## Electrical Engineering

## 100 Important Questions \& Detailed Solutions

1. Consider the circuit shown in figure


If meter has infinite resistance then find the meter reading.
A. $-3 V$
B. +3 V
C. +6 V
D. -6 V

Ans. A
Sol. Since meter has $\infty$ resistance
So, it act as open circuit


Apply voltage division
$V_{b}=\frac{360}{360+90} \times 15=12$ volt
$\mathrm{V}_{\mathrm{a}}=\frac{90}{60+90} \times 15=9 \mathrm{volt}$
$\mathrm{V}_{\mathrm{ab}}=\mathrm{V}_{\mathrm{a}}-\mathrm{V}_{\mathrm{b}}=9-12=-3$ volt
2. The value of the directional derivative of the function $\phi(x, y, z)=x y^{2}-y z^{2}+z x^{2}$ at the point $(2,-1,1)$ in the direction of the vector $p=i+2 j+2 k$ is
Ans. 1
Sol. $\phi=x y^{2}+y z^{z}+z x^{2}$

$$
\nabla \phi=\frac{\partial \phi}{\partial x} \hat{i}+\frac{\partial \phi}{\partial y} \hat{j}+\frac{\partial \phi}{\partial z} \hat{k}=\left(y^{2}+2 x z\right) \hat{i}+\left(2 x y+z^{2}\right) \hat{j}+\left(x^{2}+2 y z\right) \hat{k}
$$

$\nabla \phi_{(2,-1,1)}=5 \hat{i}-3 \hat{j}+2 \hat{k}$
The directional derivative of $\phi(x, y, z)$ at in $(2,-1,1)$ the direction of $\bar{p}$ is $\nabla \phi_{a t, p^{*}} \frac{\bar{p}}{|\bar{p}|}$
$=(5 \bar{i}-3 \overline{\mathrm{j}}+2 \overline{\mathrm{k}}) \cdot\left(\frac{\overline{\mathrm{i}}+2 \overline{\mathrm{j}}+2 \overline{\mathrm{k}}}{3}\right)$
$=\frac{5-6+4}{3}=1$
3. For the circuit shown below, taking the op-amp as ideal, the output voltage $\mathrm{V}_{\text {out }}$ in terms of the input voltages $V_{1}, V_{2}$ and $V_{3}$ is

A. $1.8 \mathrm{~V}_{1}+7.2 \mathrm{~V}_{2}-\mathrm{V}_{3}$
B. $2 \mathrm{~V}_{1}+8 \mathrm{~V}_{2}-9 \mathrm{~V}_{3}$
C. $7.2 \mathrm{~V}_{1}+1.8 \mathrm{~V}_{2}-\mathrm{V}_{3}$
D. $8 V_{1}+2 V_{2}-9 V_{3}$

Ans. d
Sol. $\frac{V_{x}-V_{1}}{1}+\frac{V_{x}-V_{2}}{4}=0, V_{x}=\frac{4 V_{1}+V_{2}}{5}$
$\frac{\left(V_{x}-V_{3}\right)}{1}+\frac{V_{x}-V_{\text {out }}}{9}=0$
$\frac{\left(4 \mathrm{~V}_{1}+\mathrm{V}_{2}\right)}{5}-\mathrm{V}_{3}+\frac{\frac{\left(4 \mathrm{~V}_{1}+\mathrm{V}_{2}\right)}{5}-\mathrm{V}_{\text {out }}}{9}=0$
$\left.4 \mathrm{~V}_{1}+\mathrm{V}_{2}-5 \mathrm{~V}_{3}\right)+\frac{\left(4 \mathrm{~V}_{1}+\mathrm{V}_{2}-5 \mathrm{~V}_{\text {out }}\right)}{9}=0$
$36 \mathrm{~V}_{1}+9 \mathrm{~V}_{2}-45 \mathrm{~V}_{3}+4 \mathrm{~V}_{1}+\mathrm{V}_{2}-5 \mathrm{~V}_{\text {out }}=0$
$V_{\text {out }}=\frac{40 \mathrm{~V}_{1}+10 \mathrm{~V}_{2}-45 \mathrm{~V}_{3}}{5}$
$\mathrm{V}_{\text {out }}=8 \mathrm{~V}_{1}+2 \mathrm{~V}_{2}-9 \mathrm{~V}$
4. A 3- $\phi$ rectifier circuit is shown below.


Given: $\mathrm{V}_{1}=\mathrm{V}_{\mathrm{an}}=\mathrm{V}_{\mathrm{m}} \sin \omega \mathrm{t}$
$\mathrm{V}_{2}=\mathrm{V}_{\mathrm{bn}}=\mathrm{V}_{\mathrm{m}} \sin \left(\omega \mathrm{t}-120^{\circ}\right)$
$\mathrm{V}_{3}=\mathrm{V}_{\mathrm{an}}=\mathrm{V}_{\mathrm{m}} \sin \left(\omega \mathrm{t}+120^{\circ}\right)$
And $L_{1}=L_{2}=L_{3}=L_{\text {s }}$ are source inductances.
Due to source inductance, there will be an overlapping angle ( $\mu$ ) after $\omega \mathrm{t}=\frac{\pi}{6}$, then what will be the volage at point ' $p$ ' w.r.t neutral during $\omega t=\frac{\pi}{6}$ to $\omega t=\frac{\pi}{6}+\mu$.
A. $\mathrm{V}_{\mathrm{an}}$
B. $\mathrm{V}_{\mathrm{cn}}$
C. $\frac{V_{a n}+V_{c n}}{2}$
D. $\frac{V_{\mathrm{an}}-V_{\mathrm{cn}}}{2}$

Ans. C

Sol.


Before $\omega t=\frac{\pi}{6} \rightarrow D_{5}, D_{6}$ conducting
After $\omega \mathrm{t}=\frac{\pi}{6} \rightarrow \mathrm{D}_{1}, \mathrm{D}_{6}$ conducting
From $\omega \mathrm{t}=\frac{\pi}{6}$ to $\omega \mathrm{t}=\frac{\pi}{6}+\mu:$

$-\mathrm{V}_{\mathrm{an}}+\mathrm{I}_{\mathrm{s}} \frac{\mathrm{d}_{\mathrm{i} \mu}}{\mathrm{dt}}+\mathrm{I}_{\mathrm{s}} \frac{\mathrm{d}\left[\mathrm{i}_{\mu}-\mathrm{I}_{\mathrm{o}}\right]}{\mathrm{dt}}+\mathrm{V}_{\mathrm{cn}}=0$
$\mathrm{V}_{\mathrm{an}}-\mathrm{V}_{\mathrm{cn}}=2 \mathrm{I}_{\mathrm{s}} \frac{\mathrm{d}_{\mathrm{i} \mu}}{\mathrm{dt}}$
Now, $V_{p}=V_{a n}-L_{s} \frac{d_{i \mu}}{d t}$
$V_{P}=V_{a n}-\left[\frac{V_{a n}-V_{c n}}{2}\right]$
$V_{p}=\frac{V_{a n}+V_{c n}}{2}$
5. Consider a negative unity feedback system with the forward path transfer function $\frac{s^{2}+s+1}{s^{3}+2 s^{2}+2 s+k}$, where $K$ is a positive real number. The value of $K$ for which the system will have some of its poles on the imaginary axis is $\qquad$ .
A. 6
B. 7
C. 9
D. 8

Ans. D
Sol. Closed loop characteristic equation.

$$
1+G(s) H(s)=0
$$

$1+\frac{5^{2}+5+1}{5^{3}+25^{2}+25+k} \times 1=0$
$5^{3}+35^{2}+35+K+1=0$
Routh array

| $5^{3}$ | 1 | 3 |
| :---: | :---: | :---: |
| $5^{2}$ | 3 | $k+1$ |
| 5 | $\frac{8-k}{3}$ | 0 |
| $5^{0}$ | $k+1$ | 0 |

For poles on $j \omega$,
$\frac{8-k}{3}=0 \Rightarrow k=8$
Value of $K=8$
6. A solid iron cylinder is placed in a region containing a uniform magnetic field such that the cylinder axis is parallel to the magnetic field direction. The magnetic field lines inside the cylinder will
A. Bend closer to the cylinder axis
B. Bend farther away from the axis
C. Remain uniform as before
D. Ease to exist inside the cylinder

Ans. A
Sol. Flux always chooses less reluctance path. So flux tried to flow inside the conductor and closer to the axis of the cylinder.
7. Let $f(x)=3 x^{3}-7 x^{2}+5 x+6$, The maximum value of $f(x)$ over the interval $[0,2]$ is
$\qquad$ (up to 1 decimal place).
Ans. range [11.9 to 12.1]
Sol. Given:
$f(x)=3 x^{3}-7 x^{2}+5 x+6$
$f^{\prime}(x)=9 x^{2}-14 x+5=0$
$x=1,0.555$
$f^{\prime \prime}(x)=18 x-14$
$f^{\prime \prime}(1)=18-14>0$ (local minima comes at $x=1$ )
$\mathrm{f}^{\prime \prime}(0.555)=18(0.555)-14<0$ (local maxima comes at $\mathrm{x}=0.555$ )
$f(0.555)=7.133$
$f(0)=6$
$f(2)=12$
So, maximum value of $f(x)=12$ comes at $x=2$
8. If $\overline{x y}=0$, then which one of the following is true?
A. $\bar{x} \bar{y} \bar{z}=x y z=x y \bar{z}+\bar{x} \bar{y} \bar{z}$
B. $\bar{x} y=1$
C. $\overline{x y}+\bar{y} x+x z=x \bar{y}+y z$
D. $\bar{x} y+\bar{y} x=x y+\overline{x y}$

Ans. C
Sol. $\overline{x y}=0 \Rightarrow \bar{x}+\bar{y}=0$
then $x=1$ and $y=1$
Consider third expression.
$\overline{x y}+\bar{y} x+x z=x \bar{y}+y z$
$0+0+z=0+z$
LHS $=$ RHS
9. The approximate transfer characteristic for the circuit shown below with an ideal operational amplifier and diode will be

A.

