GATE WALLAH

ELECTRICAL ENGINEERING

EXAM HELD ON

11th FEBRUARY 2024

AFTERNOON SESSION

DETAILED SOLUTION BY TEAM

[MCQ]

Q.1. Z-transform of finite duration discrete signal x(n) is x(z) then Z.T of y(n) = x(2n) is

(a) $Y(z)=\frac{1}{2}\left(X\left(z^{1/2}\right)+X\left(-z^{1/2}\right)\right)$

(b) $Y(z)=\frac{1}{2}\left(X\left(z^{2}\right)+X\left(-z^{2}\right)\right)$

(c) $Y(z)=\frac{1}{2}\left(X\left(z^{-1/2}\right)+X\left(-z^{-1/2}\right)\right)$

(d) $Y(z)=X\left(z^{2}\right)$

Sol. **(a)**

x[n] = {1, 2, 3, 4}

$X[z] = 1 + 2z^{-1} + 3z^{-2} + 4z^{-3}$

$$X\left[z^{\frac{1}{2}}\right]=1+2.z^{-\frac{1}{2}}+3z^{-1}+4z^{-\frac{3}{2}}$$

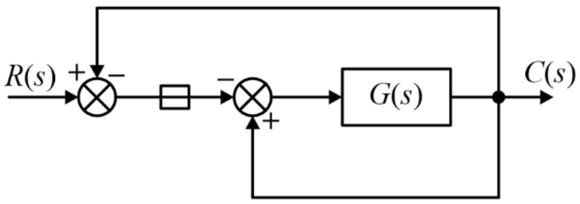
$$X\left[-z^{\frac{1}{2}}\right]=1-2.z^{-\frac{1}{2}}+3z^{-1}-4z^{-\frac{3}{2}}$$

$$Y[z]=\frac{1}{2}\left[2(1+3z^{-1})\right]=1+3z^{-1}$$

$$X[2n]=\{1,3\}\rightarrow Y[z]=1+3z^{-1}$$

[MCQ]

Q.2. For the block dig-shown in the figure the T.F c(s)/R(s) is ___________



(a) $\frac{G(s)}{1-2G(s)}$ (b) $-\frac{G(s)}{1-2G(s)}$

(c) $\frac{G(s)}{1+2G(s)}$ (d) $-\frac{G(s)}{1+2G(s)}$

Sol. **(b)**

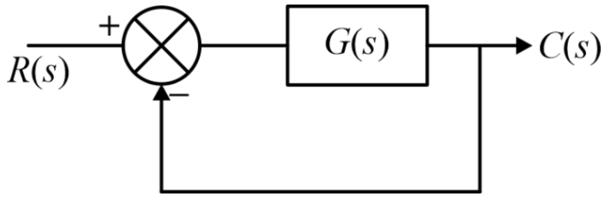
$$\frac{C[s]}{R[s]}=\frac{-G(s)}{1-G(s)-G(s)}=-\frac{G-(s)}{1-2G(s)}$$

[NAT]

Q.3. Consider the closed low system shown in the figure with

$$G(s) > \frac{k\left(S^2 - 2S + 2\right)}{S^2 + 2S + 5}.$$

The root locus for the closed loop system to be drown for $0 \leq x < \infty$. The angle of departs (0° to 360°) of the root locus branch drawn from the pole (– 1 + j2) in degrees is _______



Sol. **(7)**

$$\phi_d = 180° + \angle G(s)\big|_{s=-1+j2}$$

$$G(s) = \frac{k.(s^2 - 2s + 2)}{(s^2 + 2s + 5)}$$

$$G(s) = \frac{k(s-1+j)(s-1-j)}{(s+1+j2)(s+1-j2)}$$

$$\angle G(s)\big|_{s=-1+j2} = \frac{0° + \angle -2 + j3 + \angle -2 + j}{\angle j4 + \angle 0}$$

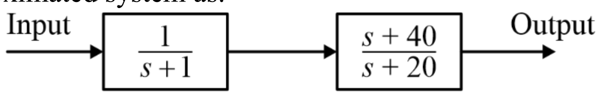
$$\frac{180° - \tan^{-1}\left(\frac{3}{2}\right) + 180° - \tan^{-1}\left(\frac{1}{2}\right)}{90°} = 270° - 82.87° \quad = 187.125°$$

$$\phi_d = 180° + 187.125°$$
$$\phi_d = 367.125°$$

$$7.125° \simeq 7°$$

[MCQ]

Q.4. Consider the cascade system as shown in the figure. Neglecting the faster component of the transient response, which one of the following option is a fist order pole. Only approximation of such that the steady value of the unit step responses of the original and the approximated system as.



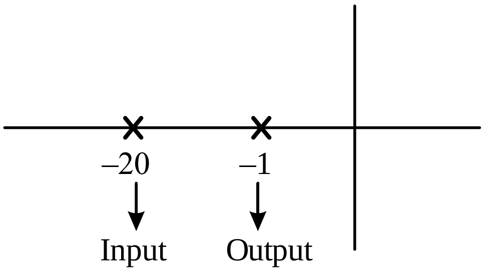
(a) $\frac{2}{s+1}$

(b) $\frac{1}{s+1}$

(c) $\frac{1}{s+20}$

(d) $\frac{2}{s+20}$

Sol. **(a)**



$$G[s]=\frac{s+40}{(s+1)(s+20)}$$

$$G[s]=\frac{40\left(1+\frac{s}{40}\right)}{(1+s)20\left(1+\frac{s}{20}\right)}=\frac{2}{s+1}$$

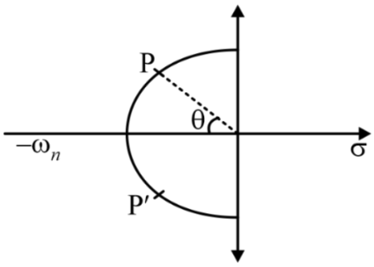
[MCQ]

Q.5. Consider the stand. 2nd equals $\frac{w_n^2}{S^2+25w_nS+w_n^2}$ with the poles P & P^n having negature real part the pole locations are also O shown in the figure number consider two such second order system defined each

System (1) $w_n = 3$ rad/se & $\theta = 60°$

System (2) $w_n = 1$ ra/se & $\theta = 70°$

Which of the following is correct?



