Q. No. 1 – 25 Carry One Mark Each

1. The bridge method commonly used for findin
g mutual inductance is

(A) Heaviside Campbell bridge (B) S
chering bridge

Answer:- (A)

(C) De Sauty bridge (D) W
ien br
idge

2. A two phase load draws the following phase currents: $i_1(t) = I_m \sin(\omega t - \phi_1)$, $i_2(t) = I_m \cos(\omega t - \phi_2)$. These currents are balanced if ϕ_1 is equal to

(A) $-\phi_2$ (B) ϕ_2 (C) $(\pi/2 - \phi_2)$ (D) $(\pi/2 + \phi_2)$

Answer:- (D)

Exp:- $I(t) = I_m \sin(\omega t - \sigma_1) = I_m \cos[90 - (\omega t - r_1)] = I_m \cos(\omega t - \phi_1 - 90^O)$

$i_x(t) = I_m \cos(\omega t - \phi_2)$

Angle difference between two currents should be -180^O (or) 180^O for balanced

$-\phi_1 + \phi_2 - 90 = -180^O \Rightarrow \phi_1 = 90 + \phi_2$

3. The slip of an induction motor normally does not depend on

(A) Rotor speed (B) Synchronous speed

(C) Shaft torque (D) Core-loss component

Answer:- (D)

Exp:- slip $= \dfrac{N_S - N_r}{N_S}$

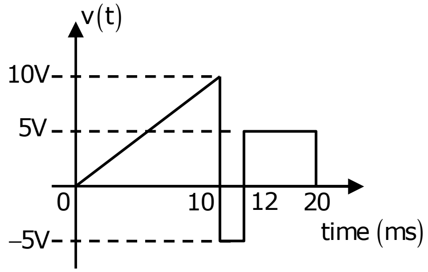
→ So depends on N_s(synchronous speed)

→ So depends on N_r(rotor speed)

→ If torque increases N_r decreases

→ It will not dependent on core loss

4. A periodic voltage waveform observed on an oscilloscope across a load is shown. A permanent magnet moving coil (PMMC) meter connected across the same load reads



(A) 4V (B) 5V (C) 8V (D) 10V

Answer:- (A)

Exp:- PMMC will read average value

$$_{avg} = \frac{\text{Area under curve}}{\text{period}}$$

$$= \frac{\left[\left[\frac{1}{2}\times 10\times 10\right]-[5\times 2]+[8\times 5]\right]\times 10^{-3}}{20\times 10^{-3}} = 4V$$

5. The bus admittance matrix of a three-bus three-line system is

$$Y = j\begin{bmatrix} -13 & 10 & 5 \\ 10 & -18 & 10 \\ 5 & 10 & -13 \end{bmatrix}$$

If each transmission line between the two buses is represented by an equivalent π-network, the magnitude of the shunt susceptance of the line connecting bus 1 and 2 is

(A) 4 (B) 2 (C) 1 (D) 0

Answer:- (B)

Exp:- $y_{11} = \frac{y_{sin12}}{2} + y_{12} + y_{13} + \frac{y_{ns}}{2} \Rightarrow \frac{y_{sin12}}{2} + \frac{y_{sin13}}{2} = 2$

$$\Rightarrow \frac{y_{sn23}}{2} + \frac{y_{sn12}}{2} = 2$$

$$\Rightarrow \frac{y_{sn13}}{2} + \frac{y_{sn23}}{2} = 2$$

$P = P_1 + P_2 - P_L \Rightarrow (40 = 20 + P_2 - 2) \Rightarrow P_2 = 22\,MW$

$P_1 = 20\ ; r_2 = 22$

6. If $x[n] = (1/3)^{|n|} - (1/2)^n u[n]$, then the region of convergence (ROC) of its Z-transform in the Z-plane will be

(A) $\frac{1}{3} < |z| < 3$ (B) $\frac{1}{3} < |z| < \frac{1}{2}$

(C) $\frac{1}{2} < |z| < 3$ (D) $\frac{1}{3} < |z|$

Answer:- (C)

Exp:- $x(n) = \left(\frac{1}{3}\right)^{|n|} - \left(\frac{1}{2}\right)^n + u(n) = \left(\frac{1}{3}\right)^n u(n) + \left(\frac{1}{3}\right)^{-n} u(-n) - \left(\frac{1}{2}\right)^n u(n)$

$$x(n) = \left(\frac{1}{3}\right)^n u(n) + (3)^n u(-n) - \left(\frac{1}{2}\right)^n u(n)$$

ROC: $|z| > \frac{1}{3}$ $\quad |z| < 3$ $\quad |z| > \frac{1}{2}$

common ROC: $\frac{1}{2} < |z| < 3$

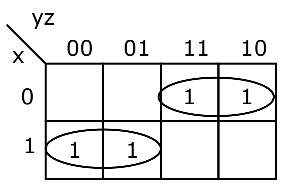
7. In the sum of products function $f(X,Y,Z) = \sum(2,3,4,5)$, the prime implicants are

(A) $\bar{X}Y, X\bar{Y}$ (B) $\bar{X}Y, X\bar{Y}\bar{Z}, X\bar{Y}Z$

(C) $\bar{X}Y\bar{Z}, \bar{X}YZ, X\bar{Y}$ (D) $\bar{X}Y\bar{Z}, \bar{X}YZ, X\bar{Y}\bar{Z}, X\bar{Y}Z$

Answer:- (A)

Exp:-



$f = xy' + x'y$

8. A system with transfer function $G(s) = \dfrac{(s^2+9)(s+2)}{(s+1)(s+3)(s+4)}$ is excited by $\sin(\omega t)$.

The steady-state output of the system is zero at

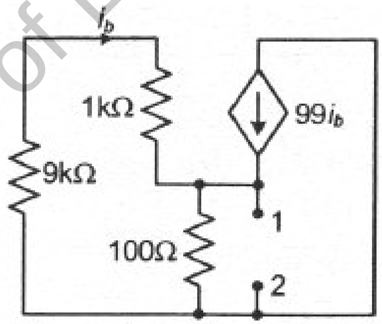
(A) $\omega = 1$ rad/s (B) $\omega = 2$ rad/s

(C) $\omega = 3$ rad/s (D) $\omega = 4$ rad/s

Answer:- (C)

Exp:- $|G(s)| = \dfrac{(9-\omega^2)\sqrt{4+\omega^2}}{\sqrt{\omega^2+1}\sqrt{\omega^2+9}\sqrt{16+\omega^2}} = 0;\ \omega^2 = 9;\ \omega = 3\text{rad/s}$

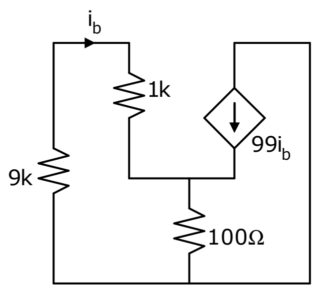
9. The impedance looking into nodes 1 and 2 in the given circuit is

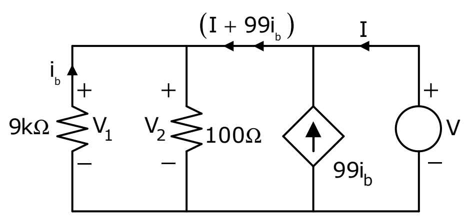


(A) 50 Ω (B) 100 Ω (C) 5kΩ (D) 10.1kΩ

Answer:- (A)

Exp:-





After connecting a voltage source of V

$$R_{th} = \frac{V}{I} = \frac{50I}{I} = 50\Omega$$

$$V_1 = V_2 \Rightarrow \quad (10k)(-i_b) = 100(I + 99i_b + i_b);$$

$$-10000i_b = 100I + 100 \times 100i_b = 100I + 10000i_b$$

$$-20000i_b = 100I \Rightarrow i_b = -\left(\frac{100}{20000}\right)\dot{I} = \left[-\frac{I}{200}\right]$$

$$V = 100[I + 99i_b + i_b] = 100\left[I + 100\left(\frac{-I}{200}\right)\right] = 50I$$

