

General Aptitude

1. Newspapers are a constant source of delight and recreation for me. The only (what bother's) trouble is that I read too (a lot/ large) many of them.

$$2. 343 = 7^3$$

$$1331 = 11^3$$

$$4913 = 17^3$$

All numbers given are cube of prime numbers so $13^3 = 2917$ satisfy the missing number.

3. The passengers were angry with the airline staff about the delay.

4. Time taken by X to mow the lawn = 2 hrs.

$$\therefore \text{Work done by X in } 1 \text{ hr} = \frac{1}{2}$$

Similarly,

Work done by Y in 1 hr = $\frac{1}{4}$

$$\text{Work done by X + Y in 1 hr} = \frac{1}{2} + \frac{1}{4} = \frac{3}{4}$$

$$\therefore \text{Total time taken by X + Y together} = \frac{4}{3} \text{ hours}$$

$$= \frac{4}{3} \times 60 \text{ minutes}$$

$$= 80 \text{ Minutes}$$

5. I am not sure if the bus that has been booked will be able to accommodate (occupy) all the students.

6. Given that $X = \{1, 2, 3\}$

$Y = \{2, 3, 4\}$

$$Z = \left\{ \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{2}{2}, \frac{2}{3}, \frac{2}{4}, \frac{3}{2}, \frac{3}{3}, \frac{3}{4} \right\}$$

$$\text{Minimum value in } Z = \frac{1}{4}$$

$$\text{Maximum value in } Z = \frac{3}{2}$$

$$\text{Product} = \frac{3}{8}$$

7. Let number of boys participated = $4x$

Number of girls participated = $3x$

Total number of students participated = $7x$

$$\text{Total passed candidates} = \frac{80}{100} \times 7x = \frac{28}{5}x$$

$$\text{Girls candidate who passed} = \frac{90}{100} \times 3x = \frac{27}{10}x$$

Boys candidate who passed = Total passed candidate – Girls candidate who passed

$$= \frac{28}{5}x - \frac{27}{10}x$$

$$= \frac{29}{10}x$$

$$= \frac{29x}{10 \times 4x} \times 100 = 72.5\%$$

8. The correct statement can be concluded from Venn diagram or using the Syllogism.

9. For all digits of a number which lie between 100 and 1000 are even,

Unit and tens digits can be filled from the set $\{0, 2, 4, 6, 8\}$

But hundred's digit does not include 0 as it will not remain a number which lie between 100 and 1000

$\therefore$ Hundreds digit set is $\{2, 4, 6, 8\}$

$$\text{Total integer be} = 5 \times 5 \times 4$$

$$\text{Total choices for } \begin{cases} \uparrow & \uparrow & \uparrow \\ \text{Units} & \text{Tens} & \text{Hundreds} \\ \text{digit} & \text{digit} & \text{digit} \end{cases}$$

Total integer = 100 numbers

10. Given that

Ganga > Rekha, Lakshmi

Lakshmi > Sana

Mita > Ganga

$\therefore$ Mita > Ganga > Rekha, Lakshmi > Sana

$\therefore$ 2 and statement 4 are correct

Electrical Engineering

1. Given that

$$\text{Mean square of random process} = E(x^2) = \frac{kt}{C}$$

Mean is given zero $\Rightarrow E(x) = 0$

We know that $E(x^2) - [E(x)]^2 = \text{variance}$

$$\text{Variance} = \frac{KT}{C}$$

$$\text{Standard deviation} = \sqrt{\text{variance}} = \sqrt{\frac{KT}{C}}$$

2. Applying R.H criteria for stability

$$\Delta(S) = S^4 + 3S^3 + 3S^2 + S + K = 0$$

S^4	1	3	K
S^3	3	1	0
	$\frac{8}{3}$	K	0
S^2	3		
	$\frac{8}{3} - 3K$		
S^1	3	0	0
	$\frac{8}{3}$		
S^0	K		

For stability, first column should be greater than zero

$$\frac{\frac{8}{3} - 3K}{\frac{8}{3}} > 0 \text{ and } k > 0$$

$$\therefore 0 < K < \frac{8}{9}$$

3.

$$H(S) = \frac{S+3}{S^2+2S+1}$$

$$H(t) = L^{-1}[H(S)]$$

$$= \mathcal{L}^{-1} \left[\frac{s+3}{s^2+2s+1} \right] = \mathcal{L}^{-1} \left[\frac{s+3}{(s+1)^2} \right]$$

$$= \mathcal{L}^{-1} \left[\frac{s+1+2}{(s+1)^2} \right] = \mathcal{L}^{-1} \left[\frac{1}{s+1} \right] + \mathcal{L}^{-1} \left[\frac{2}{(s+1)^2} \right]$$

$$H(t) = e^{-t} + 2te^{-t}$$

4. We know that

$$\text{Voltage Regulation} = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100$$

Given that $V_{FL} = 95V$

$V_{NL} = 100V$

$$\% \text{ VR} = \frac{100 - 95}{100} \times 100 = 5\%$$

5. We know that $P = VI \cos \phi$, as load and voltage are same

$\therefore I \cos \phi = \text{constant}$

$I_1 \cos \phi_1 = I_2 \cos \phi_2$

$I_1 = 200A$

$\cos \phi_1 = 1$

$\cos \phi_2 = 0.5$

$$I_2 = \frac{I_1 \cos \phi_1}{\cos \phi_2} = 400A$$

6. We know that

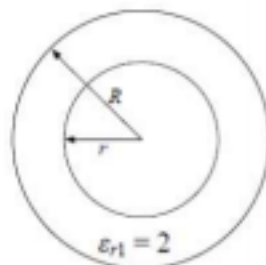


Figure (i)

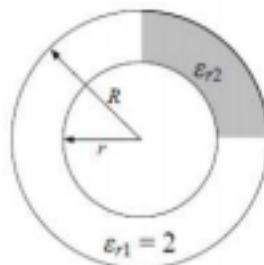
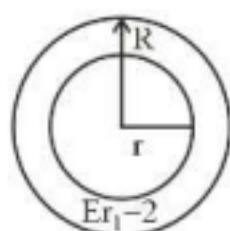


