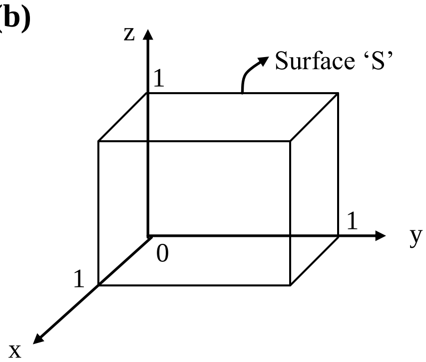
Branch: Electronics & Communication Engineering - SOLUTIONS

01. Ans: (b)

Sol:



Integral $\oint_S \vec{G}.d\vec{S} = \int_{vol} \nabla.\vec{G}\,dv$

$$\vec{G} = 2xy\hat{a}_x + 3\hat{a}_y + z^2y\hat{a}_z$$

$$\nabla.\vec{G} = 2y + 2zy$$

$$\nabla.\vec{G} = 2y(z+1)$$

$$I = \int_{x=0}^{1}\int_{y=0}^{1}\int_{z=0}^{1} 2y(z+1)dxdydz$$

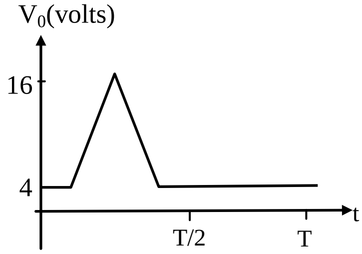
$$= 2\frac{y^2}{2}\Big|_0^1 \left(\frac{z^2}{2}+z\right)\Big|_0^1 x\Big|_0^1$$

$$\therefore I = \frac{3}{2} \qquad (I \rightarrow \text{Integral})$$

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: 2 no range

Sol: The probability density function of uniform distribution is

$$f(x) = \begin{cases} 1, & 0 < x < 1 \\ 0, & otherwise \end{cases}$$

$$E(y) = E[-2\log x] = \int_0^1 -2\log x\ f(x)\,dx$$

$$= -2\int_0^1 \log x\ dx \quad = -2\{x\log x - x\}_0^1$$

$$= -2\{(0-1)-(0)\} = 2$$

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

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

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

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

$P_c = 3200$

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

$A_c = 80V$

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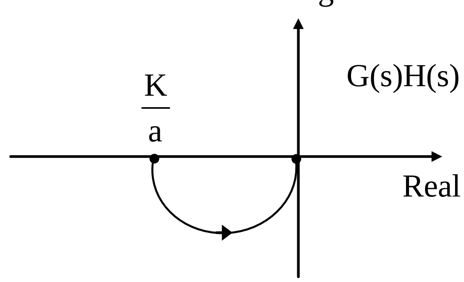
06. **Ans: (c)**

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:-

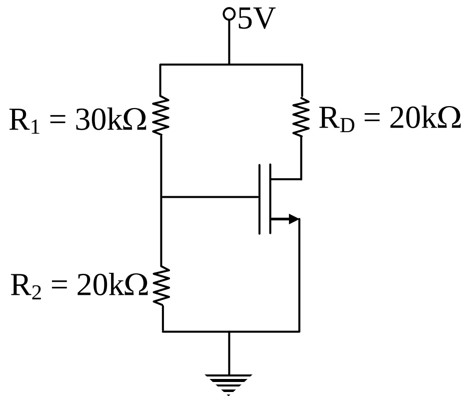
a b c	sum	carry
0 0 0	0	0
0 0 1	1	0
0 1 0	1	0
0 1 1	0	1
1 0 0	1	0
1 0 1	0	1
1 1 0	0	1
1 1 1	1	1

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: 1.61 (Range: 1.50 to 1.70)**

Sol: $V_P = 186\times10^6 = \dfrac{3\times10^8}{\sqrt{\varepsilon_r}}$

$$n = \sqrt{\varepsilon_r} = \frac{3\times10^8}{186\times10^6} = 1.61$$

10. **Ans: (c)**

Sol: $\because \underset{x\to0}{Lt}\dfrac{\tan(ax)}{x} = a$

Now, $\underset{x\to0}{Lt}\dfrac{\tan(4x)}{4x} = \dfrac{1}{4}\underset{x\to0}{Lt}\dfrac{\tan(4x)}{x}$

$$\therefore \underset{x\to0}{Lt}\frac{\tan(4x)}{4x} = \frac{1}{4}(4) = 1$$

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: (b)