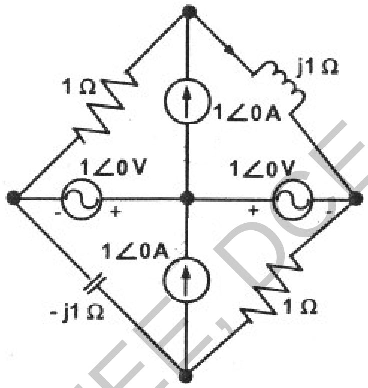
10. In the circuit shown below, the current through the inductor is

(A) $\frac{2}{1+j}$ A

(B) $\frac{-1}{1+j}$ A

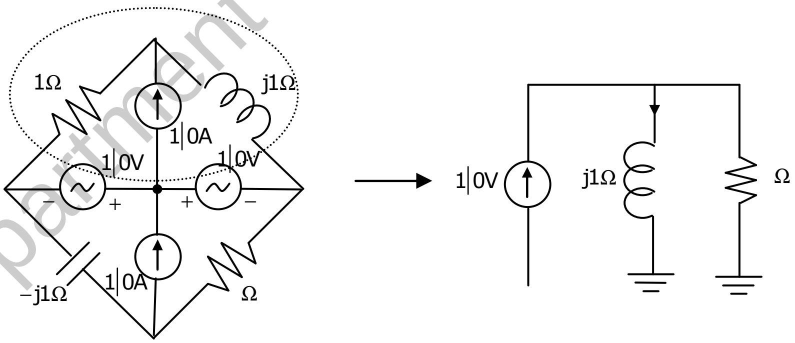
(C) $\frac{1}{1+j}$ A

(D) 0 A



Answer:- (C)

Exp:-



$$I_L = 1\underline{|0} \times \frac{1}{1+j1} = \frac{1}{1+j1} A$$

11. Given $f(z) = \frac{1}{z+1} - \frac{2}{z+3}$. If C is a counterclockwise path in the z-plane such that $|z+1| = 1$, the value of $\frac{1}{2\pi j}\oint_C f(z)\,dz$ is

(A) −2 (B) −1 (C) 1 (D) 2

Answer:- (C)

Exp:- $\frac{1}{2\pi i}\oint_C f(z)\,dz = \frac{1}{2\pi i}\left[\underbrace{\oint_C \frac{1}{z+1}dz}_{I_1} - \underbrace{\oint_C \frac{z}{z+3}dz}_{I_2}\right]$

$z=-1$ is singularity in c and z=-3 is not in c

By cauchy's integral formula $I_2 = \oint_C \frac{z}{z+3}dz = 0$

$\therefore I_1 = \oint_C \frac{1}{z+1}dz = 1;\ I_1 - I_2 = 1$

12. Two independent random variables X and Y are uniformly distributed in the interval [−1, 1]. The probability that max[X, Y] is less than 1/2 is

(A) 3/4 (B) 9/16 (C) 1/4 (D) 2/3

Answer:- (B)

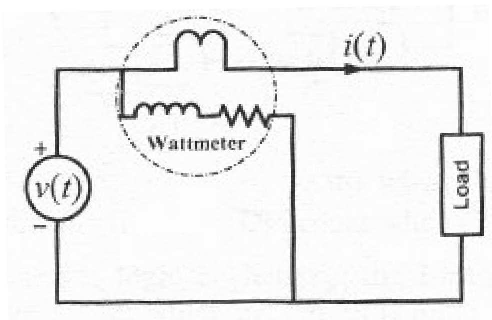
Exp:- Uniform distribution X, Y on $[-1,1]; f(x) = f(y) = \frac{1}{2}$

$$P\left(\max(x,y) \le \frac{1}{2}\right) = P\left(X = \frac{1}{2},\ -1 \le Y \le \frac{1}{2}\right).P\left(-1 \le X \le \frac{1}{2},\ Y = \frac{1}{2}\right)$$

$$= \int_{-1}^{1/2} \frac{1}{2}dx \int_{-1}^{1/2} \frac{1}{2}dy = \frac{3}{4}\times\frac{3}{4} = \frac{9}{16}$$

13. For the circuit shown in the figure, the voltage and current expressions are $v(t) = E_1\sin(\omega t) + E_3\sin(3\omega t)$ and $i(t) = I_1\sin(\omega t - \phi_1) + I_3\sin(3\omega t - \phi_3) + I_5\sin(5\omega t)$.

The average power measured by the Wattmeter is



(A) $\frac{1}{2}E_1I_1\cos\phi_1$

(B) $\frac{1}{2}\left[E_1I_1\cos\phi_1 + E_1I_3\cos\phi_3 + E_1I_5\right]$

(C) $\frac{1}{2}\left[E_1I_1\cos\phi_1 + E_3I_3\cos\phi_3\right]$

(D) $\frac{1}{2}\left[E_1I_1\cos\phi_1 + E_3I_1\cos\phi_1\right]$

Answer:- (C)

Exp:- $\Rightarrow$ in $\upsilon(t)$ only fundamental, 3^{rd} harmonics are present. 5^{th} harmonics is zero

$$P = \frac{1}{2}\left[E_1 1_1\cos\phi_1 + E_3I_3\cos\phi_3\right]$$

14. If $x = \sqrt{-1}$, then the value of x^x is

(A) $e^{-\pi/2}$ (B) $e^{\pi/2}$ (C) x (D) 1

Answer:- (A)

Exp:- Given, $x=\sqrt{-1}$; $x^x = \left(\sqrt{-1}\right)^{\sqrt{-1}} = i^i$

We know that $e^{i\theta} = \cos\theta + i\sin\theta \Rightarrow e^{i\frac{\pi}{2}} = \cos\frac{\pi}{2} + i\sin\frac{\pi}{2} = i$

$\therefore\ (i)^i = \left(e^{i\pi/2}\right)^i = e^{-\pi/2}$

15. The typical ratio of latching current to holding current in a 20A thyristor is

(A) 5.0 (B) 2.0 (C) 1.0 (D) 0.5

Answer:- (B)

16. A half-controlled single-phase bridge rectifier is supplying an R-L load. It is operated at a firing angle α and the load current is continuous. The fraction of cycle that the freewheeling diode conducts is

(A) $\frac{1}{2}$ (B) $\left(1-\frac{\alpha}{\pi}\right)$ (C) $\frac{\alpha}{2\pi}$ (D) $\frac{\alpha}{\pi}$

Answer:- (D)

17. The sequence components of the fault current are as follows: $I_{positive} = j1.5\,pu, I_{negative} = -j0.5\,pu,\ I_{zero} = -j1\,pu.$ The type of fault in the system is

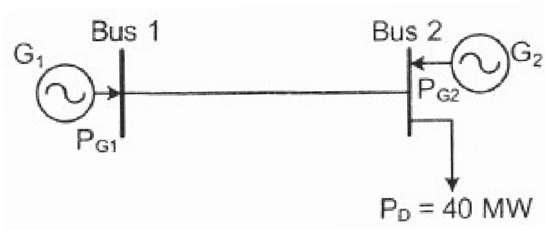
(A) LG (B) LL (C) LLG (D) LLLG

Answer:- (C)

Exp:- $I_1 = I_2 + I_0$

So LLG fault

18. The figure shows a two-generator system supplying a load of $P_D = 40\,MW$, connected at bus 2



The fuel cost of generators G_1 and G_2 are:

$C_1(P_{G1}) = 10,000\ Rs/MWh$ and $C_2(P_{G2}) = 12500\ Rs/MWh$ and the loss in the line is $P_{loss(pu)} = 0.5\ P^2_{G1(pu)}$, where the loss coefficient is specified in pu on a 100 MVA base. The most economic power generation schedule in MW is

(A) $P_{G1} = 20, P_{G2} = 22$ (B) $P_{G1} = 22, P_{G2} = 20$

(C) $P_{G1} = 20, P_{G2} = 20$ (D) $P_{G1} = 0, P_{G2} = 40$

Answer:- (A)

Exp:- $\lambda_1 = \lambda_2$

$\lambda_1 = 10,000$; $\lambda_2 = 12500$

$$4 = \frac{1}{1 - \frac{\partial P_L}{\partial P}} \Rightarrow \frac{1}{1 - P_1} \Rightarrow \frac{10,000}{1 - P_1} = 12500$$