Figure (ii)

$$C_1 = \frac{2\pi \epsilon_r}{\ln\left(\frac{b}{a}\right)} = \frac{2\pi(2\epsilon_o)}{\ln\left(\frac{R}{r}\right)}$$

$$C_1 = \frac{4\pi \epsilon_o}{\ln\left(\frac{R}{r}\right)}$$



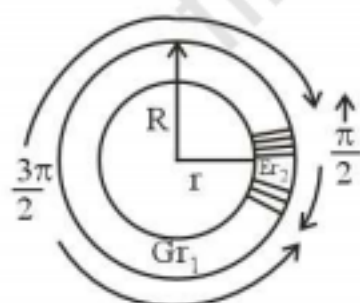
Total portion cover 2π

$$\therefore \frac{1}{4} \text{ portion covers} = \frac{2\pi}{4} = \frac{\pi}{2}$$

$\frac{\pi}{2}$ length for ϵ_{r1}

and $\frac{3\pi}{2}$ length for ϵ_{r1}

Both are connected in parallel



$$C_2 = C_{r1} + C_{r2}$$

$$= \frac{2\pi(2\epsilon_0)}{\ln\left(\frac{R}{r}\right)} \times \frac{3\pi}{2} + \frac{2\pi(\epsilon_{r2}\epsilon_0)}{\ln\left(\frac{R}{r}\right)} \times \frac{\pi}{2}$$

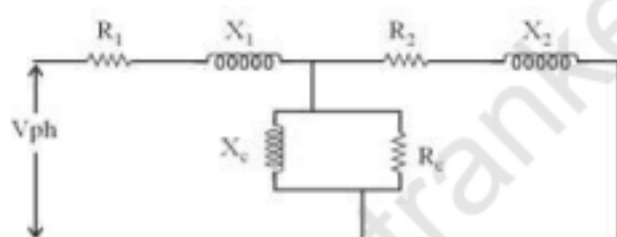
$$= \frac{\pi\epsilon_0}{\ln\left(\frac{R}{r}\right)} \left[3 + \frac{\epsilon_{r2}}{2}\right]$$

Given $C_2 = 2C_1$

$$\frac{\pi\epsilon_0}{\ln\left(\frac{R}{r}\right)} \left[3 + \frac{\epsilon_{r2}}{2}\right] = 2 \left(\frac{4\pi\epsilon_0}{\ln\left(\frac{R}{r}\right)} \right)$$

$\epsilon_{r2} = 10$

7.



$$\frac{V_1}{f} \propto \phi \propto I_m \quad I_m \propto \frac{V}{X_m}$$

$$\frac{V \downarrow}{f(= \text{constt.})} \propto \phi_m \downarrow$$

By reducing the rms value of supply voltage at rated frequency, magnetizing current changes which changes the magnetizing reactance

8.

$$H(s) = \frac{10}{s(s^2 + s + 100\sqrt{2})}$$

For finding steady state value, we will apply final value theorem

$$\lim_{t \rightarrow \infty} y(t) = \lim_{s \rightarrow 0} sY(s)$$

$$y(\infty) = \lim_{s \rightarrow 0} s \times \frac{10}{s(s^2 + s + 100\sqrt{2})}$$

$$y(\infty) = \frac{1}{10\sqrt{2}}$$

9.

$$G(s) = \frac{\pi e^{-0.25s}}{s}$$

Nyquist plot cut the negative real
Axis at ω = phase cross over frequency

$$G(j\omega) = \frac{\pi e^{-0.25j\omega}}{j\omega}$$

$$\phi = -90^\circ - 0.25\omega \times \frac{180^\circ}{\pi}$$

$$\angle G(j\omega)|_{\omega=\omega_{pc}} = -180^\circ$$

$$\phi_{\omega=\omega_{pc}} = -90^\circ$$

$$90^\circ - \left(\frac{45^\circ}{\pi} \right)$$

$$\omega_{pc} = 2\pi$$

Magnitude at cutting point

$$X = |G(j\omega)|_{\omega_{pc}}$$

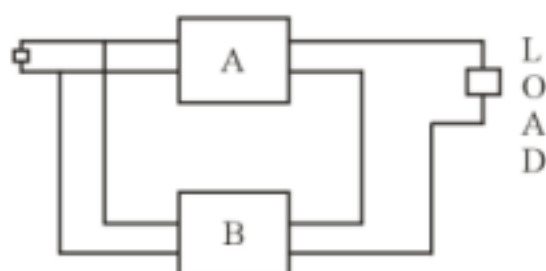
$$= \frac{\pi}{\omega_{pc}} = \frac{\pi}{2\pi}$$

$$\boxed{X = \frac{1}{2}}$$

Then, the co-ordinates becomes $(-0.5, j0)$.

10. Given $Z_{in} = 10\Omega$, $Z_{o/p} = 100\Omega$

For CCCS



Series connection is output

$$Z_{o/p} = Z_{o/p} (1 + A\beta) = 100 (1 + 9) \\ = 100 \text{ K}\Omega$$

11. We know that,

For 6-pulse converter harmonic present in AC current are $6K \pm 1$

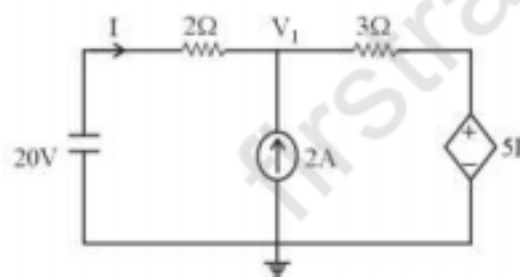
General expression $NK \pm 1$ $[k = 0, 1, 2, 3]$

For 6 pulse $n = 6$

Lowest order harmonic = 5

Lower harmonic frequency = $5 \times 50 = 250 \text{ Hz}$

12.