(a) Settling time of system (1) is more than system (2)

(b) Settling time can't be computed from the given information

(c) Settling time of both systems are same

(d) Settling time of system (2) is more than system (1)

Sol. **(d)**

System (1)

$\omega n_1 = 3$

$\theta_1 = 60°$

$$t_{s_1}=\frac{4}{\xi\omega_n}$$

$\xi = \cos 60° = \frac{1}{2}$

$t_{s_1} = \frac{4}{3 \times \frac{1}{2}} = 6\,\text{sec}$

System (2)

$\omega_{n_1} = 1, \quad \theta = 70°$

$t_{s_1} = \frac{4}{\xi \omega_n}$

$\xi_2 = \cos 70°$

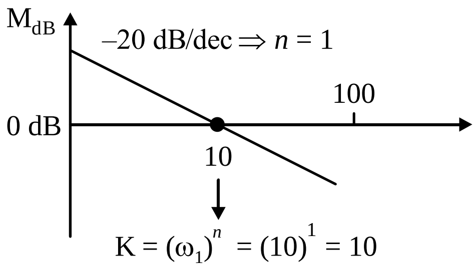
$t_{s_2} = \frac{4}{1 \times 0.342} = 11.69\,\text{sec}$

$t_{s_2} > t_{s_1}$

[NAT]

Q.6. Consider the stable closed loop system shown in the figure. The asymptotic bode magnitude plot G(s) has a constant slope of –20 dB/dec at least till 100 rad/sec with the gain crossover frequency being 10 rad/sec. The asymptotic bode phase plot remains constant at –90° at least. ω = 10 rad/sec. The steady state error of the closed system for a unit ramp input is ______ .
(Rounded off to 2 decimal phase).

Sol. **(0.1)**



$r(t) = t.\mu(t)$

$G[s] = \frac{k}{s}(T(s))$

$k_v = \lim_{s \to 0} \frac{s10}{s} T(s)$

$k_v = 10$

$e_{ss} = \frac{A}{k_v} = \frac{1}{10}$

$e_{ss} = 0.1.$

[MCQ]

Q.7. Consider a vector $\vec{u} = 2\hat{x} + \hat{y} + 2\hat{z}$ where $\hat{x}, \hat{y}, \hat{z}$ represents unit vector along the coordinate axes x, y, z respectively. The directional derivative of function t (x, y, z) = 2 *l*n (xy) + *l*n(yz) + 3ln (xz) at the points (x, y, z) = (1, 1, 1) in the direction $\vec{u}$ of is

(a) 21 (b) 7

(c) $\frac{7}{5}\sqrt{2}$ (d) 0

Sol. **(b)**

[MCQ]

Q.8. Input x(t) & output y(t) of the system related as $y(t) = e^{-t}\int_{-\infty}^{t} e^{\tau} x(\tau)\,d\tau, -\infty < t < \infty$

The system is

(a) non-linear

(b) linear & time invariant

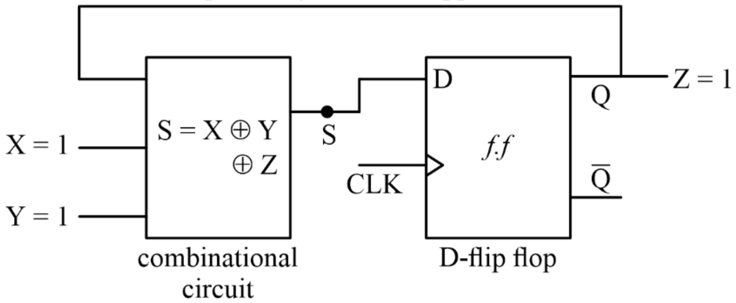
(c) linear but not time invariant

(d) non-causal

Sol. **(b)**

[MCQ]

Q.9. In the circuit, the present value of 2 is 1 neglecting delay in the combinational circuit. The values of s and Z respectively, after the application of clock will be



(a) S = 0 Z = 0

(b) S = 1 Z = 0

(c) S = 1 Z = 1

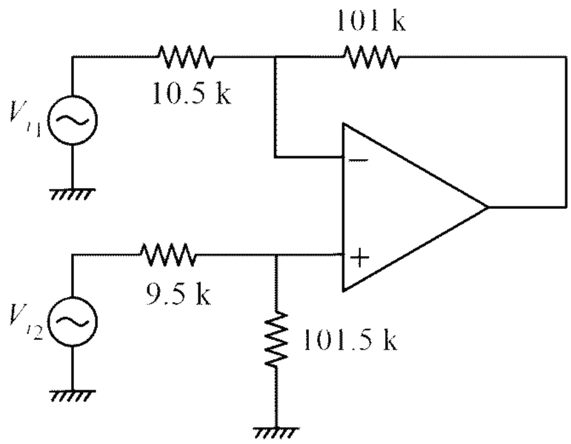
(d) S = 0 Z = 1

Sol. **(b)**

ELECTRICAL ENGINEERING

[NAT]

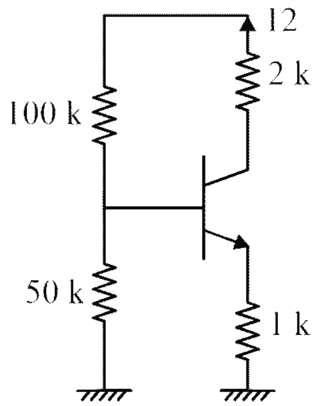
Q.10. The difference amp is shown in the figure. Assume the op-amp is ideal the CNRR is dB is _______ .



Sol. **(39.6)**

[MCQ]

Q.11. The BJT biasing circuit in the figure V_{BE} = 0.7 V, β = 1000. The Q Point I_C, V_{CE} are

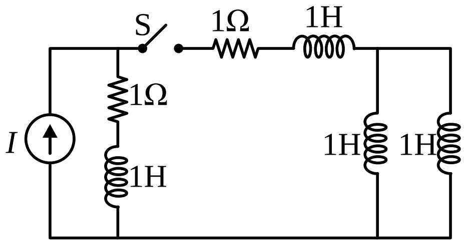


(a) 3.5 V, 2.46 mA
(b) 4.6 V, 2.46 mA
(c) 2.61 V, 3.13 mA
(d) 4.6 V, 3.17 mA

Sol. **(b)**

[MCQ]

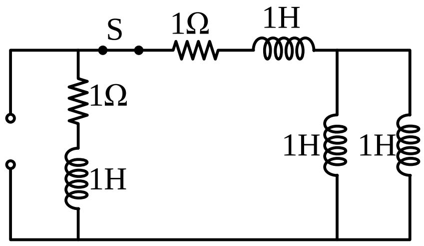
Q.12. The circuit shown in the figure with switch open in steady state. After switch S is closed, the time constant of circuit in seconds



(a) 1 (b) 1.25

(c) 1.5 (d) 0

Sol. **(b)**



$L_{eq} = 2.5$ H, $Rth = 2\ \Omega$,

$$\tau = \frac{L_{eq}}{R_{th}} = \frac{2.5}{2} = 1.25$$

[NAT]

Q.13. Let X(w) be the fourier transform of the figral

$$x(t) = e^{-t^4}.\cos t - \infty < t < \infty$$

The value of derivative of X(ω) at ω = 0 is __________

(rounded off to 1 decimal place).