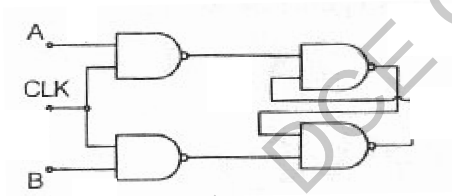
$$1 - \frac{10,000}{12500} = P_1 \Rightarrow \frac{2500}{12500} = \left[\frac{1}{5}\right] \text{p.u}$$

$$P_L = \frac{1}{5} \times 100 = 20\,\text{MW}$$

$$P_L = 0.5\left[\frac{1}{5}\right]^2 = \frac{0.5}{25}\text{ p.u} = \frac{0.5}{25} \times 100 = 2\,\text{MW}$$

$$P = P_1 + P_2 - P_L \Rightarrow 40 = 20 + P_2 - 2 \Rightarrow P_2 = 22\text{MW}$$

19. Consider the given circuit

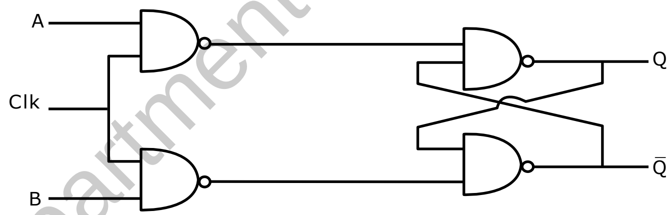


In this circuit, the race around

(A) Does not occur
(B) Occurs when CLK = 0
(C) Occurs when CLK = 1 and A = B = 1
(D) Occurs when CLK = 1 and A = B = 0

Answer:- (A)

Exp:- .



$$Q_{next} = \overline{\overline{A.CLK}.\bar{Q}}$$

$$= A.CLK + Q$$

$$\bar{Q}_{next} = A.CLK + \bar{Q}$$

If CLK = 1 and A and B = 1

then $\left.\begin{array}{l} Q_{next} = 1 \\ \bar{Q}_{next} = 1 \end{array}\right\}$ No race around

If CLK = 1 and A = B = 0

$\left.\begin{array}{l} Q_{next} = Q \\ \bar{Q}_{next} = \bar{Q} \end{array}\right\}$ No race around

Thus race around does not occur in the circuit

20. The output Y of a 2-bit comparator is logic 1 whenever the 2-bit input A is greater than the 2-bit input B. The number of combinations for which the output is logic 1, is

(A) 4 (B) 6 (C) 8 (D) 10

Answer:- (B)

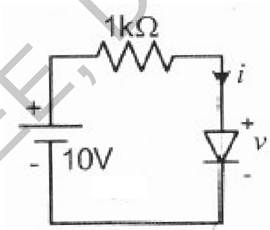
Exp:- $\left.\begin{matrix} A = A_1A_0 \\ B = B_1B_0 \end{matrix}\right\}$ A>B if $A_1B_1' + \lfloor A_1 \odot B_1 \rfloor \lfloor A_0B_0' \rfloor$

	A_1	A_0	B_1	B_0
A_1B_1'	1	0	0	0
	1	0	0	1
	1	1	0	0
	1	1	0	1
$(A_1 \odot B_1)(A_0B_0')$	0	1	0	0
	1	1	1	0

21. The i-v characteristics of the diode in the circuit given below are

$$i = \begin{cases} \dfrac{v-0.7}{500} A, & v \geq 0.7V \\ 0A, & v < 0.7V \end{cases}$$

The current in the circuit is



(A) 10 mA

(B) 9.3 mA

(C) 6.67 mA

(D) 6.2 mA

Answer:- (D)

Exp:- $10 = (1000)i + v = \dfrac{1000(v-0.7)}{500} + v = 2(v-0.7) + v$

$= 2v - 1.4 + 2v = 3v - 1.4;\ 2v=2.4 \Rightarrow v=0.8V$

$i = \dfrac{V-0.7}{500} = 6.2mA$

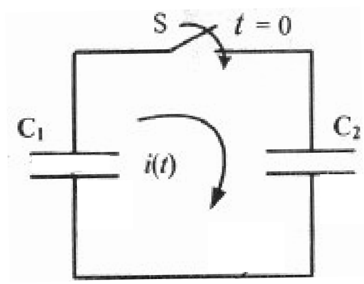
22. In the following figure, C_1 and C_2 are ideal capacitors. C_1 has been charged to 12 V before the ideal switch S is closed at t = 0. The current i(t) for all t is

(A) Zero

(B) A step function

(C) An exponentially decaying function

(D) An impulse function



Answer:- (D)

Exp:- Time constant = RC

In the given circuit, R=0

∴ Rise time = 0; hence capacitor charges instantaneously

and the current can be represented as impulse function

23. The average power delivered to an impedance $(4 - j3)\Omega$ by a current $5\cos(100\pi t + 100)$ A is

(A) 44.2 W (B) 50 W (C) 62.5 W (D) 125 W

Answer:- (B)

Exp:- $Z = 4 - j3 = R_L - JX_C$; $R_L = 4$; $I = 5\cos(100\pi t + 100) = I_m \cos(\omega t + \alpha)$

$$P = \frac{1}{2} I_m^2 R_L = \frac{1}{2} \times 5^2 \times 4 = 50W$$

24. The unilateral Lapalce transform of $f(t)$ is $\frac{1}{s^2 + s + 1}$. The unilateral Lapalce transform of t f(t) is

(A) $-\frac{s}{(s^2 + s + 1)^2}$ (B) $-\frac{2s + 1}{(s^2 + s + 1)^2}$ (C) $\frac{s}{(s^2 + s + 1)^2}$ (D) $\frac{2s + 1}{(s^2 + s + 1)^2}$

Answer:- (D)

Exp:- $L[f(t)] = F(s) = \frac{1}{s^2 + s + 1}$; $L[tf(t)] = (-1)\frac{dF(s)}{ds} = (-1)\left[\frac{-(2s + 1)}{s^2 + s + 1}\right] = \frac{2s + 1}{s^2 + s + 1}$

25. With initial condition x(1) = 0.5, the solution of the differential equation $t\frac{dx}{dt} + x = t$ is

(A) $x = t - \frac{1}{2}$ (B) $x = t^2 - \frac{1}{2}$ (C) $x = \frac{t^2}{2}$ (D) $x = \frac{t}{2}$

Answer:- (D)

Exp:- Given DE is $t\frac{dx}{dt} + x = t \Rightarrow \frac{dx}{dt} + \frac{x}{t} = 1$

$IF = e^{\int t} = e^{\log t} = t$; solution is $x(IF) = \int (IF)\, t dt$

$xt = \int t \cdot tdt \Rightarrow xt = \frac{t^2}{2} + c$; Given that $x(1) = 0.5 \Rightarrow 0.5 = \frac{1}{2} + c \Rightarrow c = 0$

$\therefore$ The required solution is $xt = \frac{t^2}{2} \Rightarrow x = \frac{t}{2}$

Q. No. 26 – 51 carry Two Marks Each

26. A 220 V, 15 kW, 1000 rpm shunt motor with armature resistance of 0.25Ω, has a rated line current of 68 A and a rated field current of 2.2 A. The change in field flux required to obtain a speed of 1600 rpm while drawing a line current of 52.8 A and a field current of 1.8 A is

(A) 18.18% increase (B) 18.18% decrease

(C) 36.36% increase (D) 36.36% decrease

Answer:- (D)

Exp:- $\frac{N_1}{N_2} = \frac{E_{b1}}{E_{b2}} \times \frac{\phi_2}{\phi_1}$

$R_a = 0.25$; $I_a = 6 - 2.2 = 65.8A; I_{a2} = 52.8 - 1.8 = 51A$

$$\frac{1000}{1600} = \left[\frac{220 - 65.8 \times 0.25}{220 - 51 \times 0.25}\right] \times \frac{\phi_2}{\phi_1}$$

$$\frac{\phi_2}{\phi_1} = 0.6364$$

$$\% \text{ decrease} = \frac{\phi_1 - \phi_2}{\phi_1} \times 100 = \left[1 - \frac{\phi_2}{\phi_1}\right] \times 100 = 36.36\% \text{ decrease}$$