Applying nodal analysis at point 1 whose voltage is assumed as V_1 .

$$\frac{V_1 - 20}{2} - 2 + \frac{V_1 - 5I}{3} = 0 \dots (1)$$

$$I = \frac{20 - V_1}{2} \dots (2)$$

Solving (1) and (2)

$$-I - 2 + \frac{V_1 - 5I}{3} = 0$$

$$8I = V_1 - 6$$

$$8I = 20 - 2I - 6$$

$$10I = 14$$

$$I = 1.4 \text{ A}$$

13.

$$\text{Wave equation } \frac{d^2 u}{dt^2} = c^2 \left(\frac{d^2 u}{dx^2} + \frac{d^2 u}{dy^2} \right)$$

$$\text{Laplace equation } \nabla^2 U = \frac{d^2 u}{dx^2} + \frac{d^2 u}{dy^2} = 0$$

$$\text{Poisson equation } \nabla^2 U = f$$

$$\text{Heat equation } \frac{du}{dt} - \alpha \left(\frac{d^2 u}{dx^2} + \frac{d^2 u}{dy^2} + \frac{d^2 u}{dz^2} \right) = 0$$

14.

$$\text{For } \frac{z^2 - 1}{z + 2}, \text{ the singularity } z = -2 \text{ lies outside the } |z| \leq 1$$

∴ By Cauchy's integral theorem

$$\int \frac{z^2 - 1}{z + 2} dz = 0 \text{ for } |z| \leq 1$$

15.

Given that

$$y = 2x^3 + 3y^2 + 4z$$

$$\int \text{grad } f \cdot dr = ?$$

$$\vec{dr} = dx\hat{i} + dy\hat{j} + dz\hat{k}$$

$$\text{grad } f = \frac{df}{dx}\hat{i} + \frac{df}{dy}\hat{j} + \frac{df}{dz}\hat{k}$$

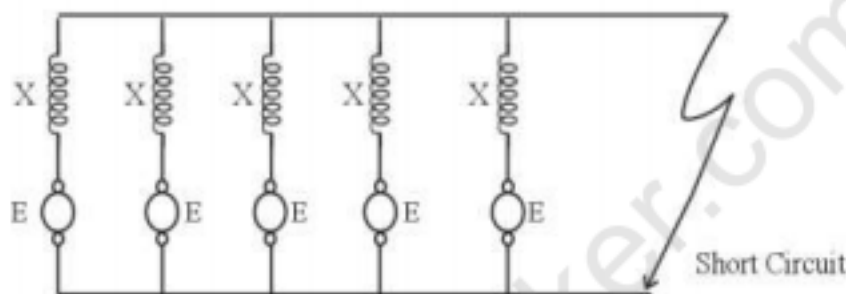
$$= 6x^2\hat{i} + 6y\hat{j} + 4\hat{k}$$

$$\int \text{grad } f \cdot \vec{dr} = \int 6x^2 dx + \int 6y dy + \int 4 dz$$

Applying the limits

$$\begin{aligned}
 \int_C \text{grad } f \cdot dr &= \left[\int_{-3}^2 6x^2 dx + \int_{-3}^{-3} 6y dy + \int_2^2 4dz \right] \\
 &= \left[\int_2^2 6x^2 dx + \int_{-3}^6 6y dy + \int_2^2 4dz \right] + \left[\int_2^2 6x^2 dx + \int_6^6 6y dy + \int_2^{-1} 4dz \right] \\
 &= [2x^3]_2^2 + [3y^2]_{-3}^6 + [4z]_2^2 \\
 &= 70 + 81 - 12 = 139
 \end{aligned}$$

16.



Net reactance of generator

$$X = \frac{0.25}{5} = 0.05 \text{ p.u.}$$

$$I_{sc} = \frac{\text{Pre-fault voltage}}{X} = \frac{1}{0.05} = 20 \text{ p.u.}$$

$$\begin{aligned}
 \text{Short Circuit MVA} &= I_{sc} \times \text{Base MVA} \\
 &= 20 \times 5 = 100 \text{ MVA}
 \end{aligned}$$

17. For NMOS transistor to be in saturation the condition will be

$$V_{GS} > V_{th}$$

$$\text{And } V_{DS} \geq V_{GS} - V_{th}$$

18.

$$I_{sec} = 5 \times 20 = 100 \text{ A}$$

$$V = I_{sec} R = 100 \times 0.01 = 1 \text{ V}$$

$$\text{VA output of CT} = V I_{sec} = 100 \times 1 = 100 \text{ VA}$$

19.

$$Y_{12} = -(Y_{12}) = -j20$$

$$\text{Series admittance of each line} = \frac{Y_{12}}{2} = \frac{-j20}{2} = -j10$$

Series reactance of each line = $\frac{1}{-j10} = j0.1 \text{ p.u.}$

20.

$$M = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

Determinant of $M = |M|$

$$|M| = 0[0-1] - 1[0-1] + 1[1-0]$$

$$|M| = 2$$

$$|M| \neq 0$$

$\therefore$ Rank of M = number of columns

$$P(M) = 3$$

$$21. H(t) = 1 + e^{-at} u(t)$$

'1' is a constant and two sided so the impulse response cannot be causal as for causal it should satisfy

$$h(t) = 0 \quad t < 0$$

$$\neq 0 \quad t > 0$$

Which it is not satisfying due to presence of constant

$\therefore$ It is not causal

22.

$$H(s) = \frac{a_1 s^2 + b_1 s + c_1}{a_2 s^2 + b_2 s + c_2}$$

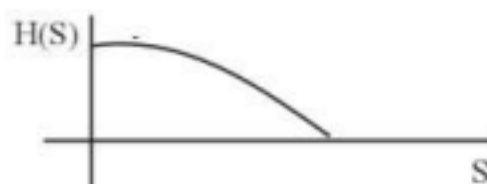
$$a_1 = b_1 = 0$$

$$H(s) = \frac{c_1}{a_2 s^2 + b_2 s + c_2}$$

At $s = 0$

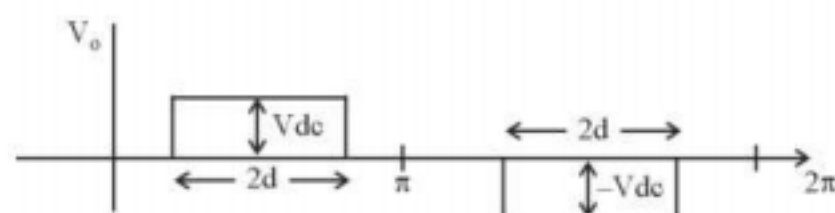
$H(0) = \text{constant}$

At $s = \infty$



$\therefore$ It is a low pass filter

23. Waveform for output voltage of single phase full bridge PWM inverter



$$V_o = \sum_{n=6k \pm 1} \frac{4V_{dc}}{n\pi} \sin nd \sin \frac{n\pi}{2} \cos n\omega t$$