B.

C.



Ans. A
Sol. The given circuit is redrawn as


When Vin > 0, diode is ON, then replaced by SC


When $\mathrm{V}_{\text {in }}<0$, diode OFF, then replaced by OC


The output characteristic is shown below

10. Find the sum of rms value of $i_{1}$ and rms value of $i_{3}$ in $\qquad$ amp in the below circuit.


Ans. range [66.5 to 67.5]

$\mathrm{i}_{1}=3 \mathrm{i}_{\mathrm{A}}$
$\mathrm{i}_{2}=3 \mathrm{i} \mathrm{c}$
$i_{3}=i_{1}-i_{2}=3\left[i_{A}-i_{c}\right]$
$\left(i_{1}\right)_{\text {rms }}^{2}=30^{2} \times \frac{120^{\circ}}{180^{\circ}} \Rightarrow\left(i_{1}\right)_{\text {rms }}=30 \sqrt{\frac{2}{3}}=24.49 \mathrm{Amp}$

$\left(i_{3}\right)_{\mathrm{rms}}^{2}=30^{2} \times \frac{120}{180}+60^{2} \times \frac{60}{180}$
$==30^{2} \times \frac{2}{3}+60^{2} \times \frac{1}{3}$
$\left(\mathrm{i}_{3}\right)_{\mathrm{rms}}=\sqrt{1800}=42.426 \mathrm{Amp}$
$i_{1, r m s}+i_{3, r m s}=66.92 \mathrm{Amp}$
11. For the circuit shown in the figure below, it is given that $\mathrm{V}_{\mathrm{CE}}=\frac{\mathrm{V}_{\mathrm{cc}}}{2}$. The transistor has $\beta$ $=29$ and $\mathrm{V}_{\mathrm{BE}}=0.7 \mathrm{~V}$ when the $\mathrm{B}-\mathrm{E}$ junction is forward biased.


For this circuit, the value of $\frac{R_{B}}{R}$ is
A. 43
B. 92
C. 121
D. 129

Ans. D
Sol. Given
$V_{C E}=\frac{V_{C C}}{2}=\frac{10}{2}=5 \mathrm{~V}$
$10=(1+\beta) I_{B} \times 4 R+I_{B} R_{B}+0.7+(1+\beta) I_{B} \cdot R$
$10=30 \mathrm{I}_{\mathrm{B}} \times 4 \mathrm{R}+\mathrm{I}_{\mathrm{B}} \mathrm{R}_{\mathrm{B}}+0.7+30 \mathrm{I}_{\mathrm{B}} \times \mathrm{R}$
$9.3=I_{B}\left[120 R+30 R+R_{B}\right]$
$9.3=I_{B}\left[150 R+R_{B}\right]$
$10=4 R(1+\beta) I_{B}+V_{C E}+(1+\beta) I_{B} \times R$
$10=120 \mathrm{RI}_{\mathrm{B}}+5+30 \mathrm{I}_{\mathrm{B}} \cdot \mathrm{R}$
$I_{B}=\frac{5}{150 R}=\frac{1}{30 R}$
Substituting equation (2) in equation (1)
$9.3=\frac{1}{30 R}\left[150+R_{B}\right]$
$279=150+\frac{R_{B}}{R} ; \frac{R_{B}}{R}=279-150=129$
12. Semiconductors are most popular for their use in
A. Generating very strong magnetic field.
B. Manufacture of bubble memories.
C. Generating electrostatic field
D. Generating regions free from magnetic field.

Ans. D
Sol. When temperature is reduced below transition temperature $T_{c}$ and magnetic field is less than the critical magnetic field Hc. Superconductors start to ripple magnetic field hence they are creating regions free from magnetic field.
13. Let be a real-valued function of a real variable defined as $f(x)=x^{2}$ for $x \geq 0$, and $f(x)=$ $-x^{2}$ for $x<0$. Which one of the following statements is true?
A. $f(x)$ is discontinuous at $x=0$.
B. $f(x)$ is continuous but not differentiable at $x=0$.
C. $f(x)$ is differentiable but its first derivative is not continuous at $x=0$.
D. $f(x)$ is differentiable but its first derivative is not differentiable at $x=0$.

Ans. D
Sol. $f(x)=\left\{\begin{array}{cc}x^{2}, & x \geq 0 \\ -x^{2}, & x<0\end{array}\right.$
$f^{\prime}(x)=\left\{\begin{aligned} 2 x, & x \geq 0 \\ -2 x, & x<0\end{aligned}\right.$
$f^{\prime \prime}(x)=\left\{\begin{array}{rr}2, & x \geq 0 \\ -2, & x<0\end{array}\right.$
The function is differentiable but its first derivative is not differentiable at $x=0$.
14. In the figure shown, self-impedances of the two transmission lines are 1.5j p.u. each, and $Z_{m}=0.5 \mathrm{j} p . u$. is the mutual impedance. Bus voltages shown in the figure are in
p.u. Given that $\delta>0$, the maximum steady-state real power that can be transferred in p.u from Bus-1 to Bus-2 is:

A. $\frac{3|E||V|}{2}$
B. $|\mathrm{E}||\mathrm{V}|$
C. $\frac{|\mathrm{E}||\mathrm{V}|}{2}$
D. $2|E||V|$

Ans. B
Sol. $P_{\text {max }}=\frac{|E||V|}{X_{\text {Th }}}$

$A=\frac{1}{2}\left[\begin{array}{ll}1 & -1 \\ 1 & -1\end{array}\right]$
$\mathrm{y}_{\text {prim }}=\mathrm{Z}_{\text {prim }}^{-1}$
$Z_{\text {prim }}=\left[\begin{array}{ll}1.5 & 0.5 \\ 0.5 & 1.5\end{array}\right]$
$1.5 \times 1.5-0.25$
$2.25-0.25=2$
$\mathrm{y}_{\text {prim }}=\frac{1}{2}\left[\begin{array}{cc}1.5 & -0.5 \\ -0.5 & 1.5\end{array}\right]$
$\mathrm{y}_{\text {Bus }}=\mathrm{A}^{\top}\left[\mathrm{y}_{\text {prim }}\right] \mathrm{A}=\frac{1}{2}\left[\begin{array}{cc}1 & 1 \\ -1 & -1\end{array}\right]\left[\begin{array}{cc}1.5 & -0.5 \\ -0.5 & 1.5\end{array}\right]=\left[\begin{array}{cc}1 & -1 \\ -1 & 1\end{array}\right]$
$Z_{\text {Bus }}=y_{\text {Bus }}^{-1}=\left[\begin{array}{ll}1 & 1 \\ 1 & 1\end{array}\right]$
15. Consider a state-variable model of a system

$$
\begin{aligned}
& {\left[\begin{array}{l}
\dot{x}_{1} \\
\dot{x}_{2}
\end{array}\right]=\left[\begin{array}{cc}
0 & 1 \\
-\alpha & -2 \beta
\end{array}\right]\left[\begin{array}{l}
x_{1} \\
x_{2}
\end{array}\right]+\left[\begin{array}{l}
0 \\
\alpha
\end{array}\right] r} \\
& y=\left[\begin{array}{ll}
1 & 0
\end{array}\right]\left[\begin{array}{l}
x_{1} \\
x_{2}
\end{array}\right]
\end{aligned}
$$

Where $y$ is the output, and $r$ is the input. The damping ratio $\xi$ and the Undamped natural frequency $\omega_{\mathrm{n}}$ (rad/sec) of the system are given by
A. $\xi=\sqrt{\beta} ; \omega_{\mathrm{n}}=\sqrt{\alpha}$
B. $\xi=\sqrt{\alpha} ; \omega_{\mathrm{n}}=\frac{\beta}{\sqrt{\alpha}}$
C. $\xi=\frac{\sqrt{\alpha}}{\beta} ; \omega_{\mathrm{n}}=\sqrt{\beta}$
D. $\xi=\frac{\beta}{\sqrt{\alpha}} ; \omega_{\mathrm{n}}=\sqrt{\alpha}$

Ans. D
Sol. We know
$\dot{X}=A X+B u$
$Y=C X=D u$
Comparing the above equation with the given problem
$A=\left[\begin{array}{cc}0 & 1 \\ -\alpha & -2 \beta\end{array}\right] B=\left[\begin{array}{l}0 \\ \alpha\end{array}\right]$
$C=\left(\begin{array}{ll}1 & 0\end{array}\right)$
Characteristic equation is
$|S I-A|=0$
$\left[\begin{array}{ll}S & 0 \\ 0 & S\end{array}\right]-\left[\begin{array}{cc}0 & 1 \\ -\alpha & -2 \beta\end{array}\right]=0$
$\left[\begin{array}{cc}S & -1 \\ \alpha & S+2 \beta\end{array}\right]=$
$\mathrm{s}^{2}+2 \mathrm{~S} \beta+\mathrm{a}=0$ (1)
$s^{2}+2 \xi \omega_{n} s+\omega_{n}^{2}=0(2)$
Comparing (1) and (2)
$\omega_{\mathrm{n}}{ }^{2}=\mathrm{a}$
$\omega_{\mathrm{n}}=\sqrt{\alpha}$
$2 \xi \omega_{\mathrm{n}}=2 \beta$
$\xi=\frac{\beta}{\omega_{\mathrm{n}}}=\frac{\beta}{\sqrt{\alpha}}$
16. Determine the output voltage in the ideal Op-amp circuit shown below.