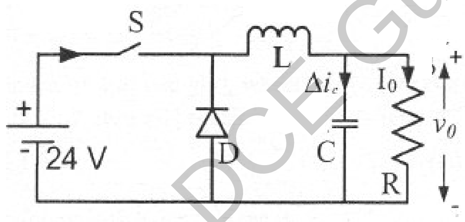
27. In the circuit shown, an ideal switch S is operated at 100 kHz with a duty ratio or50%. Given that Δi_c 1.6 A peak-to-peak and I_0 is 5A dc, the peak current in S is

(A) 6.6 A

(B) 5.0 A

(C) 5.8 A

(D) 4.2 A



Answer:- (C)

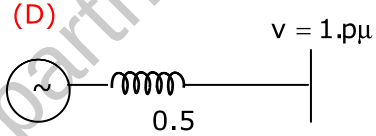
Exp:- Peak current $= I_o + \frac{\Delta i_c}{2} = 5 + \frac{1.6}{2} = 5.8A$

28. A cylindrical rotor generator delivers 0.5 pu power in the steady-state to an infinite bus through a transmission line of reactance 0.5 pu. The generator no-load voltage is 1.5 pu and the infinite bus voltage is 1 pu. The inertia constant of the generator is $5 MW_{-s} / MV$ and the generator reactance is 1 pu. The critical clearing angle, in degrees, for a three-phase dead short circuit fault at the generator terminal is

(A) 53.5 (B) 60.2 (C) 70.8 (D) 79.6

Answer:- (D)

Exp:-



$E = 1.5$ p.u

$x_S = 1$.p.u

$$P_{max} = \frac{1.5 \times 1}{1.5} = 1 \text{ p.u}$$

$$P_m = 0.5 \text{ p.u}$$

$$P_m = P_{max} \sin \delta_O \Rightarrow 80 = 30^O; \ \delta_{max} = 180 - 80 = 150^O$$

$$\delta_{or} = \cos^{-1}\left[\sin \delta_0 (\pi - 280) + \cos max\right]$$

$$= \cos^{-1}\left[0.5\left(\pi - \frac{\pi}{3}\right) + \cos 150\right] = 79.6^O$$

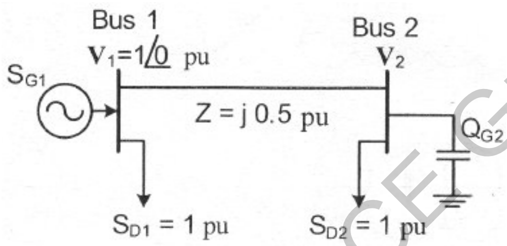
$I_{RL} = V_3 \cos\theta$

$I = \dfrac{136 \times 0.45}{5} = 12.24A$

$P = VI\cos\theta = 136 \times 12.24 \times 0.45 \cong 750\ W$

$\dfrac{y_{sn12}}{2} = 1 \Rightarrow y_{sin2} = 2$

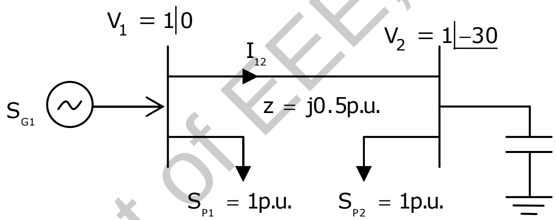
29. For the system shown below, $S_{\ 1}$ and S_{D2} are complex power demands at bus 1 and bus 2 respectively. If $|V_2| = 1$pu, the VAR rating of the capacitor (Q_{G2}) connected at bus 2 is



(A) 0.2 pu (B) 0.268 (C) 0.312 (D) 0.4 pu

Answer:- (B)

Exp:-



Line is lossless $S_{G1} = S_{D1} + S_{D2} = 1 + 1 = 2$p.u.

Power transfer from bus-1 to bus-2 is 1p.u.

$\therefore\ 1 = \dfrac{|V_1||V_2|}{X_{12}} \sin(\theta_1 - \theta_2) = \dfrac{1 \times 1}{0.5} \sin(\theta_1 - \theta_2);\ \ \sin(\theta_1 - \theta_2) = 0.5$

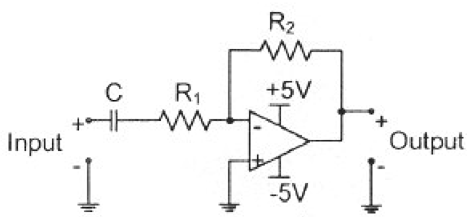
$\theta_1 - \theta_2 = \sin^{-1} 0.5 = 30;\ \theta_1 = 0\{V_1 = 1\angle 0\};\ \ \therefore\ \theta_2 = -30^o;\ V_2 = 1\angle{-30}$

$I_{12} = \dfrac{V_1 - V_2}{2} = \dfrac{1\angle 0 - 1\angle{-30}}{j0.5} = 1 - j0.288$

Current $S_{\ 2} = 1\angle{-30}$; Current in $Q_{G2} = 1\angle{-30} - [1 - j0.268] = 0.268\angle{-120}$

VAR rating of capacitor = $|V_2||I_Q| \sin(|V_2||I_2|) = 1 \times 0.268 \times \sin(+90) = 0.268$

30. The circuit shown is a



(A) Low pass filter with $f_{3dB} = \frac{1}{(R_1+R_2)C}$ rad / s

(B) High pass filter with $f_{3dB} = \frac{1}{R_1C}$ rad / s

(C) Low pass filter with $f_{3dB} = \frac{1}{R_1C}$ rad / s

(D) High pass filter with $f_{3dB} = \frac{1}{(R_1+R_2)C}$ rad / s

Answer:- (B)

Exp:- $\frac{V_o}{V_{in}} = -\frac{R_2}{R_1 + \frac{1}{sC_1}} = -\frac{sC_1R_2}{sC_1R_1+1}$; It is HPF transfer function

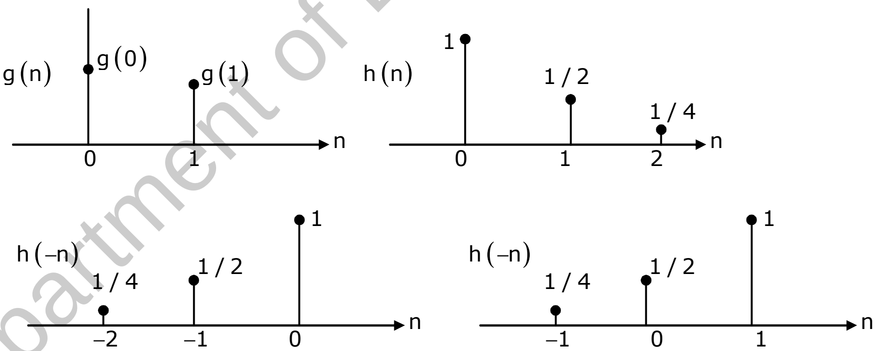
31. Let y[n] denote the convolution of h[n] and g[n], where $h\lfloor n\rfloor = (1/2)^n u\lfloor n\rfloor$ and g[n] is a causal sequence. If y[0] = 1 and y[1] = ½, then g[1] equals

(A) 0 (B) 1/2 (C) 1 (D) 3/2

Answer:- (A)

Exp:- $h[n] = \left(\frac{1}{2}\right)^n u(n);\ y(0) = 1,\ y(1) = \frac{1}{2}$

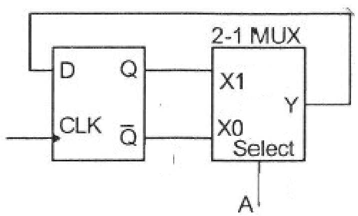
$$\text{since } y(n) = g(n) * h(n) = \sum_{m=-\infty}^{\infty} g(m)h(n-m)$$