V_{o1rms} = fundamental rms output voltage

$$V_{o1} = \frac{2\sqrt{2}}{\pi} V_{dc} \sin d \sin \frac{\pi}{2}$$

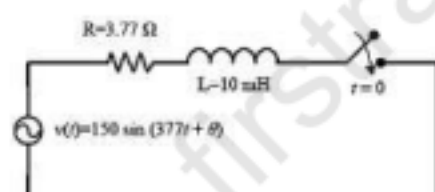
Given, $V_{o1} = 0.754 V_{dc}$

$$0.75 V_{dc} = \frac{2\sqrt{2}}{\pi} V_{dc} \sin d$$

$$d = \sin^{-1} \left[\frac{0.75}{0.9} \right] = 56.44$$

Pulse width = $2d = 112.88$

24. For series R – L circuit, $i(t)$ expression is



A. 60

B. 90

C. -30

D. -45

$$i(t) = \underbrace{\left\{ \frac{-V_m}{\sqrt{R^2 + X_L^2}} \sin(\theta - \phi) \right\}}_{\text{Complimentary Integral}} e^{-t/\tau} + \underbrace{\frac{V_m}{\sqrt{R^2 + X_L^2}} \sin(\omega t - \phi)}_{\text{Particular Integral}}$$

Complimentary
Integral

Particular
Integral

$$i(t) = Ae^{-t/\tau} + \frac{V_M}{Z} \sin(\omega t - \phi)$$

$$\text{DC offset} = A = \frac{-V_m}{Z} \sin(\theta - \phi)$$

For Maximum value of DC offset A

$$\theta - \phi = -90$$

$$\theta - \tan^{-1} \left[\frac{\omega L}{R} \right] = -90$$

$$\theta - \tan^{-1} \left[\frac{377 \times 10 \times 10^{-3}}{3.77} \right] = -90$$

$$\theta - 45^\circ = -90^\circ$$

$$\theta = -45^\circ$$

25. M is a 2×2 Matrix with Eigen value 4 and 9 If has $\lambda_1, \lambda_2, \dots, \lambda_n$ Eigen values

$$M^n \rightarrow \lambda_1^n, \lambda_2^n, \dots, \lambda_n^n \text{ Eigen values}$$

$$M^2 \rightarrow 4^2, 9^2$$

$\therefore M^2$ has Eigen values as 16 and 81

26. $V_s = 400 \text{ KV}$

$$l = 300 \text{ km}$$

$$L_1 = 1 \text{ mH / km / phase}$$

$$C_1 = 0.01 \mu\text{F / km / phase}$$

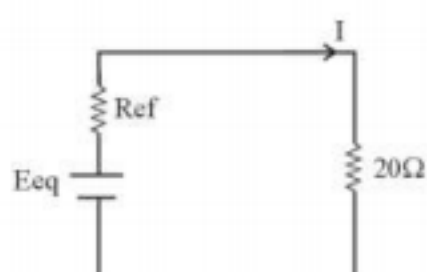
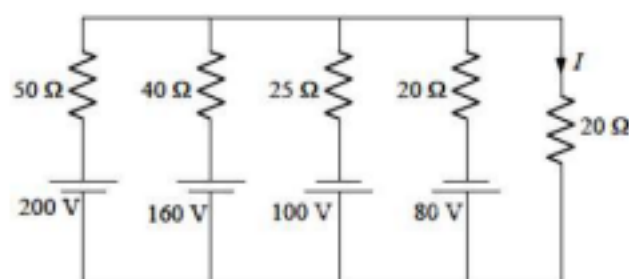
$$v = \frac{1}{\sqrt{L_1 C_1}} = \frac{1}{\sqrt{1 \times 10^{-3} \times 0.01 \times 10^{-6}}} = 3.16 \times 10^5 \text{ km / s}$$

$$\beta' = \frac{2\pi f l}{v} = \frac{2\pi \times 50 \times 300}{3.16 \times 10^5} = 0.29$$

$$A = 1 - \frac{\beta^2}{2} = 1 - \frac{(0.29)^2}{2} = 0.955$$

$$V_R = \frac{V_s}{A} = \frac{400}{0.955} = 418.85 \text{ KV}$$

27. According to Mill man's Theorem, the equivalent circuit of the given circuit is



$$E_{eq} = \frac{\frac{E_1}{R_1} + \frac{E_2}{R_2} + \frac{E_3}{R_3} + \frac{E_4}{R_4}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}$$

$$= \frac{\frac{200}{50} + \frac{160}{40} + \left[-\frac{100}{25}\right] + \left[-\frac{80}{20}\right]}{\frac{1}{50} + \frac{1}{40} + \frac{1}{25} + \frac{1}{20}}$$

$$E_{eq} = 0V$$

So, the current I flowing is 0 A

28. For synchronous motor

$$E_g = V_1 - IZ$$

$$V_t = \frac{220}{\sqrt{3}} V \text{ (Phase)}$$

$$Z = (0.25 + j 2.5) \Omega$$

$$I = 10 \angle -36.86^\circ A$$

$$E_g = \frac{220}{\sqrt{3}} - (0.25 + j2.5) \times 10 \angle -36.86^\circ$$

$$E_g = 141.658 \angle -8.7^\circ V \text{ (phase)}$$

$$E_g = 245.36 V \text{ (line)}$$

29.

$$\bigcirc \quad z = 2\pi j \text{ (sum of residues)}$$

12.