Sol. **(0)**

$$X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt$$

$$\frac{dx(\omega)}{d\omega} = \int_{-\infty}^{\infty} -jtx(t) e^{-j\omega t} dt$$

$$@\, \omega = 0$$

$$\left.\frac{dx(\omega)}{d\omega}\right|_{\omega=0} = \int_{-\infty}^{\infty} jtx(t) dt$$

$$x(t) = e^{-t4} \cos t \rightarrow \text{even}$$

$$tx(t) = \text{odd}$$

$$\int_{-\infty}^{\infty} odd\ dt = 0.$$

[MCQ]

Q.14. A three phase 50 Hz 6 pole induction motor runs at 960 rpm the stator copper less. Core less and rotateored less of the motor car be neglect the % ecoefficiency of motor

(a) 98 (b) 94

(c) 96 (d) 92

Sol. **(c)**

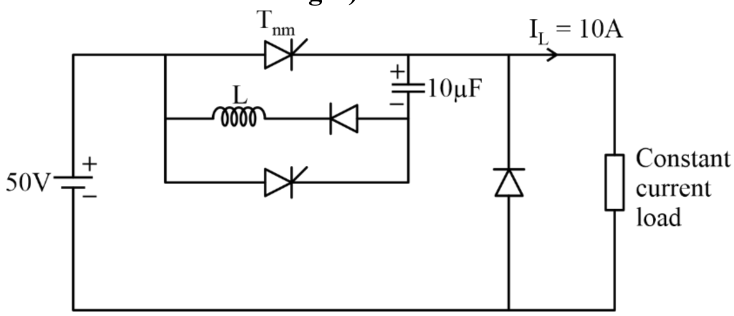
$$\eta = \frac{P_d}{P_g} = \frac{(1-s)P_g}{P_g}$$

$$\%\eta = (1-s)\times 100$$

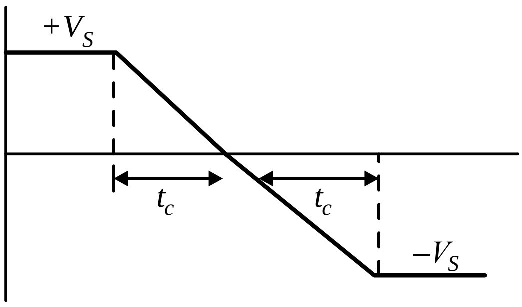
$$\eta = (1-s)\times 100$$
$$= (1-0.04)\times 100$$
$$= 96\%$$

[NAT]

Q.15. A forced commutated thyristorized step down chopper is shown below. Neglect the ON-state drop across the power device. Assume that the capacitor is initially charged to 50V with the polarity shown in the figure, the load current (I_L) can be assumed to be consumed at 10A. Initially. T main is ON and T_A is off. The turn-off five available to Tn_M in microseconds when Tn_A triggered is ______ .
(Rounded off to the nearest integer).



Sol. **(50)**



$$l_c = c\frac{dv}{ds}$$

$$I_0 = c\frac{dv}{dt}$$

In 2tc time voltage of capacitor change by 2Vs

$$I_0 = c\frac{(2V_s)}{2t_c}$$

$$t_c = \frac{CV_s}{I_0}$$

$$\frac{10\times10^{-6}\times50}{10} = 50\mu\text{sec}$$

[MCQ]

Q.16. A single-phase time based, A.C voltage controller feeds RL load. The input a.c supply is 230 volts, 50Hz. The values of R and L are 10Ω and 18.37 mH respectively. The minimum tiggering angle of the triac to obtain controller output voltage is

(a) 30° (b) 60°
(c) 45° (d) 15°

Sol. (a)

$$\alpha = \tan^{-1}\frac{\omega L}{R} = \tan^{-1}\frac{2\pi\times50\times18.37\times10^{-3}}{10}$$
$$\alpha = 30°$$

[MCQ]

Q.17. If the following switching devices have similar power ratings, which one of them is the fastest

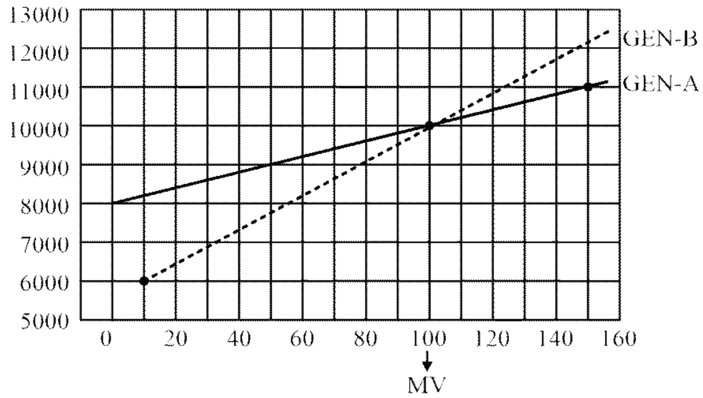
(a) G.T.O (b) Power mosfet
(c) IGBT (d) SCR

Sol. (b)

Power MOSFET since only majority (electron) career participate in current flow.

[NAT]

Q.18. The increments cost curves of the two generators (Gen A & Gen B) in a plant supplying a common load are shown in figure. If the increments cost of supplying the common load is Rs 7400 per Mwhr then common load in M.W is __________
Round off upto two decimal digit).



Sol. **(35)**

Generation (1)

$y = mx + c$

$(I.C)_z = 20, P1 + 8000$ (1)

Generation (2)

$$slope = \frac{4000}{100} = 40$$

$$(IC)_2 = 40P_2 + 6000$$

If IC is 7400

Generation (3)

$7400 = 40\ P_2 + 6000$

$40P_2 = 1400$

$P_2 = 35$

$P_1 = 0$

Common load = 35 + 0 = 35 MW

[MCQ]

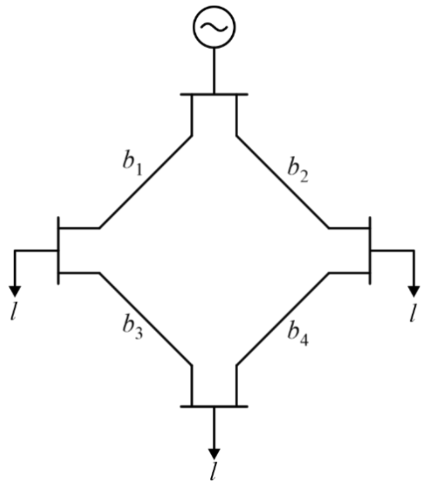
Q.19. A 3-phase 11 kV, 10 mVA synchronous generator is connected to an inductive load of power factor $\left(\frac{\sqrt{3}}{2}\right)$ via a loss less line with 3-phase inductive reactance of 5 Ω. The per phase synchronous reactance of the generator is 30 Ω with negligible armature resistance. If the generator producing the rated current at the rated voltage. Then the power factor at the terminal of generator.