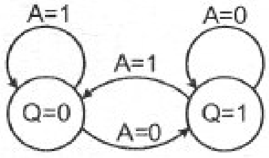


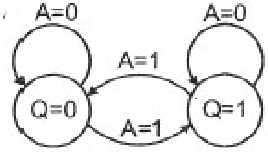
multiplying g(n) and h(-n); $y(0) = \frac{1}{4}\times 0 + \frac{1}{2}\times 0 + 1\times g(0)$

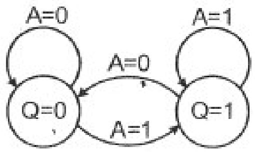
$y(1) = \frac{1}{2} = \frac{1}{2}g(0) + g(1) \Rightarrow g(1) = 0$

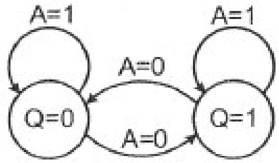
32. The state transition diagram for the logic circuit shown is



(A)


(B)


(C)


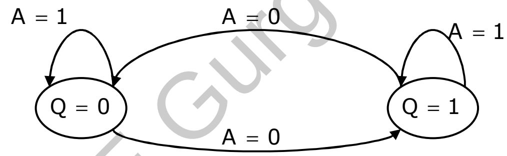
(D)


Answer:- (D)

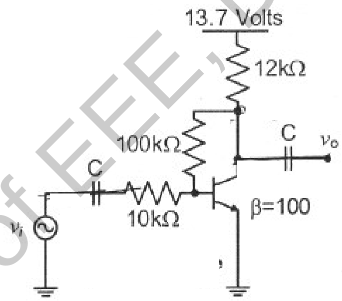
Exp:-

Present state (Q)	A	Next state
0	0	1
1	1	0
0	1	0
1	0	1

State machine



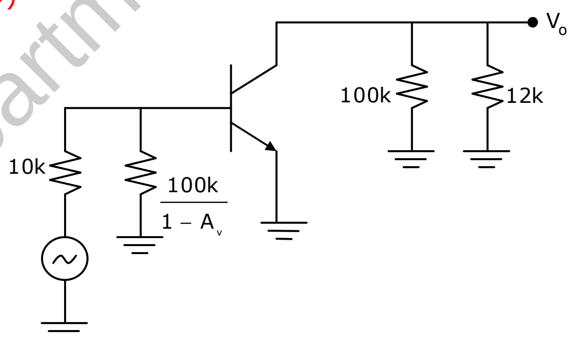
33. The voltage gain A_v of the circuit shown below is



(A) $|A_v| \approx 200$ (B) $|A_v| \approx 100$ (C) $|A_v| \approx 20$ (D) $|A_v| \approx 10$

Answer:- (D)

Exp:-



KVL in input loop, $13.7 - (I_C + I_B)12k - 100k(I_B) - 0.7 = 0$

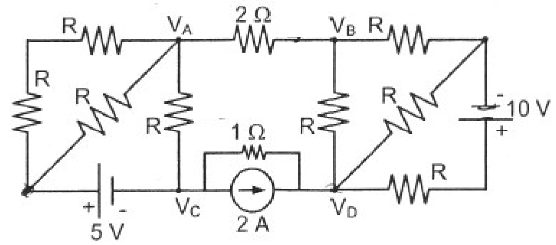
$\Rightarrow I_B = 9.9\mu A;\ I_C = \beta I_B = 0.99mA;\ I_E = 1mA$

$\therefore\ r_e = \frac{26mA}{I_E} = 26\Omega;\ z_i = \beta r_e = 2.6k\Omega;\ \therefore\ A_v = \frac{(100k\,||\,12k)}{26} = 412$

$z_i' = z_i\,||\left(\frac{100k}{1+412}\right) = 221\Omega;\ A_{vs} = A_v\frac{z_i'}{z_i' + R_s} = (412)\left(\frac{221}{221+10k}\right)$

$|A_{vs}| \approx 10$

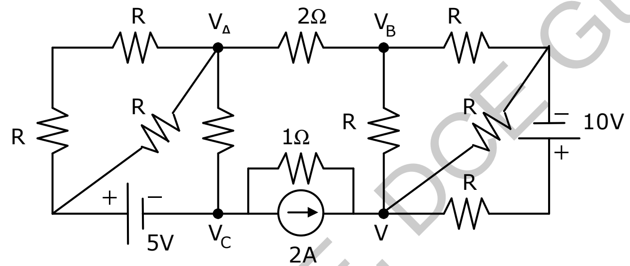
34. If $V_A - V_B = 6V$, then $V_C - V_D$ is

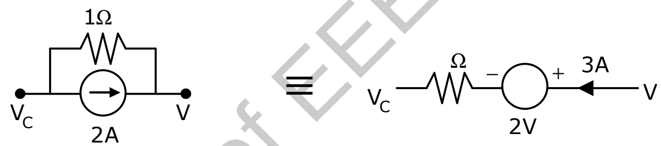


(A) −5V (B) 2V (C) 3V (D) 6V

Answer:- (A)

Exp:- $I = \frac{V_A - V_B}{2} = \frac{6}{2} = 3A$; Since current entering any network is same as leaving in $V_C - V_D$ branch also it is I = 3A





$V_D = 2 + 3 + V_C = 5 + V_C$; $V_C - V_D = -5V$

35. The maximum value of $f(x) = x^3 - 9x^2 + 24x + 5$ in the interval [1, 6] is

(A) 21 (B) 25 (C) 41 (D) 46

Answer:- (C)

EXP:- Given, $f(x) = x^3 - 9x^2 + 24x + 5$

$f'(x) = 0$ for stationary values $\Rightarrow 3x^2 - 18x + 24 = 0 \Rightarrow x=2,4$
$f''(x) = 6x - 18;\ f''(2) = 12 - 18 < 0;\ f''(4) = 24 - 18 > 0$
Hence $f(x)$ has maximum value at x=2
$\therefore$ The maximum value is $2^3 - 9 \times 2^2 + 24 \times 2 + 5 = 25$
But we have to find the maximum value in the interval $\lfloor 1, 6 \rfloor$
$\therefore f(6) = 6^3 - 9 \times 6^2 + 24 \times 6 + 5 = 41$

36. Given that $A = \begin{bmatrix} -5 & -3 \\ 2 & 0 \end{bmatrix}$ and $I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, the value of A^3 is

(A) $15A + 12I$ (B) $19A + 30I$ (C) $17A + 15I$ (D) $17A + 21I$

Answer:- (B)

Exp:- Given : $A = \begin{bmatrix} -5 & -3 \\ 2 & 0 \end{bmatrix}$;

Characteristic equation of A is $|A\text{-}I\lambda| = 0 \Rightarrow \begin{vmatrix} -5-\lambda & -3 \\ 2 & 0-\lambda \end{vmatrix} = 0$

$\Rightarrow (-5-\lambda)(-\lambda) + 6 = 0 \Rightarrow 5\lambda + \lambda^2 + 6 = 0$

$\Rightarrow \lambda^2 = -5\lambda - 6$ and $\lambda^3 = -5\lambda^2 - 6\lambda = -5(-5\lambda - 6) - 6\lambda \ (\because \lambda^2 = -5\lambda - 6)$

$\Rightarrow \lambda^3 = 25\lambda - 6\lambda + 30 = 19\lambda + 30$

Every matrix satisfies its characteristic equation $\therefore \ A^3 = 19A + 30I$

37. A single phase 10 kVA, 50 Hz transformer with 1kV primary winding draws 0.5 A and 55 W, at rated voltage and frequency, on no load. A second transformer has a core with all its linear dimensions $\sqrt{2}$ times the corresponding dimensions of the first transformer. The core material and lamination thickness are the same in both transformers. The primary windings of both the transformers have the same number of turns. If a rated voltage of 2 kV at 50 Hz is applied to the primary of the second transformer, then the no load current and power, respectively, are

(A) 0.7 A, 77.8 W
(B) 0.7 A, 155.6 W
(C) 1 A, 110 W
(D) 1 A, 220 W

Answer:- (B)

Exp:- Core loss $\propto$ core volume; $P_{c2} = (\sqrt{2})^3$; $P_{c1} = (\sqrt{2})^3 \times 55 = 155W$