Sol: $V_0 = KT\ln\left(\frac{N_{DC}N_{DB}}{n_i^2}\right)$

$\frac{V_0}{KT} = \ln\left(\frac{N_{DC}N_{DB}}{n_i^2}\right)$

$\frac{N_{DC}N_{DB}}{n_i^2} = e^{\frac{V_0}{KT}}$

$n_i^2 = \frac{N_{DC}N_{DB}}{e^{\frac{V_0}{KT}}}$

$n_i^2 = \frac{10^{16} \times 10^{14}}{e^{\frac{578\times10^{-3}}{0.02586}}}$

$n_i = 1.401 \times 10^{10}/cm^3$

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 $j\omega$ 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:

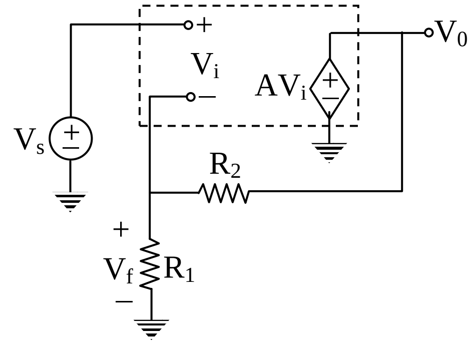


Fig. Non inverting op-amp circuit with op-amp replaced by its equivalent circuit

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

The de-sensitivity factor is $1 + A\beta$

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

$= 20\log 10^3$ dB

$= 60$dB

16. Ans: 10 (no range)

Sol: Resolution $= \Delta V_i = 5$mV

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

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

$2^n - 1 = 1000$

$2^n = 1001$

$n \approx 10$

17. Ans: (c)

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

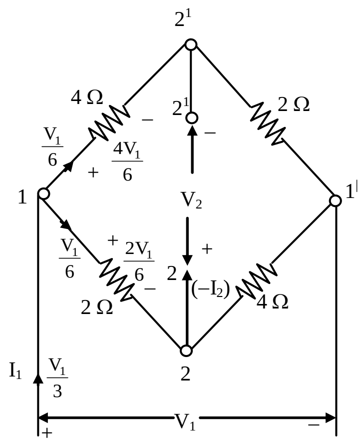
$u(t) = \delta(t) \xrightarrow{LT} U(s) = 1$

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

$y(t) = C\,e^{At}B$, 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

$I_1 = V_1/3$

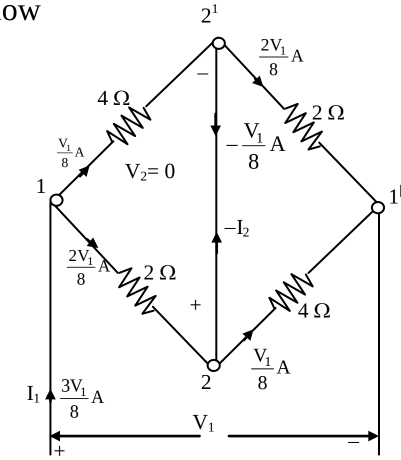
With port 2 open; $I_2 = 0$. Currents and voltage drops across different resistors are shown in above figure.

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

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) = $\frac{8}{3}\Omega$

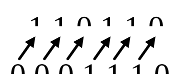
$I_1 = \frac{3V_1}{8}A$. From figure, where currents are marked, $(-I_2) = \frac{V_1}{8}A$

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

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

19. Ans: (c)

Sol:



π π 0 0 0 π

20. Ans: 0.0625 (no range)

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

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

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

By Time shifting property,

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

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

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

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: (b)

Sol: $\overline{Y}\left(z+\frac{\lambda}{4}\right)=\overline{Z}(z)$

$$\overline{Y}\left(z+\frac{\lambda}{4}\right)=(2+j3)\ \mho$$

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

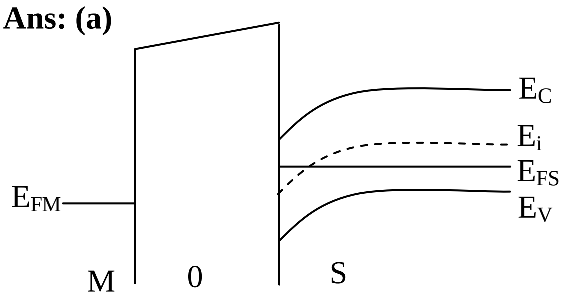
$$A=\frac{\rho\ell}{R}=\frac{(2.24\times10^{-8})(100)}{2}=1.12\times10^{-6}\,m^2$$

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

$$=1.19\times10^{-3}\ m$$

23. Ans: (a)

Sol:



At the surface, it has become from p-type to n-type ($E_{FS} > E_i \Rightarrow$ n-type).
Thus strong inversion has taken place.