A. -29 V
B. -28 V
C. -19 V
D. -23 V

Ans. A

Sol.


No current flows through the terminals of the Op-amp (since input impedance of ideal op-amp is infinite).
$\therefore \mathrm{I}_{1}=\mathrm{I}_{2}=0$
By voltage division,
$V_{A}=(15 \mathrm{~V}) \times\left(\frac{2 \mathrm{k} \Omega}{3 \mathrm{k} \Omega+2 \mathrm{k} \Omega}\right)$
$\Rightarrow V_{A}=6 \mathrm{~V}$
$V_{B}=V_{A}=6 \mathrm{~V}$
Since, $I_{2}=0$
$\Rightarrow \mathrm{I}_{3}=\mathrm{I}_{4}$
$\Rightarrow \frac{20-\mathrm{V}_{\mathrm{B}}}{2 \mathrm{k} \Omega}=\frac{\mathrm{V}_{\mathrm{B}}-\mathrm{V}_{0}}{5 \mathrm{k} \Omega}$
$\frac{20-6}{2}=\frac{6-V_{0}}{5}$
$\Rightarrow \mathrm{V}_{0}=-29 \mathrm{~V}$
17. The Power consumed in a $3 \phi, 3$ wire balanced load system is measured by two wattmeter method. The reading of wattmeter $A$ is 500 watts and wattmeter $B$ is -100 watts the power factor of system is $\qquad$
A. 0.86
B. 0.707
C. 0.56
D. 0.359

Ans. D
Sol. Given: $\mathrm{W}_{1}=500 \mathrm{~W}, \mathrm{~W}_{2}=-100 \mathrm{~W}$

$$
\begin{aligned}
& \cos \phi=\cos \left[\tan ^{-1} \sqrt{3}\left(\frac{\mathrm{~W}_{1}-\mathrm{W}_{2}}{\mathrm{~W}_{1}+\mathrm{W}_{2}}\right)\right] \\
& \mathrm{pf}=\cos \left\{\tan ^{-1} \sqrt{3}\left(\frac{600}{400}\right)\right\}=\cos \left(\tan ^{-1}(1.5 \times \sqrt{3})\right)=0.359
\end{aligned}
$$

18. A line charge exists on $z$ axis with $\rho L=10^{-9}(c / m)$. If $A$ is $(2 m, n / 2,0)$ and $B$ is ( $4 m, \pi$,

0 ) then potential difference $V_{A B}$ is
A. 5.64 V
B. 6.24 V
C. 8.91 V
D. 5.23 V

Ans. B
Sol. $\mathrm{E}=\frac{\rho \mathrm{L}}{2 \pi \varepsilon_{0} R} \hat{a}_{\mathrm{r}}$
$V_{A B}=-\int_{B}^{A \int_{B}^{A} \frac{\rho L}{2 \pi \varepsilon_{0} r} \cdot d r=\frac{\rho L}{2 \pi \varepsilon_{0}} \ln [r]_{B}^{A}} \vec{E} \cdot d l$
$V_{A B}=-\frac{10^{-9}}{2 \pi \times 8.85 \times 10^{-12}}[\ln 2-\ln 4]=6.24 \mathrm{~V}$
19. A single-phase, full-bridge rectifier fed from $230 \mathrm{~V}, 50 \mathrm{~Hz}$ sinusoidal source supply a series combination of finite resistance ' $R$ ' and a very large inductance, $L$. The two most dominate frequency components in the source current are:
A. $150 \mathrm{~Hz}, 250 \mathrm{~Hz}$
B. $50 \mathrm{~Hz}, 100 \mathrm{~Hz}$
C. $50 \mathrm{~Hz}, 0 \mathrm{~Hz}$
D. $50 \mathrm{~Hz}, 150 \mathrm{~Hz}$

Ans. D
Sol. In a single-phase full bridge diode rectifier, since load is a series combination of finite resistance (R) and a very high Inductance (L). Load current is constant ( $\mathrm{I}_{\mathrm{o}}$ )
Source current is square wave form.


Fourier series representation of source current
$\mathrm{i}_{\mathrm{s}}(\mathrm{f})=\sum_{\mathrm{n}=1,3,5}^{\infty} \frac{4 \mathrm{I}_{0}}{\mathrm{n} \pi} \sin n \omega \mathrm{t}, \left\lvert\, \begin{aligned} & \text { where } \\ & \omega=\frac{2 \pi}{\mathrm{~T}}\end{aligned}\right.$
Two most dominant frequency
Components are f,3f [fundamental and third harmonics]
$50 \mathrm{~Hz}, 150 \mathrm{~Hz}$.
20. A single bus structure is primarily found in:
A. Main frames
B. Mini and micro computers
C. Super computers
D. High performance machines

Ans. B
Sol. A single bus structure is primarily found in mini and micro computers.
21. Which of the following is measure of data transfer rate of a modem?
A. Bytes per second.
B. Band rate
C. Bits per second
D. Hertz

Ans. C
Sol. Bits per second is the measure of data transfer rate of a modem.
22. Consider the table given:

| Constructional feature | Machine type | Mitigation |
| :--- | :--- | :--- |
| (P) Damper bars | (S) Induction motor | (X) Hunting |
| (Q) Skewed rotor slots | (T) Transformer | (Y) Magnetic locking |
| (R) Compensating winding | (U) Synchronous machine | (Z) Armature reaction |
|  | (V) DC machine |  |

The correct combination that relates the constructional feature. machine type and mitigation is:
A. P-V-X, Q-U-Z, R-T-Y
B. P-T-Y, Q-V-Z, R-S-X
C. P-U-X, Q-S-Y, R-V-Z
D. P-U-X, Q-V-Y, R-T-Z

Ans. C
Sol. PUX - QSY - RVZ
23. Which is the addressing mode used in the instruction PUSH $B$ ?
A. Direct
B. Register
C. Register Indirect
D. Immediate

Ans. C
Sol. Register indirect addressing mode used in the instruction PUSH B.
24. The co-ordination number of cubic structure is $\qquad$ —.
A. 8
B. 6
C. 4
D. 2

Ans. B
Sol. The co-ordination number of cubic structure is 6 .
25. How many address lines and data lines are required to provide a memory capacity of $32 \mathrm{k} \times 16$ ?
A. 16,16
B. 15,16
C. 4,16
D. 5,16

Ans. B
Sol. Memory capacity $=32 \mathrm{k} \times 16=2^{15} \times 2^{4}$

Memory capacity is of the form $=2^{m} \times 2^{n}$
Address line required, $\mathrm{m}=15$
Data line required, $2^{4}=16$
26. Consider a solid sphere of radius 5 cm made of a perfect electric conductor. If one million electrons are added to this sphere, these electrons will be distributed.
A. Uniformly over the entire volume of the sphere
B. Uniformly over the outer surface of the sphere
C. Concentrated around the centre of the sphere
D. Along a straight line passing through the centre of the sphere

Ans. B
Sol. For a perfect conductor, the charge is present only on the surface. i.e., $\left.\begin{array}{l}P_{u}=0 \\ \bar{E}=0\end{array}\right\}$ inside the conductor

Alternate: Even if we give any number of charges, the charge will resides on its surface only.

27. There are two kind of electrical networks are shown in the figure below. Which of the following relation is true for the given circuit?

A. $R A=R B$
B. $R A=R B=0$
C. $R A<R B$
D. $R A>R B$

Ans. C

Sol.

$\Rightarrow \quad R_{A}=\frac{1 \times R_{B}}{1+R_{B}}$
$R_{A}=\frac{R_{B}}{1+R_{B}}$
$\therefore \mathrm{R}_{\mathrm{A}}<\mathrm{R}_{\mathrm{B}}$
28. Consider the circuit given below. It consists of IC-555 timer, supposed to generate a square wave of 20 kHz with $65 \%$ duty ratio, then the value of $\mathrm{R}_{A}$ and $\mathrm{R}_{B}$ required are
$\qquad$ _.