Core loss component $I_{c2} = (\sqrt{2})^3 \times I_{c1} = 2\sqrt{2}\left[\frac{55}{1000}\right] = 0.155A$

$I_{c2} = \frac{55}{1000} = 0.055A;$

Magnetizing component, $I_{\phi 1} = \sqrt{I_{e1}^2 - I_{c1}^2} = \sqrt{0.5^2 - 0.055^2} = 0.4969A$

Now reluctance $R_{l2} = \frac{R_{l1}}{\sqrt{2}}$; $\phi_{m1} = \frac{1000}{\sqrt{2}\pi f N_1}$ and $\phi_{m2} = \frac{2000}{\sqrt{2}\pi f N_1} = 2\phi_{m1}$

But $\phi_{m1} = \frac{\text{mmf}}{\text{reluctance}} = \frac{I_{\phi 1}N_1}{Rl_1}$; Also $\frac{I_{\phi 2}N_1}{Rl_2} = \phi_{m2} = 2\phi_{m1} = \frac{2I_{\phi 1}N_1}{Rl_1}$

$\therefore \ I_{\phi 2} = \frac{Rl_2}{Rl_1}(2I_{\phi 1}) = \sqrt{2}I_{\phi 1} = \sqrt{2} \times 0.4969 = 0.702A$

38. The locked rotor current in a 3-phase, star connected 15 kW, 4-pole, 230 V, 50 Hz induction motor at rated conditions is 50 A. Neglecting losses and magnetizing current, the approximate locked rotor line current drawn when the motor is connected to a 236 V, 57 Hz supply is

(A) 58.5 A
(B) 45.0 A
(C) 45.7 A
(D) 55.6 A

Answer:- (B)

Exp:- $I_2 = \frac{E_2}{z_2} = \frac{E_2}{\sqrt{R_2^2 + X_2^2}} = \frac{E_2}{X_2}$ since no losses $= \frac{E_2}{\omega_2 L_2}$

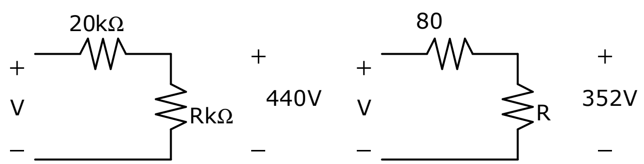
$I_2 \propto \frac{E_2}{f_2}$; $\frac{50}{I_2} = \frac{230}{50} \times \frac{57}{236} \Rightarrow I_2 = 45A$

39. An analog voltmeter uses external multiplier settings. With a multiplier setting of $20\,k\Omega$, it reads 440 V and-with a multiplier setting of $80\,k\Omega$ it reads 352 V. For a multiplier setting of $40\,k\Omega$, the voltmeter reads

(A) 371 V (B) 383 V (C) 394 V (D) 406 V

Answer:-(D)

Exp:- Let resistance of voltmeter be R kΩ



$$V=\left(\frac{440}{R}\right)20+440\ldots\ldots\ (1);\ V=352+\left(\frac{352}{R}\right)80\ldots\ldots\ldots\ldots(2)$$

Solving, V=480; R=220; $V_L=\frac{480}{40+220}\times 220=406V$

40. The input x(t) and output y{t) of a system are related as $y(t)=\int_{-\infty}^{t}x(\tau)\cos(3\tau)\,d\tau.$

The system is

(A) time-invariant and stable (B) stable and not time-invariant

(C) time-invariant and not stable (D) not time-invariant and not stable

Answer:- (B)

Exp:- $y(t)=\int_{-\infty}^{t}x(\tau)\cos(3\tau)d\tau$

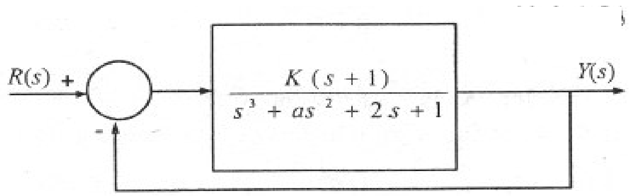
Since y(t) and x(t) are related with some function of time, so they are not time-invariant.

Let x(t) be bounded to some finite value k.

$$y(t)=\int_{-\infty}^{t}K\cos(3\tau)d\tau<\infty$$

y(t) is also bounded. Thus System is stable.

41. The feedback system shown below oscillates at 2 rad/s when



(A) $K=2$ and $a=0.75$ (B) $K=3$ and $a=0.75$

(C) $K=4$ and $a=0.5$ (D) $K=2$ and $a=0.5$

Answer:- (A)

Exp:- Characteristic equatin is $1+G(s)H(s)=0$

$$1+\frac{k(s+1)}{s^3+as^2+2s+1}=0;\ s^3+s^2a+s(k+2)+(k+1)=0$$

$$\begin{array}{c|cc} s^3 & 1 & k+2 \\ s^2 & a & k+1 \\ s^1 & \frac{(k+2)a-(k+1)}{a} & \\ s^0 & & \end{array}$$

$as^2+(k+1)=0;\ s=j\omega; s^2=-\omega^2; \omega=2$

$-a\omega^2+(k+1)=0;\ a\omega^2=k+1;$ 4a=k+1; From options, k=2, a=0.75

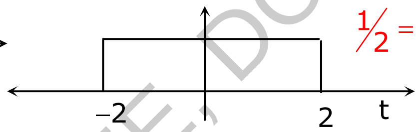
42. The Fourier transform of a signal $h(t)$ is $H(j\omega)=(2\cos\omega)(\sin 2\omega)/\omega$. The value of h(0) is

(A) 1/4 (B) 1/2 (C) 1 (D) 2

Answer:- (C)

Exp:-

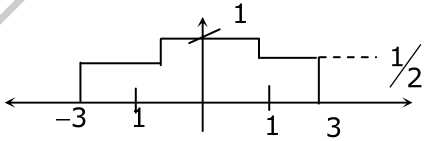
$\frac{\sin 2\omega}{\omega} \longleftrightarrow$



$\frac{1}{2}=h'(t)$

$2\cos\omega\left(\frac{\sin 2\omega}{\omega}\right) \longleftrightarrow h(t)=h'(t-1)+h'(t+1)$

$\left[e^{j\omega}+e^{-j\omega}\right]\left(\frac{\sin 2\omega}{\omega}\right)$



43. The state variable description of an LTI system is given by

$$\begin{pmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{pmatrix}=\begin{pmatrix}0 & a_1 & 0\\ 0 & 0 & a_2\\ a_3 & 0 & 0\end{pmatrix}\begin{pmatrix}x_1\\ x_2\\ x_3\end{pmatrix}+\begin{pmatrix}0\\ 0\\ 1\end{pmatrix}u$$

$$y=\begin{pmatrix}1 & 0 & 0\end{pmatrix}\begin{pmatrix}x_1\\ x_2\\ x_3\end{pmatrix}$$

where y is the output and u is the input. The system is controllable for

(A) $a_1\neq 0, a_2=0, a_3\neq 0$ (B) $a_1=0, a_2=0, a_3\neq 0$

(C) $a_1=0, a_2=0, a_3=0$ (D) $a_1\neq 0, a_2\neq 0, a_3=0$

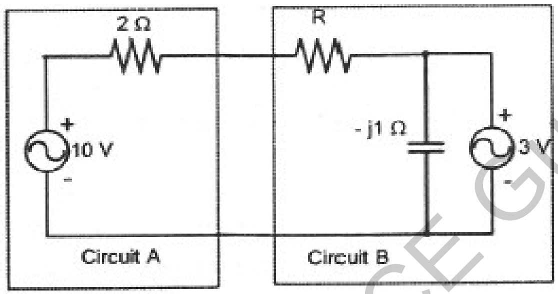
Answer:- (D)

