Y}+\overline{Y}Q(t) \qquad \text{or}$$

$$Q(t+1)=\overline{X}\,\overline{Y}+XQ(t)$$

**45. Ans: 0.5**

**Sol:** Given y(n) be a 4 point circular convolution of x(n) & h(n)

y(n) = x(n) circular convolution h(n)

Apply DFT

Y(k) = X(k) H(k)

Y(k) = {1, −2,1, −2}. {1, j, 1, −j}

= {1, – 2j, 1, 2j}

$$\text{IDFT}\ \ y(n)=\frac{1}{N}\sum_{k=0}^{N-1}Y(k)e^{j\frac{2\pi}{N}nk}$$

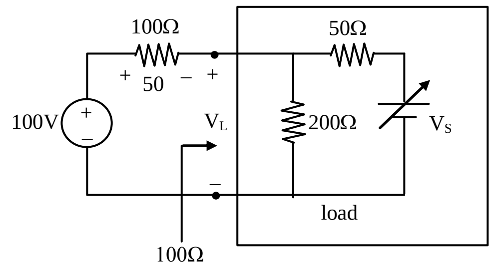
$$y(0)=\frac{1}{N}\sum_{k=0}^{N-1}Y(k)$$

N = 4

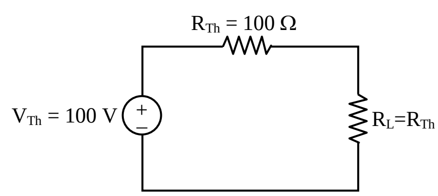
$$y(0)=\frac{1}{4}\sum_{k=0}^{3}Y(k)=\frac{1}{4}[1-2j+1+2j]=\frac{2}{4}=\frac{1}{2}$$

**46. Ans: 37.5 (Range: 37 to 38)**

**Sol:** Applying thevenin's theorem in the source side, the circuit can be redrawn as




We know that for maximum power transform, the load resistance is equal to Thevenin's resistance.




Voltage drop across load, $V_L = \dfrac{V_{Th}\times R_L}{R_{Th}+R_L}$

$$\Rightarrow V_L = \frac{V_{Th}\times R_L}{2R_{Th}}$$

$$V_L = \frac{V_{Th}}{2}$$

Consider above figure, for maximum power transferred to load

$$V_L = \frac{V_{TH}}{2}=\frac{100}{2} = 50\ \text{Volts}$$

Applying nodal analysis, we get

$$\Rightarrow \frac{50}{100}=\frac{50}{200}+\frac{50-V_s}{50}$$

$\Rightarrow \frac{50-V_s}{50} = \frac{1}{4}$

$\Rightarrow 50 - V_s = 12.5$

$\Rightarrow V_s = 37.5$ V

**47. Ans: (c)**

**Sol:** $A_c \cos 2\pi f_c t + \frac{A_c\mu}{2}\cos 2\pi(f_c + f_m)t + \frac{A_c\mu}{2}\cos 2\pi(f_c - f_m)t$

USB is attenuated by a factor of '2'

$= A_c \cos 2\pi f_c t + \frac{A_c\mu}{4}\cos 2\pi(f_c + f_m)t + \frac{A_c\mu}{2}\cos 2\pi(f_c - f_m)t$

$= \cos 2\pi f_c t + \frac{1}{8}\cos 2\pi(f_c + f_m)t + \frac{1}{4}\cos 2\pi(f_c - f_m)t$

The inphase component is

$\left[1+\frac{1}{8}\cos 2\pi f_m t + \frac{1}{4}\cos 2\pi f_m t\right].\cos 2\pi f_c t = \left[1+\frac{3}{8}\cos 2\pi f_m t\right]$