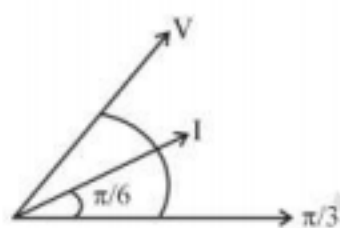
$$= 2\pi j \times \left[\lim_{z \rightarrow 2} (z+2) \frac{(z^3 + z^2 + 8)}{z+2} \right]$$

$$= 2\pi j \left[\frac{-8+4+8}{1} \right] = 8\pi j$$

30.

$$V(t) = -170 \sin \left(377t - \frac{\pi}{6} \right)$$

$$I(t) = 8 \cos \left(377t + \frac{\pi}{6} \right)$$



$$V(t) = -170 \sin \left(377t - \frac{\pi}{6} \right)$$

$$V(t) = 170 \cos \left(377t - \frac{\pi}{6} + \frac{\pi}{2} \right)$$

$$V(t) = 170 \cos \left(377t + \frac{\pi}{3} \right)$$

$$P = V_{rms} I_{rms} \cos \phi$$

$$P = \frac{170}{\sqrt{2}} \frac{8}{\sqrt{2}} \cos 30$$

$$P = 588.89 \text{ watts}$$

31. Given $R_1 = 5.39\Omega$, $R_2 = 5.72\Omega$, $X_1 = X_2 = 8.22\Omega$
for frequency $\rightarrow 10 \text{ Hz}$

$$X_1 = X_2 = 8.22 \times \frac{10}{50} = 1.644 \Omega$$

Starting phase current at 10 Hz

$$I_{pn} = \frac{V_{pn}}{\sqrt{(R_1 + R_2)^2 + (X_1 + X_2)^2}}$$

$$= \frac{100}{\sqrt{(5.39 + 5.72)^2 + (1.644 + 1.644)^2}}$$

$$I_{pn} = 8.63 \text{ A}$$

Starting line current = $I_L = \sqrt{3} I_{ph}$

$$I_L = \sqrt{3} \times 8.63$$

$$I_L = 14.95 \text{ A}$$

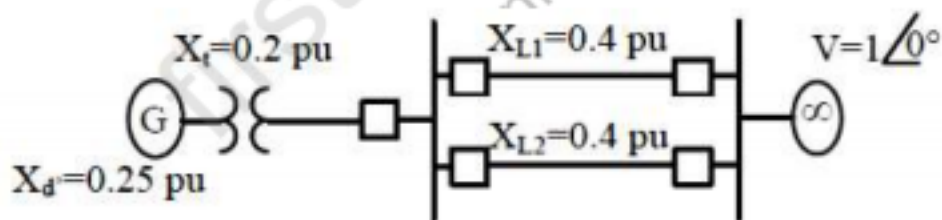
32. Given data $L = 50 \text{ mH}$, $C = 0.05 \mu\text{F}$

Critical resistance to avoid current shopping will be given as

$$R = \frac{1}{2} \sqrt{\frac{L}{C}} = \frac{1}{2} \sqrt{\frac{50 \times 10^{-3}}{0.05 \times 10^{-6}}}$$

$$R = 500 \Omega$$

33.



$$X_{eq} = 0.25 + 0.2 + \frac{0.4}{2}$$

$$X_{eq} = 0.65 \text{ PU}$$

$$P = V_{pu} I_{pu} \cos \phi$$

$$0.8 = 1 \times I_{pu} \times 0.8$$

$$I_{pu} = 1 \text{ PU}$$

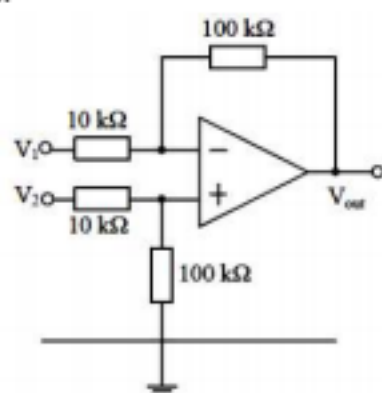
$$\vec{I} = 1 \angle -6.86^\circ \quad [\text{as } 0.8 \text{ pf lagging}]$$

$$\vec{V}_{eq} = 1 \angle 0^\circ$$

$$\vec{V} = 1 \angle 0^\circ - 36.86 \times j0.65 = 1.484 \angle 20.51^\circ \text{ Pu}$$

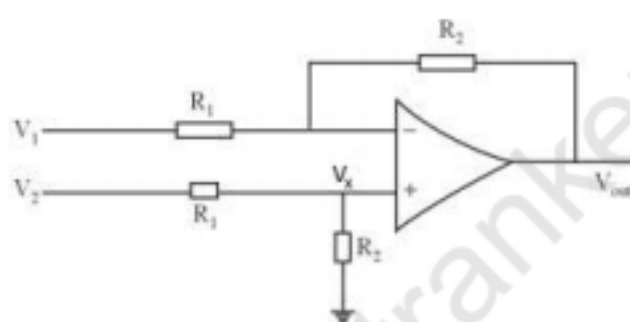
$\delta = 20.51$ degrees

34.