Exp:- $Q_c=\left[B\ \ AB\ \ A^2B\right];\ A=\begin{bmatrix}0 & a_1 & 0\\ 0 & 0 & a_2\\ a_3 & 0 & 0\end{bmatrix};\ B=\begin{bmatrix}0\\0\\1\end{bmatrix};\ AB=\begin{bmatrix}0\\a_2\\0\end{bmatrix}; A^2B=\begin{bmatrix}a_1a_2\\0\\0\end{bmatrix}$

$$Q_c = \begin{bmatrix} 0 & 0 & a_1a_2 \\ 0 & a_2 & 0 \\ 1 & 0 & 0 \end{bmatrix};\ \text{If rank of } Q_c = 3 = \text{order of matrix, then } Q_c \text{ is controllable}$$

$$\left.\begin{matrix} a_1 \neq 0 \\ a_2 \neq 0 \\ a_3 = 0 \end{matrix}\right\} \text{ then } |Q_c| \neq 0$$

44. Assuming both the voltage sources are in phase, the value of R for which maximum power is transferred from circuit A to circuit B is



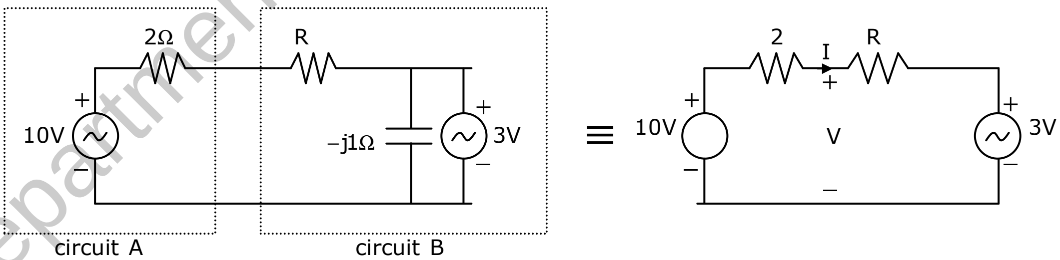
(A) 0.8 Ω (B) 1.4 Ω (C) 2 Ω (D) 2.8 Ω

Answer:- (A)

Exp:- Power transferred from circuit A to circuit A = $VI = \left(\frac{7}{R+2}\right)\left(\frac{6+10R}{R+2}\right) = \frac{42+70R}{(R+2)^2}$

$$I = \frac{10-3}{2+R} = \frac{7}{2+R};\ V = 3 + IR = 3 + \frac{7R}{2+R} = \left(\frac{6+10R}{2+R}\right)$$

$$\frac{dP}{dR} = \frac{(R+2)^2(70) - (42+70R)2(R+2)}{(R+2)^4} = 0$$



$$70(R+2)^2 = (42+70R)2(R+2);\ 5(R+2) = 2(3+5R)$$
$$5R + 10 = 6 + 10R;\ 4 = 5R;\ R = 0.8\Omega$$

45. Consider the differential equation

$$\frac{d^2y(t)}{dt^2} + 2\frac{dy(t)}{dt} + y(t) = \delta(t) \text{ with } y(t)\big|_{t=0} = -2 \text{ and } \left.\frac{dy}{dt}\right|_{t=0^-} = 0.$$

The numerical value of $\left.\frac{dy}{dt}\right|_{t=0^+}$ is

(A) −2 (B) −1 (C) 0 (D) 1

Answer:- (D)

Exp:- $\frac{d^2y(t)}{dt^2} + \frac{2\,dy(t)}{dt} + y(t) = \delta(t)$

Converting to s – domain,

$s^2y(s) - sy(0) - y'(0) + 2\left[sy(s) - y(0)\right] + y(s) = 1$

$\left[s^2 + 2s + 1\right]y(s) + 2s + 4 = 1$

$y(s) = \frac{-3 - 2s}{(s^2 + 2s + 1)}$

Find inverse lapalce transform

$y(t) = \left[-2e^{-t} - te^{-t}\right]u(t)$

$\frac{dy(t)}{d} = 2e^{-t} + te^{-t} - e^{-t}$

$\left.\frac{dy(t)}{dt}\right|_{t=0^+} = 2 - 1 = 1$

46. The direction of vector A is radially outward from the origin, with $|A| = k\,r^n$ where $r^2 = x^2 + y^2 + z^2$ and k is constant. The value of n for which $\nabla.A = 0$ is

(A) −2 (B) 2 (C) 1 (D) 0

Answer:- (A)

Exp:- We know that, $\nabla.\vec{A} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2A_r\right)$

Now, $\nabla.\vec{A} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2A_r\right)$

$= \frac{1}{r^2}\frac{\partial}{\partial r}\left(kr^{n+2}\right) = \frac{k}{r^2}\,(n+2)r^{n+1}$

$= k\,(n+2)r^{n+1}$

$\therefore$ For, $\nabla.\vec{A} = 0, \Rightarrow (n+2) = 0 \Rightarrow n = -2$

47. A fair coin is tossed till a head appears for the first time. The probability that the number of required tosses is odd, is

(A) 1/3 (B) 1/2 (C) 2/3 (D) 3/4

Answer:- (C)

Exp:- $P(\text{odd tosses}) = P(H) + P(TTH) + P(TTTTH) + ...$

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

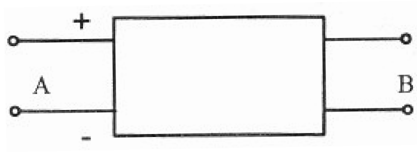
$= \frac{1}{2}\left[1 + \left(\frac{1}{4}\right) + \left(\frac{1}{4}\right)^2 + ...\right] = \frac{1}{2}\left(\frac{1}{1 - \frac{1}{4}}\right) = \frac{1}{2} \times \frac{4}{3} = \frac{2}{3}$

Common Data Questions: 48 & 49

With 10V dc connected at port A in the linear nonreciprocal two-port network shown below, the following were observed:

(i) Ω connected at port B draws a current of 3 A

(ii) 2.5Ω connected at port B draws a current of 2 A



48. For the same network, with 6V dc connected at port A, Ω connected at port B draws 7/3 A. If 8 V dc is connected to port A, the open circuit voltage at port B is

(A) 6V (B) 7V (C) 8V (D) 9V

Answer:- (B)

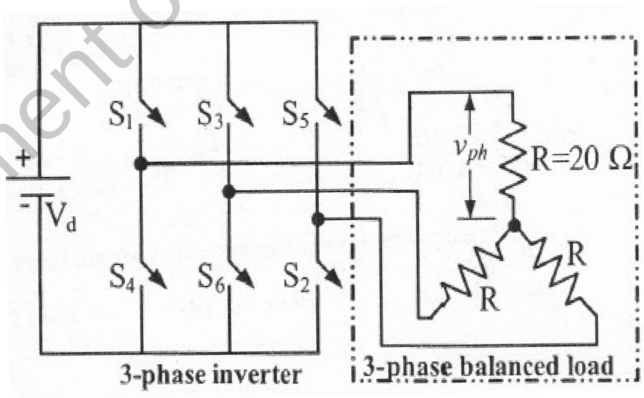
49. With 10V dc connected at port A, the current drawn by 7Ω connected at port B is

(A) 3/7 A (B) 5/7 A (C) 1 A (D) 9/7 A

Answer:- (C)

Common Data Questions: 50 & 51

In the 3-phase inverter circuit shown, the load is balanced and the gating scheme is 180° - conduction mode. All the switching devices are ideal



50. The rms value of load phase voltage is

(A) 106.1 V (B) 141.4 V (C) 212.2 V (D) 282.8 V

Answer:- (B)

Exp:- RMS value of line voltage = $V_L = \sqrt{\frac{2}{3}} V_s$

RMS value of phase voltage = $\frac{V_L}{\sqrt{3}} = \frac{\sqrt{2}}{3} V_s = \frac{\sqrt{2}}{3} \times 300 = 141.42V$

51. If the dc bus voltage $V_d = 300\,V$, the power consumed by 3-phase load is

(A) 1.5 kW (B) 2.0 kW (C) 2.5 kW (D) 3.0 kW

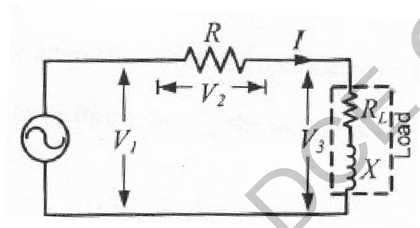
Answer:- (D)