(a) 0.63 lagging
(b) 0.63 leading
(c) 0.87 leading
(d) 0.87 lagging

Sol. **(a)**

[MCQ]

Q.20. The figure shows single line diagram of a 4-bar power N/ω. Branch b_1, b_2, b_3 and b_4 have impedances 4z, z, 2z and 4z per unit (p.u.) respectively where $z = r + jx$ with $r > 0$ and $x > \delta$. The current drawn from loads bus (marked as arrow) is equal to 'l' p.u. where $l \neq 0$. It network is to operate with minimum loss, the branch that should be opened is.



(a) b_4

(b) b_3

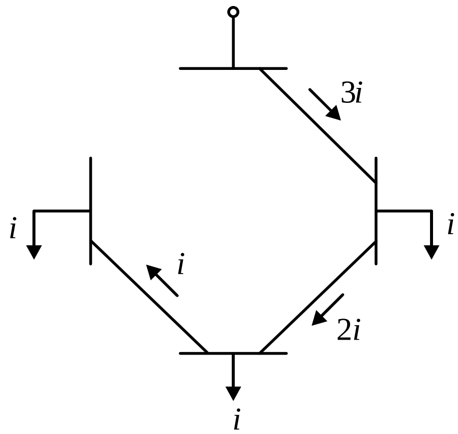
(c) b_1

(d) b_2

Sol. **(b)**

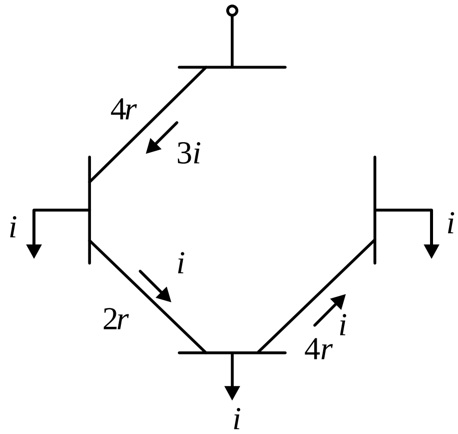
(1) if b_1 branch is removed

$P = (3i)^2r + (2i)^2 (4r) + (j)^2 (2r) = 9i^2r + 16i^2r + 2i^2r = 27i^2r$



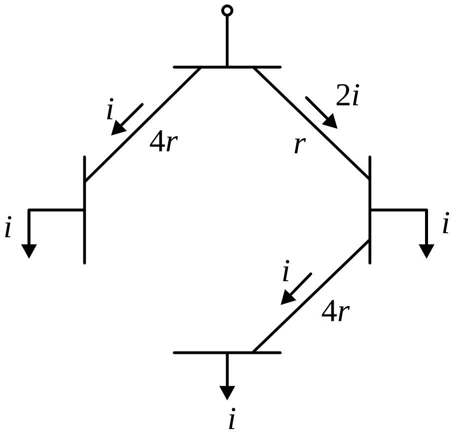
(2) if b_2 branch is removed

$P = (3i)^2 4r + (2i)^2(2r) + i^2 4r = 36i^2r + 8i^2r + 4i^2r = 48i^2r$



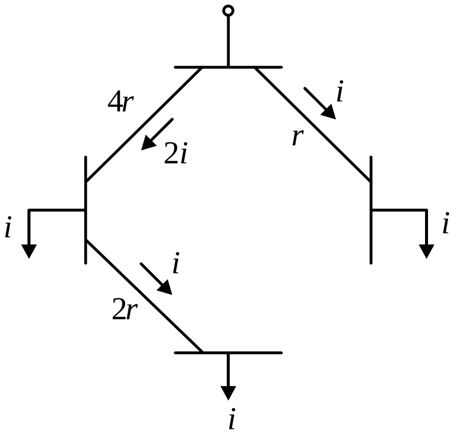
(3) if branch b_3 is removed

$P = i^2(4r) + (2i)^2 r + i^2(4r) = 12i^2r$



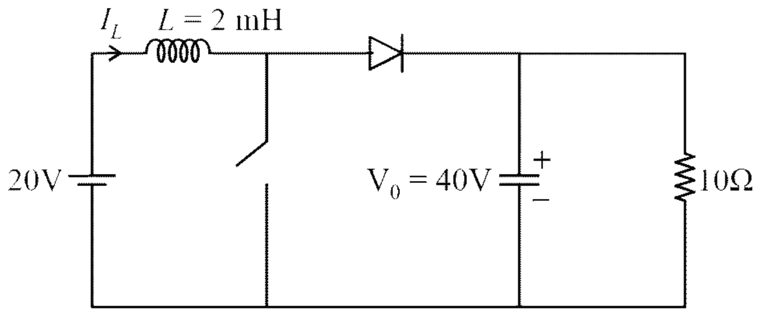
(4) if by branch is removed

$P = (2i)^2\, 4r + i^2(2r) + i^2r = 16i^2r + 3i^2r = 19i^2r$

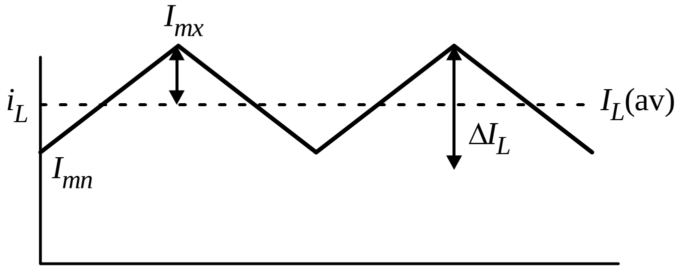


[NAT]

Q.21. In the DC to DC converter is shown in figure, the current through the inductor is continuous. The switching frequency is 500 Hz. The voltage V_0 across the load is assumed to be constant and ripple free. The peak value of inductor. Current in ampere is ________________.



Sol. **(13)**



$(I_L)_{avg} = I_s$

$P_{in} = P_{op}$

$V_S I_S = V_0 I_0$

$20 I_S = 40 \times 4$

$I_S = 8$ Amp.

$$\Delta I_L = \frac{\propto V_S}{fL}$$

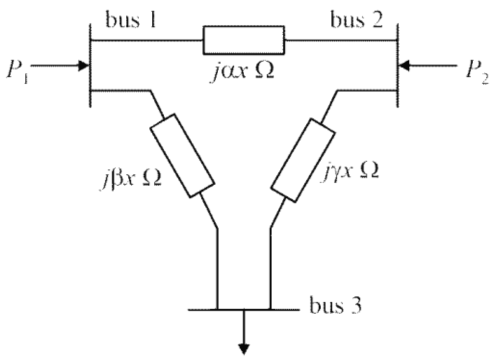
$$= \frac{0.5 \times 20}{500 \times 2 \times 10^{-3}}$$

$$= \frac{10 \times 1000}{500 \times 2} = 10A$$

$$(I_L)_{max} = 8 + \frac{10}{2} = 13 \text{ Amp.}$$

[MCQ]

Q.22. For the 3 bus lossless power network shown in the figure the voltage magnate at all the buses are equal to 1 per unit (PU) and the difference of the voltage phase angles are very small the reactance's are marked in the figure where, α, β, γ and x are strictly positive the bus inflection P_1 and P_2 are in P.U. If $P_1 = mP_2$ where m > 0 and the real power flow from bus 1 to bus 2 is 0 p.u. then which one of the following options is correct?