A. $54 \mathrm{k} \Omega \& 63 \mathrm{k} \Omega$
B. $63 \mathrm{k} \Omega \& 54 \mathrm{k} \Omega$
C. $53 \mathrm{k} \Omega \& 45 \mathrm{k} \Omega$
D. $45 \mathrm{k} \Omega \& 53 \mathrm{k} \Omega$

Ans. A
Sol. Given $\mathrm{f}=20 \mathrm{kHz}$
we know that Duty ratio $=\frac{\left(R_{A}+R_{B}\right)}{\left(R_{A}+2 R_{B}\right)}$
$\frac{R_{A}+R_{B}}{R_{A}+2 R_{B}}=0.65$
$0.65\left(R_{A}+2 R_{B}\right)=R_{A}+R_{B}$
$0.3 \mathrm{R}_{\mathrm{B}}=0.35 \mathrm{R}_{\mathrm{A}}$
Frequency of output, $f=\frac{1.44}{\left(R_{A}+2 R_{B}\right) C}$
$20 \times 10^{3}=\frac{1.44}{\left(R_{A}+2 \times \frac{0.35}{0.3} \times R_{A}\right) \times 400 \times 10^{-12}}$
$R_{A} \times(3.55)=180$
$R_{A}=54 \mathrm{k} \Omega$
$\mathrm{R}_{\mathrm{B}}=\frac{0.35}{0.3} \times 54=63 \mathrm{k} \Omega$
29. A potential field is given by $V=3 x^{2} y^{2}-y z$. Find the electric field at (4, $0,-1$ )
A. $-\hat{j}$
B. $-4 \hat{\mathrm{j}}$
C. $-3 \hat{i}+4 \hat{j}$
D. $4 \hat{\mathrm{k}}$

Ans. A
Sol. Given:
$V=3 x^{2} y^{2}-y z$
$E=-\nabla \mathbf{V}=-\left[\frac{\partial \mathbf{V}}{\partial \mathbf{x}} \hat{\mathbf{i}}+\frac{\partial \mathbf{V}}{\partial \mathbf{y}} \hat{\mathbf{j}}+\frac{\partial \mathbf{V}}{\partial \mathbf{z}} \hat{\mathbf{k}}\right]$
$E=-\left[6 x y^{2} \hat{i}+\left(6 x^{2} y-z\right) \hat{j}-y \hat{k}\right]$
Put $x=4, y=0, z=-1$
$E=-\hat{j}$
30. An 8 -pole, 50 Hz , three-phase, slip-ring induction motor has an effective rotor resistance of $0.08 \Omega$ per phase. Its speed at maximum torque is 650 RPM. The additional resistance per phase that must be inserted in the rotor to achieve maximum torque at start is
$\qquad$ $\Omega$. (Round off to 2 decimal places.) Neglect magnetizing current and stator leakage impedance. Consider equivalent circuit parameters referred to stator.
Ans. 0.52
Sol. Synchronous speed, $N_{s}=\frac{120 f}{P}=\frac{15 \times 50}{8}=750 \mathrm{rpm}$
Slip at maximum torque,

$$
\mathrm{S}_{\mathrm{T}_{\max }}=\frac{\mathrm{N}_{\mathrm{s}}-\mathrm{N}_{\mathrm{T}_{\max }}}{\mathrm{N}_{\mathrm{s}}}=\frac{750-650}{750}=\frac{100}{750}=0.1333
$$

Also, we known that,
$S_{T_{\text {max }}}=\frac{R_{2}^{\prime}}{X_{2}^{\prime}} \Rightarrow X_{2}^{\prime}=\frac{R_{2}^{\prime}}{S_{T_{\text {max }}}}=\frac{0.08}{0.1333}=0.6 \Omega$
For producing maximum torque at starting,
$S_{T_{\text {max }}}=1 \Rightarrow \frac{R_{2(\text { New })}^{\prime}}{X_{2}^{\prime}}=1 \Rightarrow R_{2(\text { New })}^{\prime}=X_{2}^{\prime}=0.6$
$\Rightarrow R_{2}^{\prime}+R_{\text {ext }}=0.6$
$R_{\text {ext }}=0.6 R_{z}{ }^{\prime}=0.6-0.08=0.52 \Omega$
 integer less than or equal to $t$ and [ t ] denotes the smallest integer greater than or equal to $t$. The coefficient of the second harmonic component of the Fourier series representing $g(t)$ is $\qquad$ —.
Ans. 0
Sol. Given that, $g(t)=\left\{\begin{array}{cc}t-|t| & t \geq 0 \\ t-|t|, & \text { otherwise }\end{array}\right\}$
Where,
$[\mathrm{t}]=$ Greatest integer less than or equal to ' t '.
[ t$]=$ smallest integer greater than or equal to ' t '.
Now,

| $\mathrm{t} \geq 0$ |  |  | $\mathrm{t}<0$ |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| $\mathrm{~g}(\mathrm{t})$ | T | $[\mathrm{t}]$ | $\mathrm{g}(\mathrm{t})$ | t | $[\mathrm{t}]$ |
| $\mathrm{t}-0$ | 0,1 | 0 | $\mathrm{t}+0$ | $-1,0$ | 0 |
| $\mathrm{t}-1$ | 1,2 | 1 | $\mathrm{t}+1$ | $-2,-3$ | -1 |
| $\mathrm{t}-2$ | 2,3 | 2 | $\mathrm{t}+2$ | $-3,-2$ | -2 |
| $\mathrm{t}-3$ | 3,4 | 3 | $\mathrm{t}+3$ | $-4,-3$ | -3 |
| . |  |  | . |  |  |
| . |  |  | . |  |  |
| . |  |  | . |  |  |



Since, $g(t)$ is non-periodic. So, Fourier series will not exist. Thus, second harmonic component of Fourier series will be 0.
32. In cylindrical coordinate system, the potential produced by a uniform ring charge is given $\phi=f(r, z)$, where $f$ is a continuous function of $r$ and $z$. Let $\bar{E}$ be the resulting electric field. Then the magnitude of $\nabla \times \overline{\mathrm{E}}$
A. increases with $r$
B. is 0
C. is 3
D. decreases with $z$

Ans. B
Sol. A uniformly charged ring can be considered as static. A static electric charge produces an electric field for which $\nabla \mathbf{x E}=\mathbf{0}$.
33. Let $\mathrm{z}(\mathrm{t})=\mathrm{x}(\mathrm{t}) * \mathrm{Y}(\mathrm{t})$, where "*" denotes convolution. Let C be a positive real-valued constant. Choose the correct expression for $z(c t)$.
A. $c . x(c t) * y(c t)$
B. $x(c t) * y(c t)$
C. $c .[x(t) * y(c t)]$
D. c. $x(c t)^{*} y(t)$

Ans. A
Sol. By convolution property of Fourier transform

$$
Z(j \omega)=X(j \omega) Y(j \omega)
$$

Fourier transform of $Z(c t) \stackrel{F T}{\longleftrightarrow} \frac{1}{|C|} Z\left(\frac{j \omega}{c}\right)$
$F T\{Z(c t)\}=\frac{1}{C} Z\left(\frac{j \omega}{c}\right)=\frac{1}{C} X\left(\frac{j \omega}{c}\right) Y\left(\frac{j \omega}{c}\right)=c \times\left(\frac{1}{C} X\left(\frac{j \omega}{c}\right)\right) \times\left(\frac{1}{c} Y\left(\frac{j \omega}{c}\right)\right)$
$Z(c t)=c\left[X(c t)^{*} y(c t)\right]$
34. A unity feedback system has open loop transfer function $G(s)$.

Polar plot of $G(j \omega)$ is shown in figure below:


Find out the value of $\theta$ $\qquad$ (in degrees). If the phase margin is $75^{\circ}$ of the feedback system.

Ans. range [100 to 110]
Sol. Gain margin $G M=\frac{1}{a}$
$=\left|\frac{1}{0.4}\right|=2.5$
And, $\mathrm{PM}=180^{\circ}-\theta$
$\theta^{\circ}=180^{\circ}-\mathrm{PM}=180^{\circ}-75^{\circ}=105^{\circ}$
35. A transistor circuit is given below. The Zener diode breakdown voltage is 5.3 V as shown. The base to emitter voltage droop to be 0.6 V . The value of the current gain $\beta$ is

A. 19
B. 24
C. 10
D. 22

Ans. A
Sol. $5.3=0.6+470 \mathrm{I}_{\mathrm{E}}$

$$
\mathrm{I}_{\mathrm{E}}=0.01 \mathrm{~A}
$$

$$
\mathrm{I}_{\mathrm{x}}=\frac{10-5.3}{4.7 \times 10^{3}}=1 \mathrm{~mA}
$$

$\mathrm{I}_{\mathrm{B}}=1-0.5=0.5 \mathrm{~mA}$
$\mathrm{I}_{\mathrm{E}}=(1+\beta) \mathrm{I}_{\mathrm{B}}$
$\Rightarrow 0.01=(1+\beta) \times 0.5 \times 10^{-3}$
$\Rightarrow(1+\beta)$
$=\frac{0.01}{0.5 \times 10^{-3}}=20 \Rightarrow \beta=19$
Since $1+\beta=20$
36. Statement I: super conducting nature has been observed in poor metallic conductor, conductor such as tin, lead rather than in good conductor such gold and silver.

Statement II: Type II superconductor are more important because they can carry very high current densities.
A. Both statements are correct and statement II is correct explanation of statement I.
B. Both statements are correct and statement II is not correct explanation of statement
I.
C. statement I is true and statement II is false.
D. statement I is false and statement II is true.

Ans. B
Sol. Super conducting nature has been observed in poor metallic conductor, conductor such as tin, lead rather than in good conductor such gold and silver.

Type II superconductor are more important because they can carry very high current densities.