Exp:- $P = 3\cdot\dfrac{{V_{ph}}^2}{R_{ph}} = 3\times\dfrac{(141.42)^2}{20} = 3000W$

Linked Answer Questions: Q.52 to Q.55 Carry Two Marks Each

Statement for Linked Answer Questions: 52 & 53

In the circuit shown, the three voltmeter readings are $V_1 = 220V, V_2 = 122V,$ $V_3 = 136V$



52. The power factor of the load is

(A) 0.45 (B) 0.50 (C) 0.55 (D) 0.60

Answer:- (A)

Exp:- $\cos\theta = \dfrac{{v_1}^2 - {v_2}^2 - {v_3}^2}{2v_1v_2} = \dfrac{220^2 - 122^2 - 136^2}{2\times122\times136} = 0.45$

53. If $R_L = 5\Omega$, the approximate power consumption in the load is

(A) 700 W (B) 750 W (C) 800 W (D) 850 W

Answer:- (B)

Exp:- $\cos\theta = \dfrac{R_L}{z};\ 0.45 = \dfrac{5}{z} \Rightarrow z = 11.11$

$I = \dfrac{V_3}{z} = \dfrac{136}{11.11} = 12.24A;\ P_L = I^2R_L = 12.24^2\times5 = 750W$

Statement for Linked Answer Questions: 54 & 55

The transfer function of a compensator is given as

$G_c(s) = \dfrac{s+a}{s+b}$

54. $G_c(s)$ is a lead compensator if

(A) $a = 1, b = 2$ (B) $a = 3, b = 2$ (C) $a = -3, b = -1$ (D) $a = 3, b = 1$

Answer:- (A)

Exp:- $\phi = \tan^{-1}\frac{\omega}{a} - \tan^{-1}\frac{\omega}{\beta}$

for phase lead ϕ should be $+$ve

$\Rightarrow \tan^{-1}\frac{\omega}{a} > \tan^{-1}\frac{\omega}{\beta}$

$\Rightarrow a < b$

both option (A) and (C) satisfier

but option (C) will pot polar and zero as

RHS of s-plane thus not possible

Option (A) is right

55. The phase of the above lead compensator is maximum at

(A) $\sqrt{2}$ rad / s (B) $\sqrt{3}$ rad / s (C) $\sqrt{6}$ rad / s (D) $1/\sqrt{3}$ rad / s

Answer:- (A)

Exp:- For a lead compensator, a<b and a and b should be positive, (in RHP) else it acts as a oscillator; $\therefore$ a=1, b=2, $\omega_{max} = \sqrt{ab} = \sqrt{2}$ rad/s

Q. No. 56 –60 Carry One Mark Each

56. Which one of the following options is the closest in meaning to the word given below?

Latitude

(A) Eligibility (B) Freedom

(C) Coercion (D) Meticulousness

Answer:- (B)

57. Choose the most appropriate alternative from the options given below to complete the following sentence:

If the tried soldier wanted to lie down, he __________ the mattress out on the balcony

(A) should take (B) shall take

(C) should have taken (D) will have taken

Answer:- (C)

58. One of the parts (A, B, C, D) in the sentence given below contains an ERROR. Which one the following is **INCORRECT**?

I requested that the should be given the driving test today instead of tomorrow.

(A) requested that (B) should be given

(C) the driving test (D) instead of tomorrow

Answer:- (B)

59. Choose the most appropriate word from the options given below to complete the following sentence:

Given the seriousness of the situation that he had to face, his ___ was impressive.

(A) beggary (C) jealousy

(B) nomenclature (D) nonchalance

Answer:- (D)

60. If $(1.001)^{1259} = 3.52$ and $(1.001)^{2062} = 7.85$, then $(1.001)^{3321} =$

(A) 2.23 (B) 4.23 (C) 11.37 (D) 27.64

Answer:- (D)

Exp:- let 1.001 = x

$x^{1259} = 3.52 \text{ and } x^{2062} = 7.85$

$x^{3321} = x^{1259}.x^{2062} = 3.52 \times 7.85 = 27.64$

Q. No. 61 –65 Carry Two Marks Each

61. The data given in the following table summarizes the monthly budget of an average household.

Category	Amount (Rs)
Food	4000
Clothing	1200
Rent	2000
Savings	1500
Other expenses	1800

The approximate percentage of the monthly budget **NOT** spent on saving is

(A) 10% (B) 14% (C) 81% (D) 86%

Answer:- (D)

Exp:- Total budget = 10,500

Expenditure other than savings = 9000

Hence, $\frac{9000}{10500} = 86\%$

62. Raju has 14 currency notes in his pocket consisting of only Rs.20 notes and Rs. 10 notes. The total money value of the notes is Rs.230. The number of Rs. 10 notes that Raju has is

(A) 5 (B) 6 (C) 9 (D) 10

Answer:- (A)

Exp:- Let the number of Rs. 20 notes be x and Rs. 10 notes be y

$20x + 10y = 230$ and $x + y = 14$

Solving above equations, we have x=9 and y=5

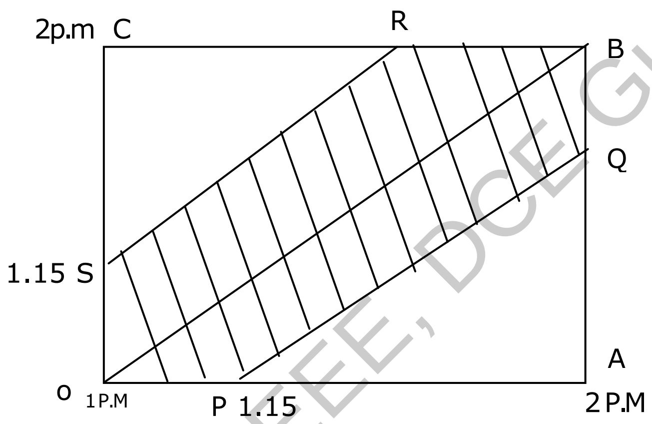
Hence the numbers of 10 rupee notes are 5

63. A and B are friends. They decide to meet between 1 PM and 2 PM on a given day. There is a condition that whoever arrives first will not wait for the other for more than 15 minutes. The probability that they will meet on that day is

(A) 1/4 (B) 1/16 (C) 7/16 (D) 9/16

Answer:- (C)

Exp:-



OB is the line when both A and B arrive at same time.

Total sample space = 60 x 60 = 3600

Favourable cases = Area of OABC – 2(Area of SRC)

$$= 3600 - 2\times\left(\frac{1}{2}\times 45\times 45\right) = 1575$$

$$\therefore \text{The required probability} = \frac{1575}{3600} = \frac{7}{16}$$

64. There are eight bags of rice looking alike, seven of which have equal weight and one is slightly heavier. The weighting balance is of unimited capacity. Using this balance, the minimum number of weighings required to identify the heavier bag is

(A) 2 (B) 3 (C) 4 (4) 8

Answer:- (A)

Exp:- Let us categorize the bags in three groups as

A_1 A_2 A_3 B_1 B_2 B_3 C_1 C_2

1st weighing A vs B

Case -1

$A_1\ A_2\ A_3 = B_1\ B_2\ B_3$

Then either C_1 or C_2 is heavier

2nd weighing

C_1 vs C_2

If $C_1 > C_2$, then C_1

If $C_1 < C_2$, then C_2

If $A_1 < A_2$, then A_2

Case -2

$A_1\ A_2\ A_3 \neq B_1\ B_2\ B_3$

Either A or B would be heavier(Say A >B)

A_1 vs A_2

If $A_1 = A_2$, then A_3

If $A_1 > A_2$, then A_1

65. **One of the legacies of the Roman legions was discipline. In the legions, ilitary law prevailed and discipline was brustal. Discipline on the battlefield kept units obedient, intact and fighting, even when the odds and conditions were against them**

Which one of the following statements best sums up the meaning of the above passage?

(A) Through regimentation was the main reason for the efficiency of the Roman legions even in adverse circumstances.

(B) The legions were treated inheritance from their seniors.

(C) Discipline was the armies' inheritance from their seniors.

(D) The harsh discipline to which the legions were subjected to led to the odds and conditions being against them.

Answer:- (A)