(a) α = mβ
(b) α = mγ
(c) β = mγ
(d) γ = mβ

Sol. **(d)**

$$P_1 = \frac{|V_1||V_3|}{\beta x}\sin(\delta_1 - \delta_3)$$

$$P_2 = \frac{|V_2||V_3|}{\gamma x}\sin(\delta_2 - \delta_3)$$

$P_1 = mP_2$

$$\frac{1\times 1}{\beta x}\sin(\delta_1 - \delta_3) = m\frac{1\times 1}{\gamma x}\sin(\delta_2 - \delta_3)$$

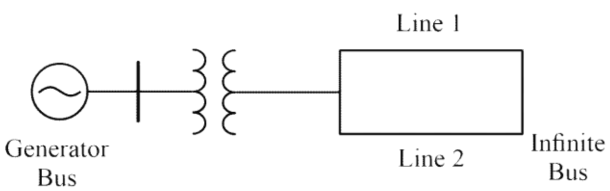
$$\delta_1 - \delta_3 \simeq \delta_2 - \delta_3$$

$$\frac{1}{\beta x} = m\frac{1}{\gamma x}$$

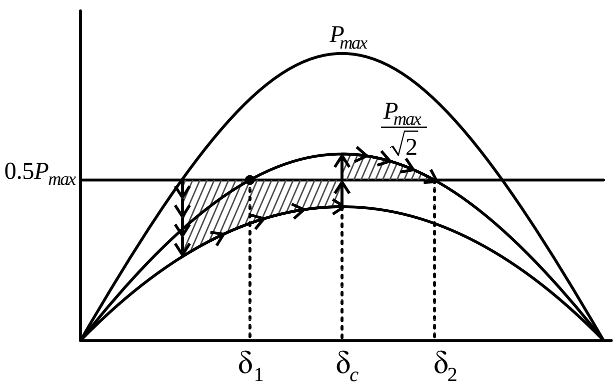
$$\gamma = m\beta$$

[NAT]

Q.23. The single line diagram of a loss less system is shown in the figure. The system is operating in steady state at a stable equilibrium point with the power output of the generator being P_{max} sin δ, where δ is the load angle and the mechanical power input is 0.5 P_{max}. A fault occurs on line 2 such that the power output of the generator is less than 0.5 P_{max}. during the fault. After fault is cleared by opening line 2, the power output of the generation is $\left(P_{max}/\sqrt{2}\right)\sin\delta$. If the critical fault clearing angle is $\frac{\pi}{2}$ radians, the accelerating area on the power angle curve is _______ times P_{max}.



Sol. **(0.107)**



$$\delta_2 = 180 - \delta_1$$

$$=180-\sin^{-1}\frac{0.5P_{max}}{\frac{P_{max}}{\sqrt{2}}}$$

$$=180-\sin^{-1}\sqrt{2}\times 0.5$$

$180-45=135$

For critical condition

Accelerating area = Deaccelerating Area

$$=\int_{90}^{135}\left(\frac{P_{max}}{\sqrt{2}}\sin\delta-0.5P_{max}\right)d\delta$$

$$=P_{max}\left[\frac{1}{\sqrt{2}}(-\cos\delta)-0.58\right]_{90}^{135}$$

$$=P_{max}\left[\frac{1}{\sqrt{2}}\left(-\frac{\cos}{35}\right)-0.5(135-90)\frac{\pi}{180}\right]=0.107$$

[NAT]

Q.24. A 3-phase star connected slip ring induction motor has the following parameter referred to the stator.

$R_S = 3\Omega$, $X_S = 2\Omega$, $X_r' = 2\Omega$, $R'_r = 2.5\Omega$.

The per phase stator to rotor effective tern ratio 3 : 1, the rotor winding is also star connected the magnetizers reactance and core less of the motor can be neglected to have maximum torque at starting the value of the extra resistance in ohms (referred to rotor side) to be connected in series with each phase of the rotor winding is ________ (2 decimals).

Sol. **(0.28)**

$$S_{T(max)}=\frac{R_2^1+(R_{ext})'}{\sqrt{R_{th}^2+(X_{th}+X_1)^2}}$$

$$1=\frac{2.5+R'_{ext}}{\sqrt{9+16}}$$

$$R'_{ext}=2.5$$

$$R_{ext(rotor)}=\frac{2.5}{9}=0.28\Omega$$

[MCQ]

Q.25. The table lists 2. Instrument transformers & their features.

Instrument-transformers		Features	
		(P)	Primary is connected in parallel to grid
(X)	Current Transformer (CT)	(Q)	Open circuited secondary is not desirable
(Y)	Potential transformer (PT)	(R)	Primary current is line current
		(S)	Secondary burden effects the primary current

The correct matching of 2 columns is

(a) X matches with P and R;Y matches with Q & S.

(b) X matches with Q and R;Y matches with P & S.

(c) X matches with Q and S;Y matches with P & R.

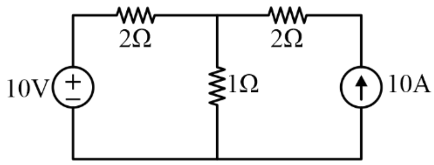
(d) X matches with P and Q;Y matches with R and S.

Sol. **(c)**

X matches with Q and S;Y matches with P & R.

[MCQ]

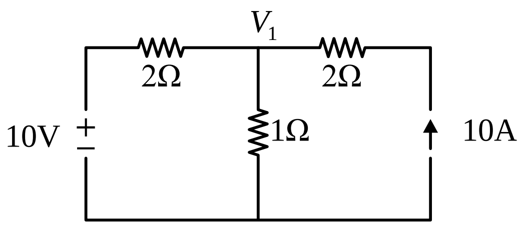
Q.26. All the element in the circuit are ideal the power aelevered by the 10V source in ________ watt.



(a) 100 (b) Depend on ∞

(c) 0 (d) –50

Sol. **(c)**



$$\frac{V_1-10}{\alpha}+\frac{V_1-0}{1}=10$$

$$\Rightarrow \frac{V_1}{\alpha}+V_1=10+\frac{10}{a}$$

$$\Rightarrow V_1 = 10V$$

So, current entering to 10 V source is 0.