Hence both statements are correct and statement II is not correct explanation of statement I
37. The figures show diagrammatic representations of vector fields $\bar{X}, \bar{Y}$ and $\bar{Z}$ respectively. Which one of the following choices is true?

A. $\nabla \bar{X}=0, \nabla \times \bar{Y} \neq 0, \nabla \times \bar{Z}=0$
B. $\nabla \bar{X} \neq 0, \nabla \times \bar{Y} \neq 0, \nabla \times \bar{Z} \neq 0$
C. $\nabla \cdot \bar{X} \neq 0, \nabla \times \bar{Y} \neq 0, \nabla \times \bar{Z} \neq 0$
D. $\nabla \bar{X}=0, \nabla \times \bar{Y}=0, \nabla \times \bar{Z}=0$

Ans. C

Sol.

$\nabla \cdot \overline{\mathrm{X}} \neq 0$
$\nabla \cdot \bar{Y}=0$
$\nabla \cdot \bar{Z} \neq 0$
$\nabla \times \overline{\mathrm{X}} \neq 0$
$\nabla \times \bar{Y} \neq 0$
$\nabla \times \bar{Z} \neq 0$
38. A certain unity negative feedback system has the open loop transfer function
$\mathrm{G}(\mathrm{s})=\frac{\mathrm{K}}{\mathrm{s}(1+\mathrm{s})(1+0.1 \mathrm{~s})}$
The system gain ' $K$ ', if the gain margin is 10 dB is $\qquad$ .

Ans. range [3.25 to 3.5]
Sol. Gain margin is obtained at $\omega=\omega_{p c}$
Where, $\omega_{\mathrm{pc}}$ is the phase cross over frequency, calculated as,
$\mathrm{CE} \Rightarrow\left(\mathrm{s}^{2}+\mathrm{s}\right)(1+0.1 \mathrm{~s})=0$
$0.1 s^{3}+0.1 s^{2}+s^{2}+s=0$
Taking imaginary part of $s=0$
$0.1 \mathrm{~s}^{3}+\mathrm{s}=0$
or $0.1 \mathrm{~s}^{2}+1=0$
or $s^{2}=-\frac{1}{0.1}=-10$
or, $\omega_{\mathrm{pc}}=\sqrt{10} \mathrm{rad} / \mathrm{sec}$
$\therefore \quad G M=\frac{1}{\left|G\left(\omega_{p c}\right)\right|}=10 \mathrm{~dB}=3.162$
$=\frac{\omega_{\mathrm{pc}} \sqrt{1+\omega_{\mathrm{pc}}^{2}} \sqrt{1+0.01 \omega_{\mathrm{pc}}^{2}}}{\mathrm{~K}}=3.162$
$=\frac{\sqrt{10} \sqrt{11} \sqrt{1.1}}{K}=3.162$
$K=\frac{11}{3.162}=3.479$
39. Two single-core power cables have total conductor resistances of $0.7 \Omega$ and $0.5 \Omega$, respectively. and their insulation resistances (between core and sheath) are $600 \mathrm{M} \Omega$
and $900 \mathrm{M} \Omega$, respectively. When the two cables are joined in series, the ratio of insulation resistance to conductor resistance is $\qquad$ $\times 10^{6}$.
Ans. 300

Sol.

$\mathrm{R}_{\mathrm{C}_{\text {Total }}}=\mathrm{R}_{\mathrm{C}_{1}}+\mathrm{R}_{\mathrm{C}_{2}}$ (series)
$0.7+0.5=1.2$
$\mathrm{R}_{\text {ins }}^{\text {Total }}$ $=\frac{600 \times 900}{1500}=360 \times 10^{6}$
$\frac{\mathrm{R}_{\mathrm{ins}_{\text {Total }}}}{\mathrm{R}_{\mathrm{C}_{\text {Total }}}}=\frac{360 \times 10^{6}}{1.2}=360 \times 10^{6}$
40. The star network has been converted into the delta network for the same value of the following given circuit elements in each star branch. Which of the following option(s) are correct?
A. For inductor, each inductor in the branch of delta network, $L_{\Delta}=3 L_{y}$
B. For capacitor, each capacitor in the branch of delta network, $C_{\Delta}=\frac{C_{y}}{3}$
C. For inductor, each inductor in the branch of delta network, $C_{\Delta}=\frac{L_{y}}{3}$
D. For capacitor, each capacitor in the branch of delta network, $C_{\Delta}=3 C_{y}$

Ans. A, B
Sol. While converting the star network into the delta network,


Circuit impedance varies by $\mathrm{Z}_{1}=\frac{\mathrm{Z}_{\mathrm{a}} \mathrm{Z}_{\mathrm{b}}+\mathrm{Z}_{\mathrm{b}} \mathrm{Z}_{\mathrm{c}}+\mathrm{Z}_{\mathrm{a}} \mathrm{Z}_{\mathrm{c}}}{\mathrm{Z}_{\mathrm{c}}}$
$Z_{2}=\frac{Z_{a} Z_{b}+Z_{b} Z_{c}+Z_{a} Z_{c}}{Z_{a}}$
$Z_{3}=\frac{Z_{a} Z_{b}+Z_{b} Z_{c}+Z_{a} Z_{c}}{Z_{b}}$
When it is given that all the star network branch values are same, we get that all delta branches will also have same values of $Z_{\Delta}=3 Z_{y}$
i.e., for inductor, $Z \propto L$, so $L_{\Delta}=3 L_{y}$
and for capacitor, $Z \propto \frac{1}{C}$, so $C_{\Delta}=\frac{C_{y}}{3}$.
41. The armature of a star connected alternator is uniformly wound with T coils, each coil having $N$ full pitched turns. The generated emf per conductor is $4 V(r m s)$. The line emf (in $V$ ) is-
A. $\mathrm{E}_{\text {line }}=\frac{8 \sqrt{3}}{\pi} \mathrm{NT}$
B. $\mathrm{E}_{\text {line }}=\frac{4 \sqrt{3}}{\pi} \mathrm{NT}$
C. $\mathrm{E}_{\text {line }}=\frac{2 \sqrt{3}}{\pi} \mathrm{NT}$
D. $\mathrm{E}_{\text {line }}=\frac{\sqrt{3}}{\pi} \mathrm{NT}$

Ans. A
Sol. $\mathrm{EMF} /$ Conductor $=4 \mathrm{~V}$
EMF/Turn = 8V

Total turns $=\mathrm{NT}$
Total turns/Phase $=\frac{\mathrm{NT}}{3}$
for 3- $\phi$ system $\sigma=60^{\circ}$
$\mathrm{K}_{\mathrm{d}}=\frac{\sin \frac{\sigma}{2}}{\frac{\sigma}{2}}$ (Approximation)
$\mathrm{K}_{\mathrm{d}}=\frac{\sin 30^{\circ}}{30^{\circ} \times \frac{\pi}{180^{\circ}}}$
$\mathrm{K}_{\mathrm{d}}=\frac{1}{2} \times \frac{6}{\pi}=\frac{3}{\pi}$
Total induced emf $=\mathrm{K}_{\mathrm{d}} \times$ No. of turns/ phase $\times \mathrm{emf}$ in each turn per phase
$=\mathrm{K}_{\mathrm{d}}=8 \times \frac{\mathrm{NT}}{3}$
$\mathrm{E}_{\mathrm{ph}}=\frac{\mathrm{NT}}{3} \times 8 \times \frac{3}{\pi}=\frac{8}{\pi} \mathrm{NT}$
$E_{\text {line }}=\frac{8 \sqrt{3}}{\pi} N T$
42. A certain unity negative feedback system has the open loop transfer function

$$
\mathrm{G}(\mathrm{~s})=\frac{\mathrm{K}}{\mathrm{~s}(1+\mathrm{s})(1+0.1 \mathrm{~s})}
$$

The system gain ' K ', if the gain margin is 10 dB is $\qquad$ .
Ans. Range [3.25 to 3.5]
Sol. Gain margin is obtained at $\omega=\omega_{p c}$
Where, $\omega_{\mathrm{pc}}$ is the phase cross over frequency, calculated as,
$\mathrm{CE} \Rightarrow\left(\mathrm{s}^{2}+\mathrm{s}\right)(1+0.1 \mathrm{~s})=0$
$0.1 s^{3}+0.1 s^{2}+s^{2}+s=0$
Taking imaginary part of $s=0$
$0.1 \mathrm{~s}^{3}+\mathrm{s}=0$
or $0.1 \mathrm{~s}^{2}+1=0$
or $s^{2}=-\frac{1}{0.1}=-10$
or, $\omega_{\mathrm{pc}}=\sqrt{10} \mathrm{rad} / \mathrm{sec}$
$\therefore \quad \mathrm{GM}=\frac{1}{\left|\mathrm{G}\left(\omega_{\mathrm{pc}}\right)\right|}=10 \mathrm{~dB}=3.162$
$=\frac{\omega_{\mathrm{pc}} \sqrt{1+\omega_{\mathrm{pc}}^{2}} \sqrt{1+0.01 \omega_{\mathrm{pc}}^{2}}}{\mathrm{~K}}=3.162$
$=\frac{\sqrt{10} \sqrt{11} \sqrt{1.1}}{K}=3.162$
$K=\frac{11}{3.162}=3.479$
43. Two generators have cost functions $F_{1}$ and $F_{2}$. Their incremental-cost characteristics are:

$$
\begin{aligned}
& \frac{\mathrm{dF}_{1}}{\mathrm{dP}_{1}}=40+0.2 \mathrm{P}_{1} \\
& \frac{\mathrm{dF}_{2}}{\mathrm{dP}_{2}}=32+0.4 \mathrm{P}_{2}
\end{aligned}
$$