- A. 600 mV
C. 400 mV

- B. 500 mV
D. 100 mV



$$V_x = V_2 \frac{R_2}{R_1 + R_2} \quad [\text{Voltage division Rule}]$$

$$V_{out} = V_x \left[1 + \frac{R_2}{R_1} \right] - V_1 \frac{R_2}{R_1}$$

$$V_{out} = V_2 \frac{R_2}{R_1 + R_2} \left[1 + \frac{R_2}{R_1} \right] - V_1 \frac{R_2}{R_1}$$

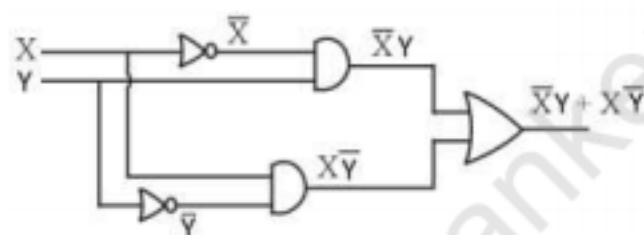
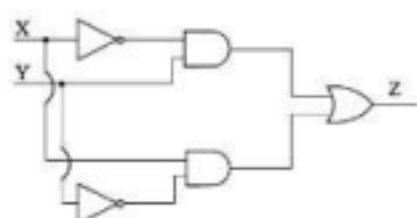
$$V_{out} = V_2 \frac{R_2}{R_1 + R_2} \left[1 + \frac{R_2}{R_1} \right] - V_1 \frac{R_2}{R_1}$$

$$V_{out} = V_2 \frac{R_2}{R_1} - V_1 \frac{R_2}{R_1} = \frac{R_2}{R_1} (V_2 - V_1)$$

$$V_{out} = \frac{100}{10} (50 - 10)$$

$$V_{out} = 400mV$$

35.



$$\text{Output} = \bar{X}Y + X\bar{Y}$$

$$= X \oplus Y$$

The above expression is for XOR gate

36. Discharging of capacitor equation

$$V_C(t) = V_0 e^{-t/\tau}$$

$$\text{Where } \tau = RC = (10^3)(10^{-7}) = 10^{-4} \text{ sec}$$

$$V_0 = 100V$$

$$V_C(t) = 100 e^{-10^4 t}$$

$$V_C(t) = 1V$$

$$1 = 100 e^{-10^4 t}$$

$$T = 0.46 \text{ msec}$$

37.

$$f(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos nt + \sum_{n=1}^{\infty} b_n \sin nt.$$

$$a_n = \frac{2}{T} \int_0^T x(t) \cos n\omega t \, d(\omega t)$$

$$a_1 \Big|_{\substack{\omega=1 \\ T=2\pi}} = \frac{2}{2\pi} \int_0^{2\pi} A \sin t \cos t \, dt$$

$$= \frac{A}{\pi} \int_0^{\pi} \sin t \cos t \, dt$$

$$a_1 = \frac{A}{\pi} \int_0^{\pi} \frac{\sin 2t}{2} = \frac{A}{2\pi} \left[\frac{-\cos 2t}{2} \right]_0^{\pi}$$

$$a_1 = 0$$

$$b_n = \frac{2}{T} \int_0^T x(t) \sin n\omega t \, d(\omega t)$$

$$b_1 = \frac{2}{2\pi} \int_0^{\pi} A \sin t \sin t \, dt$$

$$b_1 = \frac{A}{\pi} \int_0^{\pi} \sin^2 t \, dt$$

$$b_1 = \frac{A}{\pi} \int_0^{\pi} \left(\frac{1}{2} - \frac{\cos 2t}{2} \right) dt$$

$$b_1 = \frac{A}{2}$$

38.

$$A = 2x\hat{i} + 3y\hat{j} + 4z\hat{k}, U = x^2 + y^2 + z^2$$

$$UA = (2x^3 + 2xy^2 + 2xz^2)\hat{i} + (3x^2y + 3y^3 + 3yz^2)\hat{j} \\ + (4x^2z + 4y^2z + 4z^3)\hat{k}$$

$$\text{div}(UA) = \frac{d}{dx}(2x^3 + 2xy^2 + 2xz^2) + \frac{d}{dy}(3x^2y + 3y^3 + 3yz^2) \\ + \frac{d}{dz}(4x^2z + 4y^2z + 4z^3)$$

$$\text{div}(UA) = (6x^2 + 2y^2 + 2z^2) + (3x^2 + 9y^2 + 3z^2) + (4x^2 + 4y^2 + 12z^2)$$

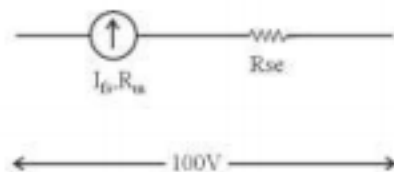
$$\text{at } (1, 1, 1) \Rightarrow x = 1, y = 1, z = 1$$

$$\text{div}(UA) = 45$$

39. PMMC Instrument

$$I_{fs} = 10 \text{ mA}$$

$$R_m = 10\Omega$$



$$100 = I_{fs} (R_m + R_{se})$$

$$100 = 10 \times 10^{-3} (10 + R_{se})$$

$$R_{se} = 10000 - 10 = 9990\Omega$$

40.

$$\begin{bmatrix} \cdot \\ \cdot \\ \cdot \end{bmatrix} = \begin{bmatrix} 1 \\ -2\beta \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ \alpha \end{bmatrix} r$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

We know

$$\dot{X} = Bu$$

$$Y = CX + Du$$

Comparing the above equation with the given problem

$$A = \begin{bmatrix} 0 & 1 \\ -\alpha & -2\beta \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ \alpha \end{bmatrix}$$

$$C = (1 \quad 0)$$

Characteristic equation is

$$|S I - A| = 0$$

$$\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ -\alpha & -2\beta \end{bmatrix} = 0$$

$$\begin{vmatrix} s & -1 \\ \alpha & s+2\beta \end{vmatrix} =$$

$$s^2 + 2\beta s + \alpha = 0 \quad (1)$$

$$s^2 + 2\xi\omega_n s + \omega_n^2 = 0 \quad (2)$$

Comparing (1) and (2)

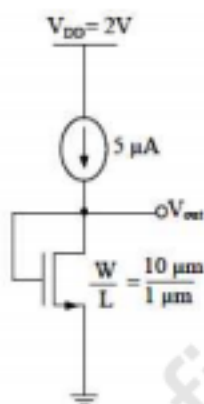
$$\omega_n^2 = \alpha$$

$$\omega_n = \sqrt{\alpha}$$

$$2\xi\omega_n = 2\beta$$

$$\xi = \frac{\beta}{\omega_n} = \frac{\beta}{\sqrt{\alpha}}$$

41.