Hence, power delivered by 10 V source is 0 W.

[MCQ]

Q.27. Simplified form of the Boolean function

$F(P,Q,R,S) = \bar{P}\bar{Q} + \bar{P}QS + P\bar{Q}\bar{R}\bar{S} + P\bar{Q}R\bar{S}$

(a) $\bar{P}Q + R\bar{S}$ (b) $P\bar{S} + Q\bar{R}$

(c) $\bar{P}S + \bar{Q}\bar{S}$ (d) $\bar{P}\bar{Q} + \bar{Q}\bar{S}$

Sol. **(c)**

[MSQ]

Q.28. Let X be a discreate random variable that is uniformly distributed over the set (– 10, – 9, ….0, …, 9, 10). Which of the following random variable is/are uniformly distributed.

(a) x^3 (b) $(x - 5)^2$

(c) $(x + 10)^2$ (d) x^2

Sol. **(a, c)**

$[-1000, -(9)^3, \ldots 0^3, \ldots 9^3, 10^3]$

[MCQ]

Q.29. Suppose signal $y(t)$ is obtained by the time reversal of signal $x(t)$, i.e. $y(t) = x(-t)$ which one of the following option is always take about when y(t) is convolved with $x(t)$.

(a) Odd signal (b) Causal signal

(c) Even signal (d) Anticasual signal

Sol. **(c)**

$Z(t) = x(-t) * x(t)$

$Z(-t) = x(t) * x(-t)$

So, $Z(t) = Z(-t)$

Correlation of $x(t)$.

[MCQ]

Q.30. $u(t)$ is unit step signal then ROC of Laplace transform of signal is

$x(t) = e^{t^2}(u(t-2) - u(t-10))$

(a) $-\infty$ to ∞ (b) 1 to 10

(c) $\text{Re}(s) \leq 1$ (d) $\text{Re} \geq 10$

Sol. **(a)**

So, signal t = 1 to 10

Finite duration

ROC = $-\infty$ to ∞.

[NAT]

Q.31. Consider the complex function $f(z) = \cos z + e^{z^2}$. The coefficient of z^5 in the layler series exparmion of $f(z)$ about the origin is _______ (rounded off to 1 decimal place).

Sol. **(0)**

[MSQ]

Q.32. Which of the following complex function is/are analytic on the complex plane?

(a) $f(z) = z^2 - z$

(b) $f(z) = e^{|z|}$

(c) $f(z) = I_m(z)$

(d) $f(z) = j\,\mathrm{Re}(z)$

Sol. **(a, b)**

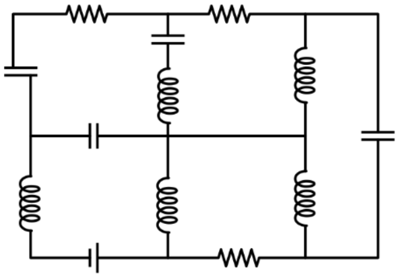
[NAT]

Q.33. The sum of eigen values of matrix $A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}^2$ is ___________ (rounded off to the nearest integer)

Sol. **(29)**

[MCQ]

Q.34. The number of junction in the circuit is



(a) 9

(b) 6

(c) 7

(d) 8

Sol. **(6)**

[MSQ]

Q.35. Let $f(t)$ be a real valued function whose second derivate is positive for $-\infty < t < \infty$. Which of the following statements is are always time?

(a) The minimum value of $f(t)$ connot be negative

(b) Has at least one local maximum

(c) $f(t)$ cannot have two distinct local minimum

(d) $f(t)$ has at least one local minimum

Sol. **(a, c, d)**

[NAT]

Q.36. The given equation represents a magnetic field strength $\vec{H}(r,\theta,\phi)$ in the spherical co-ordinate system, in the space. Here, $\hat{r}$ and $\hat{\theta}$ represent the unit rector along r and θ, respectively. The value of P in the equation should be ____________.
(round off to the nearest integer)

$$\vec{H}(r,\theta,\phi)=\frac{1}{r^3}\left(P\cos\theta\hat{a}_r+\sin\theta\hat{a}_\theta\right)$$

Sol. **(2)**

$$\vec{\nabla}\cdot\vec{B}=0$$

$$\vec{B}=\mu H$$

$$\vec{\nabla}\cdot\vec{H}=0$$

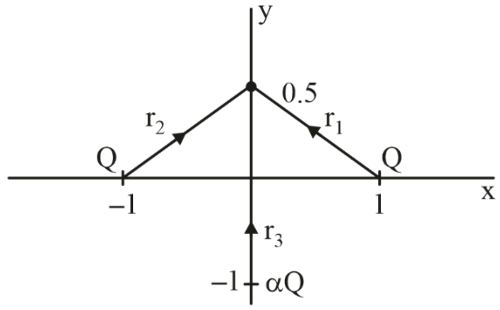
$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(\frac{r^2}{r^3}P\cos\theta\right)+\frac{1}{r\sin\theta}\left(\frac{\partial}{\partial\theta}\times\frac{\sin^2\theta}{r^3}\right)$$

$$P=2$$

[NAT]

Q.37. In the (*X*, *Y*, *Z*) co-ordinate system, three point charge Q, Q and αQ are located in free space (–1, 0, 0), (1, 0, 0) and (0, –1, 0) respectively. The value of 'α' for the electric field to be zero at (0, 0.5, 0) is ________ .
(Rounded off to 1 decimal places.)

Sol. **(–1.61)**



$$\vec{r}_1=-\hat{a}_x+0.5\hat{a}_y$$

$$\vec{r}_1=\hat{a}_x+0.5\hat{a}_y$$

$$\vec{r}_3=1.5\hat{a}_y$$

$$E_P=\frac{Q}{4\pi\varepsilon r_1^2}\hat{a}_{r_1}+\frac{Q}{4\pi\varepsilon r_2^2}\hat{a}_{r_2}+\frac{\alpha Q}{4\pi\varepsilon r_3^2}\hat{a}_{r_3}$$

$$E_P=\frac{Q}{4\pi\varepsilon}\left[\frac{1}{r_1^2}\hat{a}_{r_1}+\frac{1}{r_2^2}\hat{a}_{r_2}+\frac{\alpha}{r_3^2}\hat{a}_{r_3}\right]=0$$

$$E_P = \left[\frac{1}{(1.25)^{3/2}}\left(\hat{a}_x + 0.5\hat{a}_y\right) + \frac{1}{(1.25)^{3/2}}\left(-\hat{a}_x + 0.5\hat{a}_y\right) + \frac{\alpha\hat{a}_y}{(1.5)^{3/2}}\right] = 0$$

$$\alpha = -\frac{(1.5)^2}{(1.25)^{3/2}} = -1.61$$

[NAT]

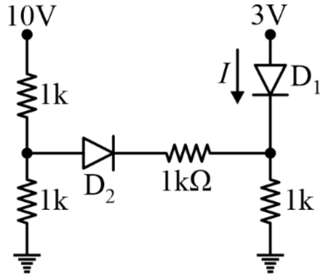
Q.38. Consider the stable closed loop system shown in the figure. The magnitude and phase value of frequency response of G(s) are given in the table. The value of the gain kI(> 0) for a 50° phase margin is ____________.