They need to deliver a combined load of 260 MW. Ignoring the network loses, for economic operation, the generations $P_{1}$ and $P_{2}$ (in MW) are
A. $P_{1}=120, P_{2}=140$
B. $P_{1}=P_{2}=130$
C. $P_{1}=160, P_{2}=100$
D. $P_{1}=140, P_{2}=120$

Ans. C
Sol. Coordination equation,

$$
\begin{align*}
& \frac{d F_{1}}{d P_{1}}=\frac{d F_{2}}{d P_{2}} \\
& 40+0.2 P_{1}=32+0.4 \mathrm{P}_{2}  \tag{1}\\
& \mathrm{P}_{1}+\mathrm{P}_{2}=260 \mathrm{MW}  \tag{2}\\
& \quad \mathrm{P}_{1}-2 P_{2}=-40 \ldots \ldots . .(1) \\
& \Rightarrow \frac{-P_{1} \pm P_{2}=-260 \ldots \ldots . .(2)}{-3 P_{2}=-300} \\
& \mathrm{P}_{2}=100 \mathrm{MW} \\
& \mathrm{P}_{1}=160 \mathrm{MW}
\end{align*}
$$

44. For the circuit shown below, assume that the OPAMP is ideal.


Which one of the following is TRUE?
A. $v_{0}=v_{s}$
B. $\mathrm{v}_{\mathrm{o}}=1.5 \mathrm{v}_{\mathrm{s}}$
C. $\mathrm{V}_{\mathrm{o}}=2.5 \mathrm{v}_{\mathrm{s}}$
D. $v_{0}=5 v_{\mathrm{s}}$

Ans. C
Sol. At node (1)
$V_{x}=\frac{V_{s} \times 2 R}{4 R}=\frac{V_{s}}{2}$


At node (2)
$\frac{V_{x}}{R}+\frac{V_{x}-V_{y}}{R}=0$
$2 V_{x}=V_{y}$
$V_{y}=\frac{2 V_{s}}{2}=V_{s}$
At node (3)
$\frac{V_{y}}{R}+\frac{\left(V_{y}-V_{x}\right)}{R}+\frac{\left(V_{y}-V_{0}\right)}{R}=0$
$V_{s}+V_{s}-\frac{V_{s}}{2}+V_{s}-V_{0}=0$
$3 V_{s}-\frac{V_{s}}{2}=V_{0}$
$\mathrm{V}_{0}=\frac{5 \mathrm{~V}_{\mathrm{s}}}{2} ; \mathrm{V}_{0}=2.5 \mathrm{~V}_{\mathrm{s}}$
45. An alternator with internal voltage of $1 \angle \delta_{1}$ p.u. and synchronous reactance of 0.4 p.u. is connected by a transmission line of reactance $0.1 \mathrm{p} . \mathrm{u}$. to a synchronous motor having synchronous reactance 0.35 p.u. and internal voltage of $0.85 \angle \delta_{2}$ p.u. If the real power
supplied by the alternator is 0.866 p.u., then $\left(\delta_{1}-\delta_{2}\right)$ is $\qquad$ degrees. (Round off to 2 decimal places.) (Machines are of non-salient type. Neglect resistances.)
Ans. 60
Sol. Total power transferred,

$P=\frac{E_{f} V}{X_{\text {eq }}} \sin \left(\delta_{1}-\delta_{2}\right)$
$\Rightarrow 0.866=\frac{1 \times 0.85}{0.85} \sin \left(\delta_{1}-\delta_{2}\right)$
Total reactance of the system,
$X_{\text {eq }}=j 0.4+j 0.1+j 0.35=j 0.85$ p.u.
$\sin \left(\delta_{1}-\delta_{2}\right)=0.866$
$\left(\delta_{1}-\delta_{2}\right)=60^{\circ}$
46. A 3- $\phi$ rectifier circuit is shown below.


Given: $\mathrm{V}_{1}=\mathrm{V}_{\mathrm{an}}=\mathrm{V}_{\mathrm{m}} \sin \omega \mathrm{t}$
$\mathrm{V}_{2}=\mathrm{V}_{\mathrm{bn}}=\mathrm{V}_{\mathrm{m}} \sin \left(\omega \mathrm{t}-120^{\circ}\right)$
$\mathrm{V}_{3}=\mathrm{V}_{\mathrm{an}}=\mathrm{V}_{\mathrm{m}} \sin \left(\omega \mathrm{t}+120^{\circ}\right)$
And $L_{1}=L_{2}=L_{3}=L_{s}$ are source inductances.
Due to source inductance, there will be an overlapping angle $(\mu)$ after $\omega t=\frac{\pi}{6}$, then what will be the volage at point ' p ' w.r.t neutral during $\omega \mathrm{t}=\frac{\pi}{6}$ to $\omega \mathrm{t}=\frac{\pi}{6}+\mu$.
A. Van
B. $\mathrm{V}_{\mathrm{cn}}$
C. $\frac{\mathrm{Van}_{\mathrm{a}}+\mathrm{V}_{\mathrm{cn}}}{2}$
D. $\frac{V_{a n}-V_{c n}}{2}$

Ans. C

Sol. $\quad \omega t=\frac{\pi}{6}$
Before $\omega \mathrm{t}=\frac{\pi}{6} \rightarrow \mathrm{D}_{5}, \mathrm{D}_{6}$ conducting
After $\omega \mathrm{t}=\frac{\pi}{6} \rightarrow \mathrm{D}_{1}, \mathrm{D}_{6}$ conducting
From $\omega \mathrm{t}=\frac{\pi}{6}$ to $\omega \mathrm{t}=\frac{\pi}{6}+\mu$;

$-\mathrm{V}_{\mathrm{an}}+\mathrm{I}_{\mathrm{s}} \frac{\mathrm{d}_{\mathrm{i} \mu}}{\mathrm{dt}}+\mathrm{I}_{\mathrm{s}} \frac{\mathrm{d}\left[\mathrm{i}_{\mu}-\mathrm{I}_{0}\right]}{\mathrm{dt}}+\mathrm{V}_{\mathrm{cn}}=0$
$V_{a n}-V_{c n}=2 I_{s} \frac{d_{i \mu}}{d t}$
Now, $\mathrm{V}_{\mathrm{P}}=\mathrm{V}_{\mathrm{an}}-\mathrm{L}_{\mathrm{s}} \frac{\mathrm{d}_{\mathrm{i}}}{\mathrm{dt}}$
$V_{P}=V_{a n}-\left[\frac{V_{a n}-V_{c n}}{2}\right]$
$V_{p}=\frac{V_{a n}+V_{c n}}{2}$
47. In mesh analysis,
(1) Mesh is a loop that does not contain any other loop within it.
(2) Supermesh requires the implementation of both KVL and KCL.
(3) Loop can be clockwise or counter-clockwise which does not affect the validity of solution.
Which of the above statements are correct?
A. 1 and 2
B. 2 and 3
C. 1 and 3
D. 1, 2 and 3

Ans. D
Sol. Mesh current loop is one of its own and does not contain any other loop within. A supermesh does not have its own current and requires KVL and KCL both for solving the equations.
The direction of the mesh current loops are random which can go in clockwise or counterclockwise.
Hence, all the statements are correct.
48. A 3-Bus network is shown. Consider generators as ideal voltage sources. If row 1, 2 and 3 of the $Y_{\text {Bus }}$ matrix correspond to Bus 1, 2 and 3, respectively, then $Y_{B u S}$ of the network is:

A. $\left[\begin{array}{ccc}-\frac{1}{2} \mathrm{j} & \frac{1}{4} \mathrm{j} & \frac{1}{4} \mathrm{j} \\ \frac{1}{4} \mathrm{j} & -\frac{1}{2} \mathrm{j} & \frac{1}{4} \mathrm{j} \\ \frac{1}{4} \mathrm{j} & \frac{1}{4} \mathrm{j} & -\frac{1}{2} \mathrm{j}\end{array}\right]$
B. $\left[\begin{array}{ccc}-4 j & 2 j & 2 j \\ 2 j & -4 j & 2 j \\ 2 j & 2 j & -4 j\end{array}\right]$
C. $\left[\begin{array}{ccc}-\frac{3}{4} \mathrm{j} & \frac{1}{4} \mathrm{j} & \frac{1}{4} \mathrm{j} \\ \frac{1}{4} \mathrm{j} & -\frac{3}{4} \mathrm{j} & \frac{1}{4} \mathrm{j} \\ \frac{1}{4} \mathrm{j} & \frac{1}{4} \mathrm{j} & -\frac{3}{4} \mathrm{j}\end{array}\right]$
D. $\left[\begin{array}{ccc}-4 j & \mathrm{j} & \mathrm{j} \\ \mathrm{j} & -4 \mathrm{j} & \mathrm{j} \\ \mathrm{j} & \mathrm{j} & -4 \mathrm{j}\end{array}\right]$