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

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

$$+8x\cos(2x)-4\sin(2x)$$

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

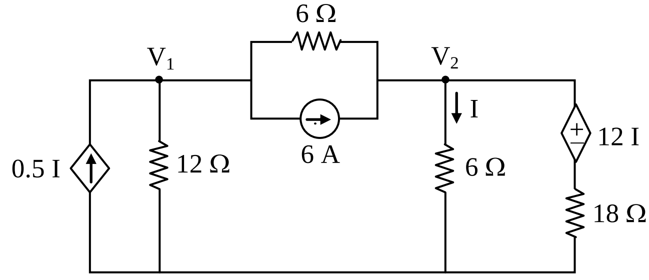
$\Rightarrow$ f(x) = x + 8x.cos(2x)

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

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

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 $\rightarrow$

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

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

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

$\Rightarrow$ True Assumption

$\Rightarrow V_3 = -1.32V$ is Correct

30. Ans: 0.863 (Range 0.7 to 1.0)

Sol: Maximum width of depletion region is

$x_{d\,max}=\sqrt{\frac{4\varepsilon_s\phi_F}{qN_A}}$

$\phi_F = V_T \ln\frac{N_A}{n_i}=0.0259\ln\left(\frac{10^{15}}{1.5\times 10^{10}}\right)$

$= 0.2877V$

$$x_{d\max} = \sqrt{\frac{4\times 11.7\times 8.85\times 10^{-14}\times 0.2877}{1.6\times 10^{-19}\times 10^{15}}}$$
$$= 8.63\times 10^{-5}\,\text{cm}$$
$$= 0.863\,\mu\text{m}$$

31. Ans: (b)

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

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

$$\Rightarrow A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$
$$= \begin{bmatrix} 15 & 0 & 0 \\ 0 & 14 & 0 \\ 0 & 0 & 13 \end{bmatrix}_{3\times 3} \quad \text{for } n = 3$$

$\Rightarrow A_{3\times 3}$ 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 $A_{3\times 3}$ matrix then the eigen values of matrix $A^2_{3\times 3}$ 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: (b)

Sol: $P_e = Q\left[\sqrt{\frac{E_d}{2N_0}}\right]$

$$E_d = \int_0^T [s_1(T) - s_2(T)]^2\, dt$$
$$= \int_0^T s_1^2(t)\,dt + \int_0^T s_2^2(t)dt - 2\int_0^T s_1(t)s_2(t)dt$$
$$= A^2T + A^2T - 2\left[-A^2T\right]$$
$$= 4A^2T$$
$$P_e = Q\left[\sqrt{\frac{2A^2T}{N_0}}\right]$$

33. Ans: (d)

Sol: Initial energy (W_i)

$$= \frac{1}{2}C_1V^2 = \frac{1}{2}\times 100\times 10^{-6}\times 100\times 100$$
$$= 0.5\text{J}$$

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

$$V = \frac{Q}{C} = \frac{10\times 10^{-3}}{500\times 10^{-6}} = 20\,\text{V}$$
$$W_1 = \frac{1}{2}C_1V^2 = \frac{1}{2}\times 100\times 10^{-6}\times (20)^2 = 0.02\text{J}$$
$$W_2 = \frac{1}{2}C_2V^2 = \frac{1}{2}\times 400\times 10^{-6}\times (20)^2 = 0.08\text{J}$$

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

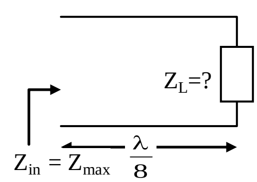
Energy dissipated = $W_i - W_f$ = 0.5 – 0.1

= 0.4J

34. Ans: (a)

Sol: On the transmission line wherever V is maximum there the impedance is also maximum.