ω	magnitude in dB	Phase in degree
0.5	– 7	– 40
1.0	– 10	– 80
1.0	– 18	+30
10.0	– 40	– 20

Sol. **(1.12)**

[NAT]

Q.39. The diode are ideal, find the current I from D_1 diode ____________ mA.



Sol. **(1.67)**

[NAT]

Q.40. Single phase half-controlled bridge converte supplies inductive load with constant load current. Triggening angle is 60°. The ratio of rms vlaue of fundamental component of input current to the rms value of the total input current of bridge __________ (3 decimal places)

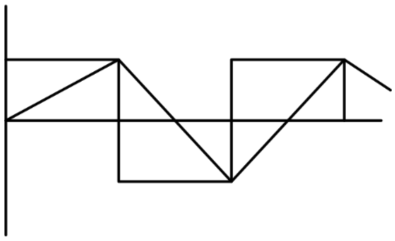
Sol. **(0.955)**

$$\frac{I_{s1}}{I_s} = \frac{\frac{2\sqrt{2}I_0}{\pi}\cos\frac{\alpha}{2}}{I_0\sqrt{\frac{\pi-\alpha}{\pi}}} = \frac{2\sqrt{2}}{\sqrt{\pi}\sqrt{\pi-\alpha}}.\cos\frac{\alpha}{2}$$

$$= \frac{2\sqrt{2}\cos 30}{\sqrt{\pi}\sqrt{\pi - \frac{\pi}{3}}} = \frac{2\sqrt{2} \times \frac{\sqrt{3}}{2}}{\pi\frac{\sqrt{2}}{\sqrt{3}}} = \frac{3}{\pi} = 0.955$$

[MCQ]

Q.41. Single phase full bridge voltage source inverter feeds a purely inductive load. The inverter output voltage is a square wave in 180°. Conduction mode. The fundamental frequency of the output voltage is 50Hz. If the DC input voltage of the inverter is 100 V and the value of the load inductance is 20 mH, the peak to peak load current in ampere in ________.
(Nearest integer).



Sol. **(50)**

$$v_L = L\frac{d\ell_L}{dt}$$

$$V_s = \frac{L(2I_p)}{\frac{T}{2}}$$

$$V_s = \frac{2LI_p \times 2}{T}$$

$$2I_p = \frac{V_s T}{2L} = \frac{100 \times \frac{1}{50}}{2 \times 20 \times 10^{-3}}$$

$$2I_0 = \frac{2}{2 \times 20 \times 10^{-3}} = \frac{1000}{20}$$

$$2I_p = 50 \text{ Amp}$$

[NAT]

Q.42. A 5 kW, 220 V DC shunt motor has 0.5 Ω are armature resistance including brushes. The motor draws a no-load current of 3A. The field current is constant 1 A. Assuming that the core and rotational losses are constant and independent of the load, the current in (A) drawn by the motor while delivering the rated load for the best possible efficiency is _______ .

Sol. **(37.28)**

[MSQ]

Q.43. Let 'x' discrete uniformly distributed over {–10, –9, ……0, ……9, 10}.
Which of the following are uniformly distributed.

(a) x^3 (b) $(x-5)^2$

(c) $(x+10)^2$ (d) x^2

Sol. **(a, c,)**

For uniform distribution $X_1^3 = X_2^3 \Rightarrow X_1 = X_2$

$(X_1-5)^2 = (X_2-5)^2$ does't implise $x_1 = x_2$.

X^2 is equal for $x = \pm 10; (x-5)^2 = 25 \Rightarrow x = 10, x = 0$

$x = \pm 9, \ldots . x = \pm 1$

$x = 0$

[NAT]

Q.44. $f(z) = \cos z + e^{z^2}$ coefficient of z^5 in Taylor series of $f(z)$ about origin ____________.

Sol. **(0)**

$f(z) = \cos z + e^{z^2}$

Both cos z and e^{z^2} contains only even power of z.

$\therefore$ coefficient of any odd power of $z = 0$

[MCQ]

Q.45. Which of the following matrix has inverse?

(a) $\begin{bmatrix} 1 & 4 & 8 \\ 0 & 4 & 2 \\ 1 & 2 & 4 \end{bmatrix}$ (b) $\begin{bmatrix} 1 & 2 & 3 \\ 2 & 4 & 6 \\ 3 & 2 & 9 \end{bmatrix}$

(c) $\begin{bmatrix} 1 & 4 & 8 \\ 0 & 4 & 2 \\ 3 & 12 & 24 \end{bmatrix}$ (d) $\begin{bmatrix} 1 & 4 & 8 \\ 0 & 4 & 2 \\ 0.5 & 2 & 4 \end{bmatrix}$

Sol. **(a)**

For 'A' to have inverse; |A| ≠ 0.

Option (a): Det. = 1 (12) –4 (–2) + 8 (–4) = –12 ≠ 0

Option (b): c_1 and c_3 are proportional

Option (c): $R_3 = 3R_1 \Rightarrow$ Det = 0

Option (d): $R_1 = 2.\ R_3 \Rightarrow$ Det = 0

[MCQ]

Q.46. Which of the following is/are analytic on complex plane?

(a) $z^2 - z$ (b) $e^{|z|}$

(c) $\text{Im}(z)$ (d) $j\,\text{Re}(z)$

Sol. **(a)**

Option (a): Polynomial in 'z'

Option (b): $|z|$ is not differentiable at $z = 0$

Option (c & d): Cauchy Riemann euations are valid.

[NAT]

Q.47. Sum of the eigen value of $A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}^2$ is ________

Sol. **(29)**

$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \rightarrow \lambda_1, \lambda_2$ are eigen values

$\Rightarrow \lambda_1 + \lambda_2 = 5; \lambda_1.\lambda_2 = -2$

$A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}^2 \rightarrow \lambda_1^2, \lambda_2^2$

$\therefore \lambda_1^2 + \lambda_2^2 = (\lambda_1 + \lambda_2)^2 - 2\lambda_1.\lambda_2$

$= 25 - 2\,(-2) = 29$

[MCQ]

Q.48. $f(t) = [\max(0,t)]^2$; for $-\infty < t < \infty$; which is/are true?

(a) $f(t)$ is differentiable, and its derivative is continuous.

(b) $f(t)$ is differentiable, but its derivative is not continuous.

(c) $f(t)$ and its derivative are differentiable.