Ans. C
Sol. $\mathrm{I}_{1}+\mathrm{I}_{3}+\mathrm{I}_{4}=\mathrm{I}_{2}$

$$
\begin{align*}
& \mathrm{I}_{1}=\left(\mathrm{V}_{1}-\mathrm{V}_{2}\right)(-j 1)  \tag{1}\\
& \mathrm{I}_{1}=(-j 1) \mathrm{V}_{1}+(j 1) \mathrm{V}_{2}  \tag{2}\\
& \mathrm{I}_{2}=\mathrm{V}_{2}(-\mathrm{j} 1)  \tag{3}\\
& \mathrm{I}_{3}=\left(\mathrm{V}_{3}-\mathrm{V}_{2}\right)(-j 1) \\
& \mathrm{I}_{3}=(-j 1) \mathrm{V}_{2}+(\mathrm{j} 1) \mathrm{V}_{3}  \tag{4}\\
& \mathrm{I}_{4}=\left(\mathrm{V}_{4}-\mathrm{V}_{2}\right)(-j 1) \\
& \mathrm{I}_{4}=(\mathrm{j} 1) \mathrm{V}_{2}-(\mathrm{j} 1) \mathrm{V}_{4} \tag{5}
\end{align*}
$$

From equation (1) \& (3)
$\mathrm{I}_{1}+\mathrm{I}_{3}+\mathrm{I}_{4}=\mathrm{V}_{2}(-\mathrm{j} 1)$
$V_{2}=(j 1)\left[(-j 1) V_{1}+(j 1) V_{2}+(j 1) V_{2}+(-j 1) V_{3}+(j 1) V_{2}-(j 1) V_{4}\right]$
$V_{2}=V_{1}-3 V_{2}+V_{3}+V_{4}$
$4 V_{2}=V_{1}+V_{3}+V_{4}$
$V_{2}=\frac{1}{4} V_{1}+\frac{1}{4} V_{3}+\frac{1}{4} V_{4}$
Now,
$I_{1}=(1 j 1) V_{1}+(j 1)\left[\frac{1}{4} V_{1}+\frac{1}{4} V_{3}+\frac{1}{4} V_{4}\right]$
$I_{1}=-j \frac{3}{4} V_{1}+j \frac{1}{3} V_{3}+j \frac{1}{4} V_{4}$
$I_{3}=(-j 1)\left[V_{3}-\frac{1}{4} V_{1}-\frac{1}{4} V_{3}-\frac{1}{4} V_{4}\right]$
$I_{3}=j \frac{1}{4} V_{1}-j \frac{3}{4} V_{3}+j \frac{1}{4} V_{4}$
$I_{4}=(j 1)\left[\frac{1}{4} V_{1}+\frac{1}{4} V_{3}+\frac{1}{4} V_{4}\right]-(j 1) V_{4}$

$$
\begin{align*}
& I_{4}=j \frac{1}{4} V_{1}+j \frac{1}{4} V_{3}-j \frac{3}{4} V_{4}  \tag{9}\\
& {\left[\begin{array}{l}
I_{1} \\
I_{2} \\
I_{3}
\end{array}\right]=\underbrace{\left[\begin{array}{ccc}
-j \frac{3}{4} & j \frac{1}{4} & j \frac{1}{4} \\
j \frac{1}{4} & -j \frac{3}{4} & j \frac{1}{4} \\
j \frac{1}{4} & j \frac{1}{4} & -j \frac{3}{4}
\end{array}\right]}_{Y_{\text {BUS }}}\left[\begin{array}{l}
V_{1} \\
V_{3} \\
V_{4}
\end{array}\right]}
\end{align*}
$$

49. In a digital multimeter $4 \frac{1}{2}$ display is used. The value of 0.7235 V is display on 10 V range as $\qquad$ volts.
Ans. 0.723
Sol. Resolution, $R=\frac{1}{10^{n}}=\frac{1}{10^{n}}=0.0001$
Resolution of 10 V range $=10 \times 0.0001=0.001 \mathrm{~V}$
So it can measure only upto 3 decimal places 0.7235 will be display as 0.723 V .
50. The currents passing through the different resistances are shown in below given electrical network. What will be the value of the current passing through the R5 resistance shown in the figure?

A. 10 A
B. -10 A
C. Can be found only when source voltage and resistor values are known.
D. -5 A

Ans. B

Sol.


Apply KCL at Node 'b'
Assume $\mathrm{V}_{1}$ delivers a current " $\mathrm{ia}_{\mathrm{a}}$ "
$i_{a}=1+5$
$\mathrm{i}_{\mathrm{a}}=6 \mathrm{~A}$
Apply KCL at node 'a'
$\mathrm{i}_{\mathrm{a}}+4+\mathrm{I}=0$
$6+4+\mathrm{I}=0$
$\mathrm{I}=-10$ Amp's
51. Consider the buck-boost converter shown. Switch Q is operating at 25 kHz and 0.75 duty-cycle. Assume diode and switch to be ideal. Under steady-state condition, the average current flowing through the inductor $\qquad$ A.


Ans. range [24 to 24]
Sol. $I_{L}=\frac{\alpha V_{d c}}{R(1-\alpha)^{2}}=\frac{0.75 \times 20}{10(1-0.75)^{2}}=24 \mathrm{~A}$
52. Out of the following options, the most relevant information needed to specify the real power (P) at the PV buses in the load flow analysis is
A. Solution of economics load dispatch
B. rated voltage of generator
C. rated power output of generator
D. base power of generator

Ans. A
Sol. For generator buses, the solution of economic load dispatch is a processor to the load flow analysis.
53. Let $f$ be a real valued function of a real variable defined as $f(x)=x-[x]$, where [ $x$ ] denotes the largest integer less than or equal to $x$. The value of $\int_{0.25}^{1.25} f(x) d x$ is
$\qquad$ (up to 2 decimal places).

Ans. 0.5
Sol. $f(x)=x-[x]=\{x\}=$ fractional part of $x$
Graph of fractional part of $x$ is given below.


It is periodic with period 1 .
$\int_{0.25}^{1.25} f(x) d x=\int_{0}^{1} f(x) d x=\frac{1}{2} \times 1 \times 1=0.5$
54. A negative feedback $\left(\beta=2 \times 10^{-3}\right)$ is applied to an amplifier of open loop gain $10^{4}$. What is the new overall gain of the feedback amplifier if the open loop gain of the internal amplifier is reduced by $20 \%$ ?
A. 266.67
B. 470.58
C. 522.24
D. 345.5

Ans. B
Sol. Given:
$A=10^{4}$
$\beta=2 \times 10^{-3}$
$A_{f}=\frac{A}{1+A \beta}$
internal gain reduces by $20 \%$ so, $A^{\prime}=0.8 A$
So $A_{f}=\frac{0.8 \times 10^{4}}{1+0.8 \times 10^{4} \times 2 \times 10^{-3}}=470.58$
55. Find the number of prime implicants, essential prime implicants, and minimized expression for the below function.
$F(A, B, C, D)=\Sigma m(0,2,5,9,15)+\Sigma d(6,7,8,10,12,13)$
A. $3,3, \bar{B} \bar{D}+A \bar{C}+B D$
B. $4,3, \bar{B} \bar{D}+A \bar{C}+B D$
C. $4,4, B \bar{D}+A \bar{C}+\bar{B} D$
D. $3,4, B \bar{D}+A \bar{C}+\bar{B} D$

Ans. A

Sol.

| CD | 00 | 01 | 11 | 10 |
| :---: | :---: | :---: | :---: | :---: |
| 00 | 1 |  |  | 1 |
| 01 |  | 1 | $\mathbf{x}$ | x |
| 11 | X | x | 1 |  |
| 10 | x | 1 |  | X |

Number of Prime Implicants $=3$
Number of Essential Prime Implicants $=3$
$\Rightarrow \mathrm{F}=\overline{\mathrm{B}} \overline{\mathrm{D}}+\mathrm{A} \overline{\mathrm{C}}+\mathrm{BD}$
56. In a charge free region for which $\sigma=0, \epsilon=\epsilon_{0} \epsilon_{r}$ and $\mu=\mu_{0}, H=5 \cos \left(10^{11} t-4 y\right) \hat{a}_{z}$ $A / m$. Determine the electric flux density $D$.
A. $\vec{D}=20 \times 10^{-11} \sin \left(10^{11} t-4 y-\frac{\pi}{2}\right) \hat{a}_{x}$
B. $\vec{D}=20 \times 10^{-11} \sin \left(10^{11} t-4 y-\pi\right) \hat{a}_{x}$
C. $\vec{D}=20 \times 10^{-11} \sin \left(10^{11} t-4 y-\frac{\pi}{2}\right) \hat{a}_{z}$
D. $\vec{D}=20 \times 10^{-11} \sin \left(10^{11} t-4 y-\pi\right) \hat{a}_{z}$