**48. Ans: (b)**

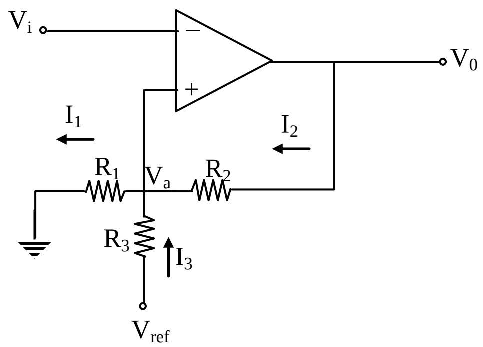
**Sol:**
- (SP) = 8086H
- (DE) = 8085H
- (HL) exchanged with (DE)
  After execution
  (HL) = 8085H, (DE) = ××××H
- (HL) = 8085H = 1000 0000 1000 0101
  (SP) = 8086H = 1000 0000 1000 0110
  (HL) = 010BH = 0000 0001 0000 1011
- (HL) = 010BH copied into (SP)
  $\Rightarrow$ (SP) = 010BH
- 8085 microprocessor calls delay subroutine and after execution of subroutine, microprocessor returns to main program.
  SP contents decremented by 2 for CALL operation
  SP contents incremented by 2 for RETURN operation
  i.e., (SP) = 010BH – 2 + 2
  = 010BH
- 8085 microprocessor pushes DE pair contents to stack. SP contents will be decremented by 2 for PUSH operation.
  (SP) = 010BH – 2 = 0109H
- 8085 microprocessor executes RST 7 software interrupt where it calls respective ISR and returns to main execution.
  (SP) = 0109H – 2 + 2 = 0109H
- 8085 microprocessor contents of top 2 stack locations back into PSW. SP contents will be incremented by 2 for POP operation.
  (SP) = 0109H + 2 = 010BH
- (SP) = 010BH

**49. Ans: 2.19 (2.18 to 2.20)**

**Sol:** Apply KCL at $V_a$

$I_1 = I_2 + I_3$

$$\frac{V_a}{R_1} = \frac{V_{ref} - V_a}{R_3} + \frac{V_0 - V_a}{R_2}$$




$$V_a\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right] = \frac{V_{ref}}{R_3} + \frac{V_0}{R_2}$$

$V_a = V_{UTP}$ when $V_0 = +V_{sat}$

$V_a = V_{LTP}$ when $V_0 = -V_{sat}$

$$V_a = \frac{\dfrac{V_{ref}}{R_3} + \dfrac{V_{sat}}{R_2}}{\left[R_1^{-1} + R_2^{-1} + R_3^{-1}\right]}$$

$$V_{UTP} = \frac{\dfrac{-10}{10} + \dfrac{12}{50}}{\left[\dfrac{1}{10} + \dfrac{1}{10} + \dfrac{1}{50}\right]} = -3.4545 \text{ V}$$

$V_{LTP} = -5.6363$ V

$V_H = V_{UTP} - V_{LTP}$

$V_H \approx 2.19$

**50. Ans: (d)**

**Sol:** $$X(\omega) = \frac{1}{(2 + j\omega)^2}$$

$$H(\omega) = \frac{1}{4 + j\omega}$$

$$Y(\omega) = X(\omega).H(\omega) = \frac{1}{(4 + j\omega)(2 + j\omega)^2}$$

$$= \frac{1/4}{4 + j\omega} - \frac{1/4}{2 + j\omega} + \frac{1/2}{(2 + j\omega)^2}$$

$$y(t) = \frac{1}{4}e^{-4t}u(t) - \frac{1}{4}e^{-2t}u(t) + \frac{1}{2}te^{-2t}u(t)$$

$$y(3) = \frac{1}{4}e^{-12} - \frac{1}{4}e^{-6} + \frac{3}{2}e^{-6} = \frac{1}{4}e^{-12} + \frac{5}{4}e^{-6}$$

**51. Ans: (c)**

**Sol:** $P_1 = 600$ W

$P_2 = 300$ W

$$\therefore\ \theta = \tan^{-1}\left(\sqrt{3}\,\frac{P_1 - P_2}{P_1 + P_2}\right)$$

$$= \tan^{-1}\left[\sqrt{3}\left(\frac{600 - 300}{600 + 300}\right)\right] = 30°$$

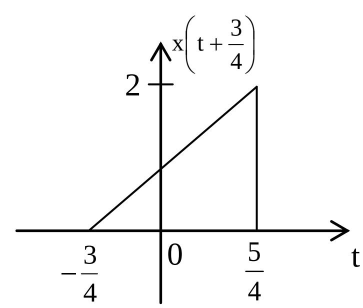
$P = P_1 + P_2 = 600 + 300 = 900$ W

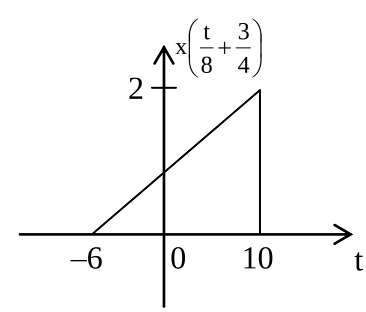
$$\tan\theta = \frac{Q}{P} \Rightarrow \tan 30° = \frac{Q}{900}$$