(d) $f(t)$ is not differentiable.

Sol. **(a)**

$f(t) = [\max(0,t)]^2 = t^2.$

$\Rightarrow f'(t) = 2t \quad f''(t) = 2$

[MCQ]

Q.49. $\vec{u} = 2\hat{x} + \hat{y} + 2\hat{z}$ where $\hat{x}, \hat{y}, \hat{z}$ are unit vectors along x, y, z respective. The directional derivative of the function $f(x, y, z) = 2\ln(xy) + \ln(yz) + 3\ln(xz)$ at (1, 1, 1) in direction of $\vec{u}$ is

(a) 21 (b) 7

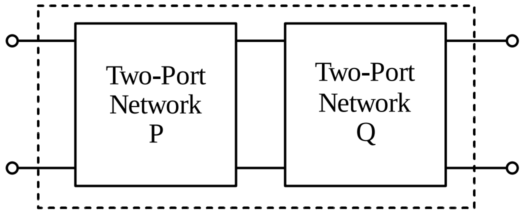
(c) $\frac{7}{5\sqrt{2}}$ (d) 0

Sol. **(b)**

[NAT]

Q.50. Two passive two-port networks P and Q are connected as shown in the figure. The 0impedance matrix of network P is $Z_P = \begin{bmatrix} 40\Omega & 60\Omega \\ 80\Omega & 100\Omega \end{bmatrix}$. The admittance matrix of network Q is $Y_Q = \begin{bmatrix} 5\,S & -2.5\,S \\ -2.5\,S & 1\,S \end{bmatrix}$. Let the ABCD matrix of the two-port network R in the figure be $\begin{bmatrix} \alpha & \beta \\ \gamma & \delta \end{bmatrix}$. The value of β in Ω is _______.

(rounded off to 2 decimal places)



Two-Port Network R

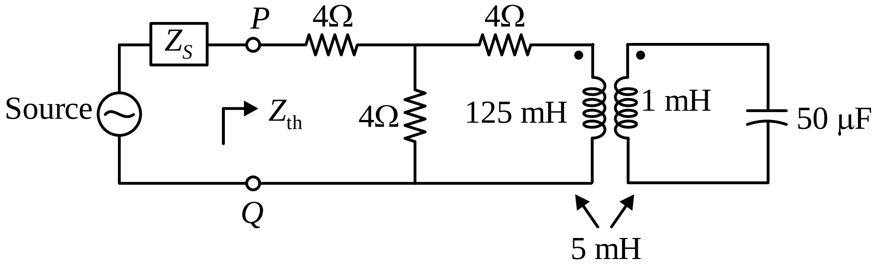
Sol. **(a)**

Magnitude of magnetic field intensity = 2.5

[NAT]

Q.51. For the circuit shown in the figure, the source frequency is 5000 rad/sec. The mutual inductance between the magnetically coupled inductors is 5 mH with their self inductances being 125 mH and 1 mH. The Thevenin's impedance, Z_{th} between the terminals P and Q in Ω is _______.

(Rounded off to 2 decimal places).



Sol. **(5.33)**

[MCQ]

Q.52. The decimal number system uses the characters 0, 1, 2, ……. 8, 9, and the octal number system uses the character 0, 1, 2, …… 6, 7.

For example, the decimal number 12 (= $1 \times 10^1 + 2 \times 10^0$) is expressed as 14 (= $1 \times 8^1 + 4 \times 8^0$) in the octal number system.

The decimal number 108 in the octal number system is

(a) 154 (b) 168

(c) 108 (d) 150

Sol. **(a)**

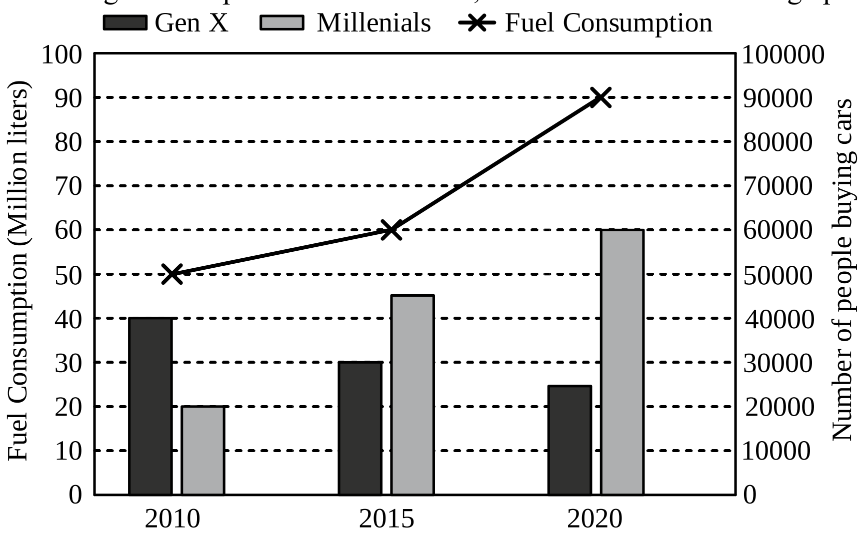
8	108	
8	13	4
	1	5

$(108)_{10} = (154)_8$

[MCQ]

Q.53. The chart below shows the data of the number of cars bought by Millennials and Gen X people in a country from the year 2010 to 2020 as well as the yearly fuel consumption of the country (in Million liters).

Considering the data presented in the chart, which one of the following options is true?



(a) The decrease in the number of Gen X car buyers from 2015 to 2020 is more than the increase in the number of Millennial car buyers from 2010 to 2015.

(b) The increase in the number of Millennial car buyers from 2010 to 2015 is more than the decrease in the number of Gen X car buyers from 2010 to 2015.

(c) The increase in the number of Millennial car buyers from 2015 to 2020 is less than the decrease in the number of Gen X car buyers from 2010 to 2015.

(d) The percentage increase in fuel consumption from 2010 to 2015 is more than the percentage increase in fuel consumption from 2015 to 2020.

Sol. **(b)**

[MCQ]

Q.54. If, for non-zero real variable x, y and real parameter $a > 1$,
$x : y = (a + 1) ; (a - 1)$,
Then the ratio $(x^2 - y^2) : (x^2 + y^2)$ is

(a) $2a : (a^2 + 1)$ (b) $a : (a^2 + 1)$

(c) $a : (a^2 - 1)$ (d) $2a : (a^2 - 1)$

Sol. **(a)**

$$\frac{x^2 - y^2}{x^2 + y^2} = \frac{\frac{x^2}{y^2} - 1}{\frac{x^2}{y^2} + 1}$$

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

$$= \frac{4a}{2a^2 + 2} = \frac{2a}{a^2 + 1}$$

❑❑❑

GATE WALLAH

SOLDIERS

THANK YOU