$\therefore Z_{max} = Z_0$ (VSWR) = 25×2.4 = 60 Ω



$$Z_{in} = Z_{max} = Z_0\left[\frac{Z_L + jZ_0}{Z_0 + jZ_L}\right]$$
$$\left\{\begin{array}{l} \because Z_{in} = Z_0\left[\dfrac{Z_L + jZ_0\tan\beta\ell}{Z_0 + jZ_L\tan\beta\ell}\right] \\ \because \ell = \dfrac{\lambda}{8}, \beta\ell = \dfrac{\pi}{4} \end{array}\right\}$$
$$60 = 25\left[\frac{Z_L + j25}{25 + jZ_L}\right]$$

$$2.4(25+jZ_L)=Z_L+j25$$
$$(60-j25)=Z_L(1-j2.4)$$
$$Z_L=\frac{60-j25}{1-j2.4}\times\frac{1+j2.4}{1+j2.4}$$
$$=\frac{120+j119}{6.76}=17.75+j17.6\Omega$$
$$Z_L=17.75+j17.6\ \Omega$$

35. Ans: (d)

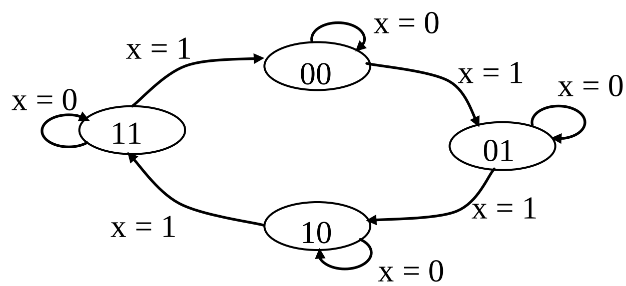
Sol: % Efficiency of AM System,

$$\%\eta=\frac{K_a^2 P_m}{1+K_a^2.P_m}\times 100\%$$
$$\frac{0.1^2\times 100}{1+0.1^2.\times 100}\times 100\ \%=\frac{1}{1+1}\times 100\ \%$$
$$=50\%$$

36. Ans: (c)

Sol:

P.S	i/p	FF i/ps	N.S
Q_1Q_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

$$CE=1+\frac{k}{(z-1)(z-1+3)(z-1+4)}=0$$
$$z^3+4z^2+z+k-6=0$$

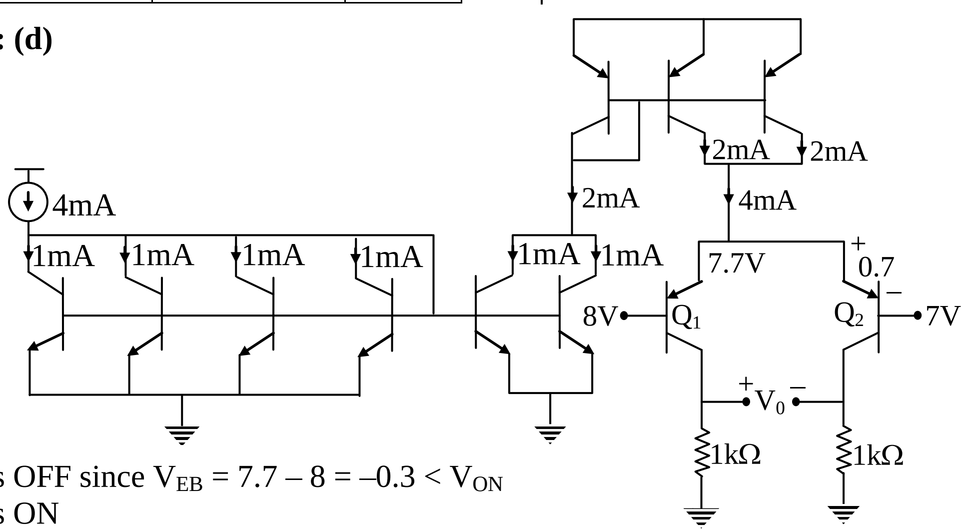
z^3	1	1
z^2	4	k – 6
z^1	$\frac{10-k}{4}$	
z^0	k – 6	