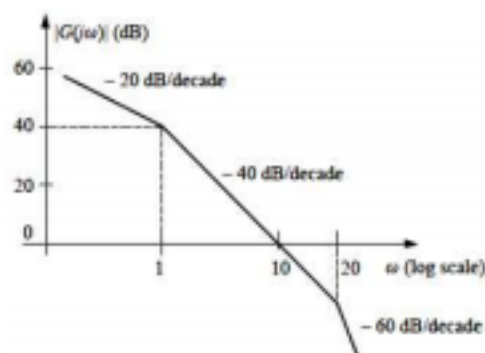
$$I_D = \frac{1}{2} (\mu_n C_{ox}) \left(\frac{W}{L} \right) (V_{gs} - V_t)^2$$

$$5 \times 10^{-6} = \frac{1}{2} (100 \times 10^{-6}) \times (10) \times (V_{out} - 0.5)^2$$

$$(V_{out} - 0.5)^2 = 0.01$$

$$V_{out} = 0.6V = 600mV$$

42.



From the given Bode plot,

$$T(s) = \text{Transfer function} = \frac{K}{s \left(1 + \frac{s}{1}\right) \left(1 + \frac{s}{20}\right)}$$

It has three poles and no zero

So, statement 1 is false

$$\angle T(s) = -90 - \tan^{-1} w - \tan^{-1} \frac{w}{20}$$

$$\angle T(jw) | w \rightarrow \infty = -270^\circ$$

So, statement 2 is true

43. Load supplied previously before adding extra load

12 KW at pf of 0.6

$$S_{\text{Load}} = 12 + j16$$

Now, Let P be extra load added (Q_{extra} = as unity p.f)

$$S_{\text{Load}} = 12 + P + j16$$

$$|S_{\text{Load}}| = \sqrt{(12 + P)^2 + 16^2}$$

$$\text{Rated KVA } |S_{\text{rated}}| = 25$$

$$25 = \sqrt{(12 + P)^2 + 16^2}$$

$$25^2 = (12 + P)^2 + 16^2$$

$$P = 7.5, -31.2$$

So, 7.20 KW is extra load which is added

44.

$$M^{-1} M = I$$

$$\begin{bmatrix} U_1^T \\ U_2^T \end{bmatrix} \begin{bmatrix} V_1 & V_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} U_1 T_{V1} & U_1 T_{V2} \\ U_2 T_{V1} & U_2 T_{V2} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$U_1^T V_1 = 1 \quad U_1^T V_2 = 0$$

$$U_2^T V_1 = 0 \quad U_2^T V_2 = 1$$

Statement 1 and 2 are both correct

45.

$$V_{sr} I_{sr} \cos \phi = V_o I_o$$

For single phase fully – controlled converter

$$I_o = I_{sr} = 10A$$

$$\cos \phi = \frac{V_o}{V_{sr}} = \frac{180}{230} = 0.78$$

46. Given that

Switch frequency, $f_s = 250\text{Hz}$

Load resistance $R_L = 24\Omega$

Supply voltage $V_s = 48\text{V}$

$T_{ON} = 1 \text{ msec}$

$$T = \frac{1}{f_s} = 4\text{ms}$$

$$\alpha = \frac{T_{ON}}{T} = 0.25$$

$$\text{Load power} = \frac{V_o^2}{R} = \frac{(\alpha V_s)^2}{R} = \frac{(0.25 \times 48)^2}{24}$$

$$P = 6 \text{ watts}$$

47. $P_o = 120\text{w}$, $V_s = 24\text{V}$, $V_o = 48\text{V}$

$$V_o = \frac{V_s}{1-\alpha}$$

$$1-\alpha = \frac{24}{48}$$

$$\alpha = 0.5 \text{ [Duty cycle]}$$

$$P_o = V_o I_o = 120$$

$$I_o = \frac{120}{48} = 2.54 \text{ A}$$

$$V_{s1s} = V_o I_o$$

$$I_s = \frac{120}{24} = 5 \text{ A}$$

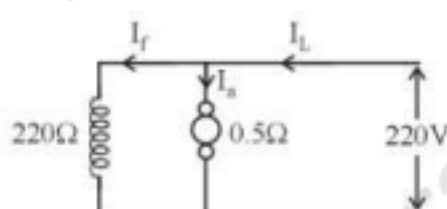
At boundary of continuous & discontinuous

$$I_L = I_s = \frac{\Delta I_L}{2}$$

$$\Delta I_L = \frac{\alpha V_s}{f L_c} = 2 \times 5$$

$$L_c = \frac{0.5 \times 24}{50 \times 10^3 \times 10} = 24 \mu\text{H}$$

48.



No load

$$I_{NL} = 3 \text{ A}$$

$$I_c = \frac{220}{R_f} = \frac{220}{220} = 1 \text{ A}$$

$$I_a = I_L - I_f = 2 \text{ A}$$

$$\text{Back cmf} = E_{bN} = V - I_a R_a$$

$$= 220 - 2 \times 0.5 = 219 \text{ V}$$

Full load

$$I_{FL} = 25 \text{ A}$$

$$N_f = 1500 \text{ rpm}$$

$$I_f = 1 \text{ A}$$

$$I_a = I_{FL} - I_f = 24 \text{ A}$$

$$E_{bF} = V - I_a R_a = 220 - 24 \times 0.5 = 208 \text{ V}$$

We know $E \propto \text{speed } (N)$

$$\frac{E_{bF}}{E_{bN}} = \frac{N_f}{N_N} \quad (N_N = \text{speed at no load})$$

$$\frac{208}{219} = \frac{1500}{N_N}$$

$$N_N = 1579.33 \text{ rpm}$$

49.

$$\text{Ac line current rms} = (I_s)_{\text{rms}} = I_o \sqrt{\frac{2}{3}} = 100 \sqrt{\frac{2}{3}} = 81.65 \text{ A}$$

50.