$$\Rightarrow Q = \frac{900}{\sqrt{3}} = 300\sqrt{3} \text{ VAR}$$

**52. Ans: (d)**

**Sol:**




**53. Ans: (a)**

**Sol:** Given $(2xy - 9x^2)dx + (2y + x^2 + 1)dy = 0$

Here, $M = 2xy - 9x^2$ and $N = 2y + x^2 + 1$

Now, $\frac{\partial M}{\partial y} = 2x = \frac{\partial N}{\partial x}$

$\therefore$ The given D.E is exact

Now the general solution of the given D.E is

$\int(2xy - 9x^2)dx + \int(2y + 0 + 1)dy = C$

$\Rightarrow x^2y - 9\frac{x^3}{3} + y^2 + y = C$ ........ (1)

but y = – 3 at x = 0

Now (1) becomes

$0 - 0 + 9 - 3 = C$

$\Rightarrow C = 6$

$\therefore$ The solution of a given D.E is

$x^2y - 3x^3 + y^2 + y = 6$

**54. Ans: 0.02**

**Sol:**

$d = 5 \times 10^{-2}$ m,

B = 0.1 T,

$E = 0.1 \times 10^{-3}$ V

$$v = \frac{E}{Bl} = \frac{0.1\times10^{-3}}{(0.1)(5\times10^{-2})} = 0.02 m/s$$

**55. Ans:0 (No range)**

**Sol:** $\delta(t^2 - a^2) = \frac{1}{2|a|}[\delta(t+a) + \delta(t-a)]$

$$I = \int_{-1}^{1}\frac{1}{4}[\delta(t-2) + \delta(t+2)]dt$$

$$I = \frac{1}{4}\int_{-1}^{1}\delta(t-2)dt + \frac{1}{4}\int_{-1}^{1}\delta(t+2)dt$$

From sifting property

$$\int_{t_1}^{t_2} x(t)\delta(t-t_0)dt = x(t_0) \quad t_1 \le t_0 \le t_2$$

$$= 0 \qquad \text{otherwise}$$

$I = 0 + 0 = 0$

**56. Ans: (d)**

**Sol:** (PART AND THE WHOLE) A fragment is a piece of broken bone; a shard is a piece of broken pottery. (d)

**57. Ans: (a)**

**58. Ans: (d)**

**Sol:** irretrievably means impossible to recover or get back, so irrevocably is the correct synonym, which means not capable of being changed : impossible to revoke.

**59. Ans: (b)**

**Sol:** Indiscriminate (adj.) means not discriminating or choosing randomly; haphazard; without distinction.

**60. Ans: (a)**

**Sol:** $a_0 = 1$; $a_n = 2a_{n-1}$ if n is odd

$a_n = a_{n-1}$ if n is even

$a_{100} = a_{100-1} = a_{99} = 2.a_{99-1}$

$= 2.a_{99} = 2.a_{98-1} = 2a_{97}$

$= 2.2a_{97-1} = 2^2.a_{96}$ ……… $2_{50}.a_0 = 2^{50}$

**61. Ans: (c)**

**Sol:** A = 1; B = 1

(a) B = B + 1 = 2

(b) & (c) A = A × B = 1 × 2 = 2

Step 2: B = 2 + 1 = 3; A = A × B = 2 × 3 = 6

Step 3: B = 3 + 1 = 4; A = A×B = 6 × 4 = 24

Step 4: B = 4 + 1 = 5; A = 24 × 5 = 120

Step 5: B = 5 + 1 = 6; A = 120 × 6 = 720

**62. Ans: (a)**

**Sol:** Ratio of efficiency (P & Q) = 2 : 1

Ratio of efficiency (P + Q, R) = 3 : 1

If R does 1 unit work, then P& Q together do 3 units.

Out of 3 units, P does 2 units and Q does 1 unit.

$\therefore$ Ratio of efficiency (P, Q & R) = 2 : 1 : 1
Hence, earnings should be divided in the ratio is 2 : 1 : 1

**63. Ans: (c)**
**Sol:** In 1972, A was as old as the number formed by the last two digits of his year of birth.
So, A was born in 1936 (as in 1972, he is 36 yrs older also, last two digits of 1936 are 36).
Hence, B was born in 1936 + 15 = 1951
so, he is 21 yrs old in 1972

**64. Ans: (b)**
**Sol:** Difference (in thousands) between the numbers of customers in the 2 complexes in:
January: 22 – 20 = 2
February: 25 – 24 = 1
March: 20 – 15 = 5
April: 28 – 25 = 3
May: 20 – 14 = 6 [Max]
June: 20 – 15 = 5

**65. Ans: (b)**
**Sol:** The issue is more about punishing criminals, and so punishment is more important than crime prevention (correct answer B).