10 – k = 0

k = 10

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 × 1k) = –4V.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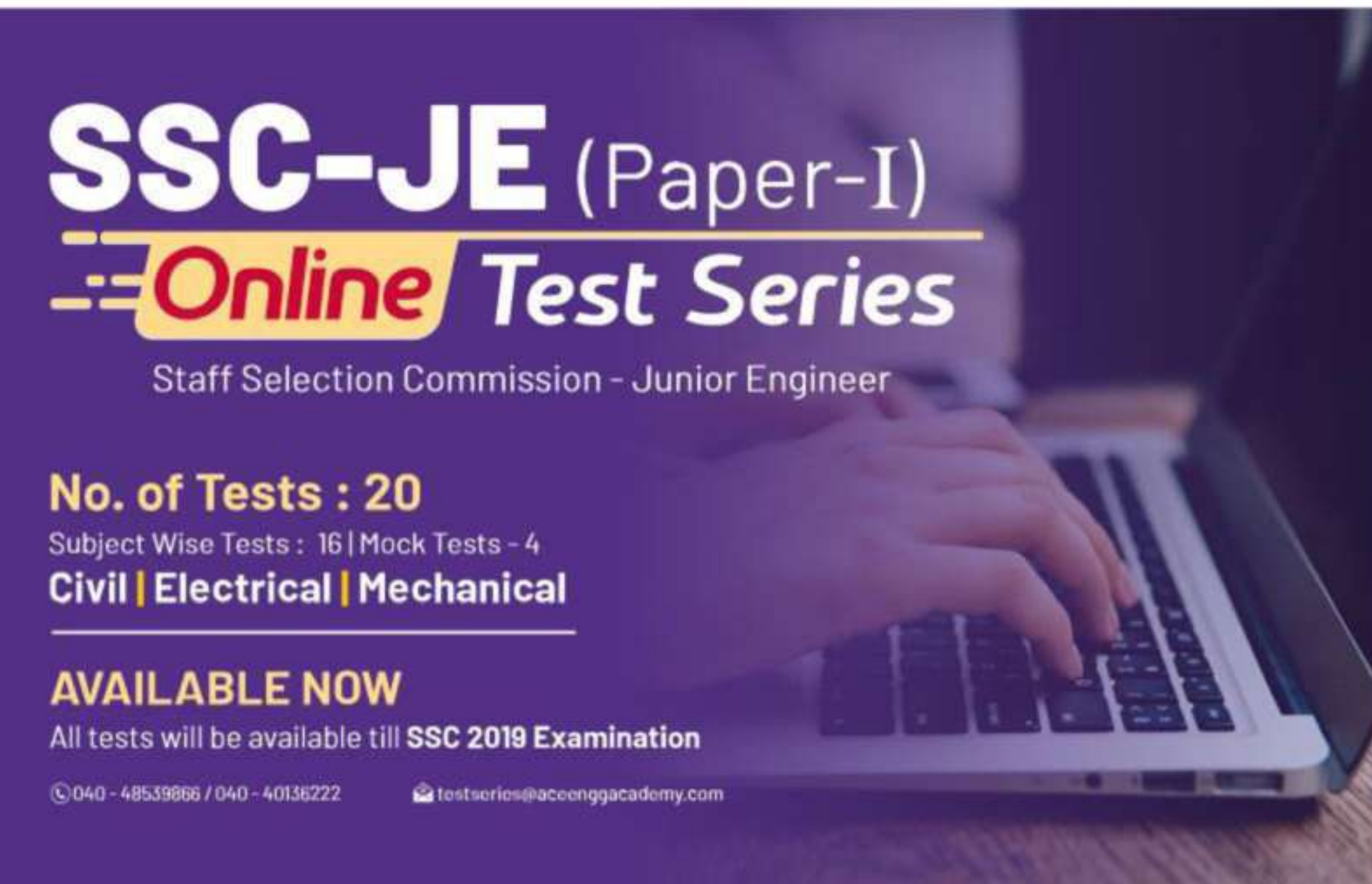
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39. Ans: 91 (range: 88 to 93)

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

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

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

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

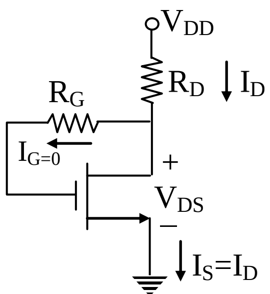
$$= 0.4548$$

Percentage of energy

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

40. Ans: (a)

Sol: DC analysis



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

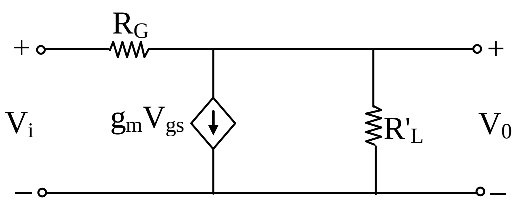
$$I_D = \frac{1}{2}K_n(V_{GS} - V_{TH})^2$$