RS \ PQ				
	00	01	11	10
00	0	1	1	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0

RS \ PQ				
	00	01	11	10
00	0	1	1	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0

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

51.

$$P = 0.02$$

$$n = 50$$

$$\lambda = np = 50(0.02) = 1$$

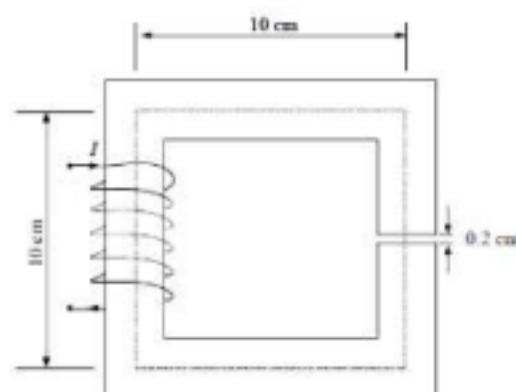
$$P(x \geq 2) = 1 - P(x < 2)$$

$$= 1 - [P(x=0) + P(x=1)]$$

$$= 1 - \left[\frac{e^{-\lambda} \lambda^0}{0!} + \frac{e^{-\lambda} \lambda^1}{1!} \right] = 1 - e^{-\lambda}(1 + 1)$$

$$P(x \geq 2) = 1 - e^{-1} (1 + 1) = 0.26$$

52.



$$L_{air} = 0.2 \text{ cm}$$

$$L_m = 40 \text{ cm}$$

$$\text{Given } B_0 = 1 \text{ Tesla at } \mu_r \rightarrow \infty$$

$$L_{core} = 40 - 0.2 = 39.8 \text{ cm}$$

 Let a = uniform cross-sectional area

We know that

$$\phi = \text{flux} = \frac{\text{MMF}}{\text{Total Reluctance}} = \frac{NI}{S}$$

$$S_T = S_{airgap} + S_{core}$$

$$= \frac{L_{air}}{\mu_0 (1) A} + \frac{L_{core}}{\mu_0 \mu_r A}$$

$$S = \frac{1}{\mu_0 A} \left[L_{air} + \frac{L_{core}}{\mu_r} \right]$$

$$\text{Case 1: when } \mu_r \rightarrow \infty, B = 1 \text{ T}$$

$$\text{MMF} = NI_1 = B_1 A \left[L_{air} + \frac{L_{core}}{\mu_r} \rightarrow \infty \right] \frac{1}{\mu_0 A}$$

$$NI_1 = 1 (a) [l_{air}] \times \frac{1}{\mu_0 A} = \frac{L_{air}}{\mu_0}$$

$$NI_1 = \frac{l_{air}}{\mu_0} \quad (1)$$

Case 2:

$$\mu_r = 1000$$

MMF = Same

$$NI_1 = B_2 A \left[L_{air} + \frac{L_{core}}{\mu_r} \right] \frac{1}{\mu_o A}$$

Put NI_1 from (1)

$$\frac{L_{air}}{\mu_o} = B_2 \frac{1}{\mu_o} \left[L_{air} + \frac{L_{core}}{1000} \right]$$

$$0.2 = B_2 \left[0.2 + \frac{39.8}{1000} \right]$$

$$B_c = 0.834 \text{ Tesla}$$

53. Fault current for SLG fault

$$I_{F1G} = \frac{3V}{X_1 + X_2 + X_0 + 3X_n}$$

Fault current for 3 ϕ fault

$$I_{f3\phi} = \frac{V}{X_1}$$

$$\frac{3V}{X_1 + X_2 + X_0 + 3X_n} = \frac{V}{X_1}$$

$$X_n = \frac{2X_1 - X_0 - X_2}{3}$$

$$X_n = \frac{2(0.25) - 0.05 - 0.15}{3}$$

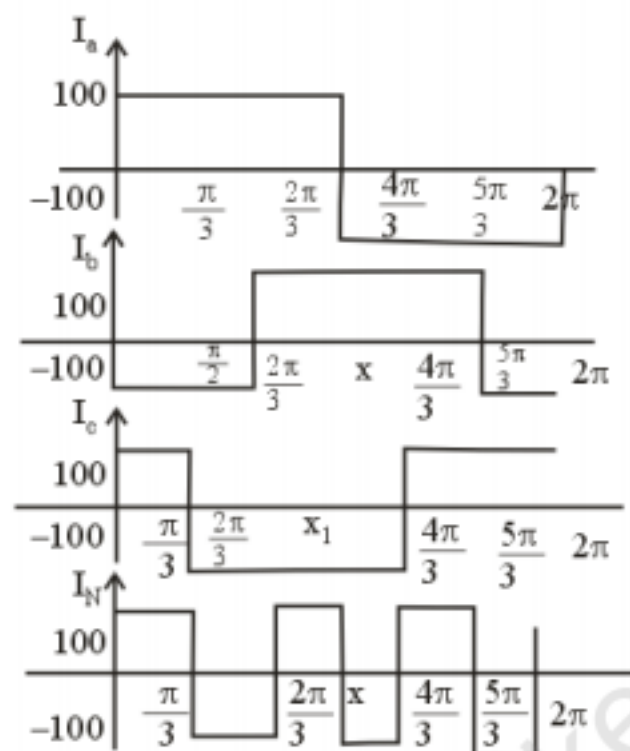
$$X_n = 0.1 \text{ Pu}$$

$$X_n (\text{in } \Omega) = 0.1 \times \frac{30^2}{50}$$

$$X_n (\text{in } \Omega) = 1.8 \Omega$$

$$\left[Z_{pu} = \frac{Z_{base} \times MVA}{KVL} \right]$$

54.



$$I_N = I_a + I_b + I_c$$

$$(I_N)_{rms} = 100A$$

55.

$$D(s) = \frac{3\left(s + \frac{1}{3T}\right)}{\left(s + \frac{1}{T}\right)}$$

$$T(s) = \frac{1+3TS}{1+TS}$$

 Frequency at which $\angle T(j\omega)$ is maximum (i)

$$\omega_m = \frac{1}{T\sqrt{\alpha}}$$

$$T(s) = \frac{1+\alpha TS}{1+TS} \text{ is The general phase lead compensator}$$

$$\therefore \alpha = 3$$

$$\omega_m = \frac{1}{T\sqrt{3}} = \frac{1}{\sqrt{3}T^2}$$