Solve quadratic equation in I_D

$I_D = 1.06$mA

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

AC Analysis



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

$A_V = -g_m R'_L$

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

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

$R'_L = 4.52\text{k}\Omega$

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

$= -3.27 \approx -3.3$

41. Ans: 3.2 (3.1 to 3.3)

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

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: (d)

Sol: The average power density at the earth is given by

$$W_{avg} = \frac{P_{avg}}{4\pi r^2}$$

$$= \frac{10}{4\pi \times (380 \times 10^6)^2}$$

$W_{avg} = 5.5 \times 10^{-18}\ \text{W/m}^2$

But, $W_{avg} = \frac{E_{rms}^2}{\eta_0}$

$$E_{rms} = \sqrt{377 \times 5.5 \times 10^{-18}}$$

$\therefore E_{rms} = 45.5$ nV/m

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 kΩ , voltage across Zener diode is $24\times\frac{15\times10^3}{(15+5)\times10^3}=24\times\frac{15}{20}$ = 18 V

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

Power through $R_S=I_S^2R_S=(1.2\times10^{-3})^2\times5\times10^3$
= 7.2 mW

45. Ans: 50 (no range)

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

46. Ans: 3.78 (Range: 3.50 to 4.00)

Sol: Given
E_y = 10 sin (5x) cos (4y) sin (ωt–24z)
Direction of propagation: + z
E_Z = 0 and hence TE mode
a = 1.586 cm
b = 0.793 cm

$$E_y=\frac{-j\omega\mu}{h^2}\left(\frac{m\pi}{a}\right)c\sin\left(\frac{m\pi}{a}x\right)\cos\left(\frac{n\pi}{b}y\right)e^{-j\beta\bar{z}}$$

$\frac{m\pi}{a}=5$ and $\frac{n\pi}{b}=4$

$m=\frac{5\times1.586}{\pi}$ $\quad n=\frac{4\times0.793}{\pi}$

m = 2.52 $\quad$ n = 1.009

$m\simeq3$ $\quad$ $n\simeq1$

The mode is: TE_{31}
Cutoff frequency is given by

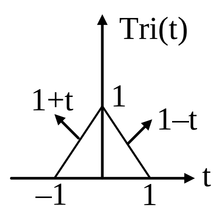
$$f_C(TE_{31})=\frac{c}{2\sqrt{\varepsilon_r}}\sqrt{\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2}$$

$$=\frac{3\times10^{10}}{2\sqrt{81}}\sqrt{\left(\frac{3}{1.586}\right)^2+\left(\frac{1}{0.793}\right)^2}$$

$\therefore f_C$ = 3.78 GHz

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

Sol: $\text{Tri}(t)\leftrightarrow\text{Sinc}^2(f)$
x(t) = Tri(t), X(f) = Sinc^2(f)



Using parseval's theorem

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

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

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

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

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

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, $R_b = 40000 \times 5 = 200kbps$

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

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

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

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

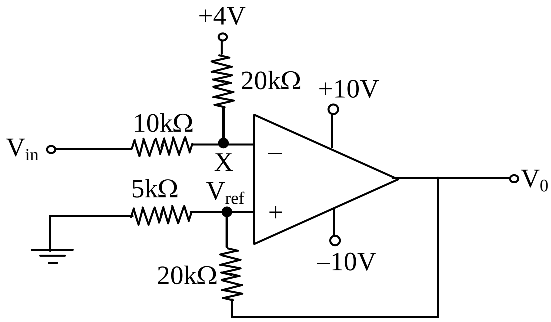
$$H(z) = \frac{\frac{1}{100}}{1.02-2.02z^{-1}+z^{-2}+\left(\frac{4}{100}\right)}$$

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

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

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

$$= \underset{s \to 0}{Lt}\; s\,G(s)H(s) = 0$$

55 Ans: 1.52 no range

Sol: Consider

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

$$\left.\begin{array}{l}\text{Given that C: } x = t^2,\ y = t^3,\ 0 \le t \le 1 \\ \Rightarrow dx = 2t\,dt,\ dy = 3t^2\,dt\end{array}\right\} \text{...... (2)}$$

Using (2), (1) becomes

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

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

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

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

Then, 2(3x + 2x) = 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)


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