Ans. A
Sol. $\nabla \times \vec{H}=J_{C}+J_{d}=0+J_{d}$

$$
\begin{aligned}
& \nabla \times \vec{H}=\left|\begin{array}{ccc}
a_{x} & a_{y} & a_{z} \\
\frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\
0 & 0 & 5 \cos \left(10^{11} t-4 y\right)
\end{array}\right| \\
& =a_{x}\left(-5 \sin \left(10^{11} t-4 y\right) \times(-4)\right)-a_{y} .0+a_{z} .0 \\
& =20 \sin \left(10^{11} t-4 y\right) a_{x} \\
& \vec{J}_{d}=20 \sin \left(10^{11} t-4 y\right) \hat{a}_{x} \\
& \vec{J}_{d}=j \omega \vec{D}
\end{aligned}
$$

$$
\begin{aligned}
& \vec{D}=\frac{\vec{j}_{d}}{j \omega}=\frac{20 \sin \left(10^{11} t-4 y\right) \hat{a}_{x}}{10^{11} \angle 90^{\circ}} \\
& \vec{D}=20 \times 10^{-11} \sin \left(10^{11} t-4 y-\frac{\pi}{2}\right) \hat{a}_{x}
\end{aligned}
$$

57. In a single-phase transformer, the total iron loss is 2500 W at nominal voltage of 440 V and frequency 50 Hz . The total iron loss is 850 W at 220 V and 25 Hz . Then, at nominal voltage and frequency, the hysteresis loss and eddy current loss respectively are:
A. 1600 W and 900 W
B. 900 W and 1600 W
C. 250 W and 600 W
D. 600 W and 250 W

Ans. B
Sol. $W_{i}=W_{h}+W_{e}$
$W_{i}=A_{f}+\mathrm{Bf}^{2}$
$\frac{V_{2}}{f_{2}}=\frac{V_{1}}{f_{1}}=$ constant
$B_{m 2}=B_{m 1}$
$\frac{W_{i}}{f}=A+B f$
$\frac{2500}{50}=A+B(50)$
$\frac{850}{250}=A+B(25)$
$16=25 B$
$B=0.64$
$A=18$
$W_{h}=A \times f=18 \times 50=900 \mathrm{~W}$
$W_{e}=B \times f^{2}=0.64 \times 50^{2}=1600 \mathrm{~W}$
58. How many address lines and data lines are required to provide a memory capacity of $32 \mathrm{k} \times 16$ ?
A. 16,16
B. 15,16
C. 4,16
D. 5,16

Ans. B

Sol. Memory capacity $=32 \mathrm{k} \times 16=2^{15} \times 2^{4}$
Memory capacity is of the form $=2^{m} \times 2^{n}$
Address line required, $m=15$
Data line required, $2^{4}=16$
59. An incandescent lamp is marked $40 \mathrm{~W}, 240 \mathrm{~V}$. If resistance at room temperature ( $26^{\circ} \mathrm{C}$ ) is $120 \Omega$, and temperature coefficient of resistance is $4.5 \times 10^{-3} /{ }^{\circ} \mathrm{C}$, then its 'ON' state filament temperature in ${ }^{\circ} \mathrm{C}$ is approximately $\qquad$
Ans. 2470.44
Sol. $\mathrm{P}=40 \mathrm{~W}$
$\mathrm{V}=240 \mathrm{~V}$
Now $\mathrm{R}_{\text {lamp }}=\frac{\mathrm{V}^{2}}{\mathrm{P}}=\frac{240^{2}}{40}=1440 \Omega$
AT $\mathrm{t}=26^{\circ}, \mathrm{R}=120 \mathrm{~W}$ and $\mathrm{a}=4.5 \times 10^{-3} /{ }^{\circ} \mathrm{C}$
Now $R_{\text {lamp }}=R\left[1+\alpha\left(t_{2}-t_{1}\right)\right]$
$\therefore 1440=120\left[1+4.5 \times 10^{-3}\left[\theta_{2}-26\right]\right]$
$\mathrm{t}_{2}=2470.44^{\circ} \mathrm{C}$
60. The partial differential equation that can be formed from $z=a x+b y+a b$ has form $\left(p=\frac{\partial z}{\partial x} ., q=\frac{\partial z}{\partial y}\right)$.
A. $z=p x+q y$
B. $z=p x+q y$
C. $z=p x+q y+p q$
D. $z=q y+p q$

Ans. C
Sol. $z=a x+b y+a b$
Differentiating given equation with respect to ' $x$ '
$\frac{\partial z}{\partial \mathrm{x}}=\mathrm{a}$
$\mathrm{p}=\mathrm{a}$
Again differentiating with respect to ' $y$ '

$$
\begin{equation*}
\frac{\partial z}{\partial y}=b \Rightarrow q=b \tag{2}
\end{equation*}
$$

Using (1) and (2), given equation becomes
$z=p x+q y+p q$ which is required partial differential equation.
61. A lossless transmission line with 0.2 p.u. reactance per phase uniformly distributed along the length of the line, connecting a generator bus to a load bus, is protected up to 80 $\%$ of its length by a distance relay placed at the generator bus. The generator terminal voltage is 1 p.u. There is no generation at the load bus. The threshold p.u. current for operation of the distance relay for a solid three phase-to-ground fault on the transmission line is closest to:
A. 6.25
B. 3.61
C. 1.00
D. 5.00

Ans. A


Sol.
$I_{f}=\frac{V}{0.8 \times \text { line }}=\frac{1}{0.8 \times 0.2}=\frac{1}{0.16}=6.25$
62. A $400 \mathrm{~V}, 50 \mathrm{KVA}$, delta connected synchronous motor with synchronous reactance of 3 $\Omega$ is supplying a 12 kW load with initial power factor of 0.86 lagging. The windage and frictional losses are 2 kW and core losses are 1.5 kW . Now if flux is increased by $30 \%$, the excitation voltage will become $\qquad$ volt.

Ans. range [490 to 494]
Sol. Power input $=$ Power output + Mechanical losses + Core losses
$=12+2+1.5+0$
$=15.5 \mathrm{~kW}$
input power $\mathrm{P}_{\text {in }}=3 \mathrm{~V}_{\mathrm{p}} \mathrm{I}_{\mathrm{p}} \cos \phi$
$I_{P}=\frac{15.5 \times 10^{3}}{3 \times 400 \times 0.86}=15 \mathrm{~A}$
Excitation emf per phase $E_{1}=V_{p}-j \times I_{p}$
$=400 \angle 0^{\circ}-j 3 \times 15 \angle-\cos ^{-1} 0.86$
$=379 \angle-5.86^{\circ}$ volt
Now, flux is increased by $30 \%$,
Since E $\alpha \phi$

So emf also increases by $30 \%$.
$E_{2}=1.3 \times E_{1}=1.3 \times 379=492.7 \mathrm{~V}$
63. Consider the two continuous-time signals defined below:
$x_{1}(t)=\left\{\begin{array}{l}|t|,-1 \leq t \leq 1 \\ 0, \text { otherwise }\end{array}\right.$
$x_{2}(t)=\left\{\begin{array}{c}1-|t|,-1 \leq t \leq 1 \\ 0, \text { otherwise }\end{array}\right.$
These signals are sampled with a sampling period of $T=0.25$ seconds to obtain discretetime signals $x_{1}[n]$ and $x_{2}[n]$, respectively. Which one of the following statements is true?
A. The energy of $x_{1}[n]$ is greater than the energy of $x_{2}[n]$.
B. The energy of $x_{2}[n]$ is greater than the energy of $x_{1}[n]$.
C. $x_{1}[n]$ and $x_{2}[n]$ have equal energies.
D. Neither $\mathrm{x}_{1}[\mathrm{n}]$ nor $\mathrm{x}_{2}[\mathrm{n}]$ is a finite energy signal.

Ans. A
Sol. $x_{1}(t)=\left\{\begin{array}{cc}|t|, & -1 \leq t \leq 1 \\ 0, & \text { otherwise }\end{array}\right.$

$\mathrm{T}_{\mathrm{s}}=$ sampling time-period
$=0.25 \mathrm{sec}$
$x_{1}(n)=\{1,0.75,0.5,0.25,0,0.25,0.5,0.75,1\}$


Now, $x_{2}(t)=\left\{\begin{array}{cc}1-|t|, & -1 \leq t \leq 1 \\ 0, & \text { otherwise }\end{array}\right.$


Since, $x_{1}(n)$ is having one more non-zero sample of amplitude ' 1 ' as compared to $x_{2}(n)$.
Therefore, energy of $x_{1}(n)$ is greater than energy of $x_{2}(n)$.
64. The Boolean function $(A+B)(A+C)$ is a reduced form of
A. $A+B C$
B. $(A+B) \cdot(B+C)$
C. $\bar{A} B+A \bar{B} C$
D. $(A+C) \cdot B$

Ans. A
Sol. $(A+B)(A+C)=A+A C+A B+B C=A+B C$
65. To increase attraction capacity of electromagnet
A. Core length should increase
B. Core area should increase
C. Flux density should decreases
D. Flux density should increases

Ans. D
Sol. Attraction capacity depends on current, No. of turns and permeability.
So, to increase attraction capacity of electromagnet flux density should increase.
66. Which of the following material is used for making core for high-speed reading and storing of information in computer?
A. Ferrite
B. Piezoelectric
C. Pyroelectric
D. Ferromagnetic above $768^{\circ} \mathrm{C}$

Ans. A
Sol. Ferrites are used for making core for high-speed reading and storing of information in computer.
67. A capacitive voltage divider is used to measure the bus voltage $\mathrm{V}_{\text {bus }}$ in a high-voltage 50 Hz AC system as shown in the figure. The measurement capacitors $\mathrm{C}_{1}$ and $\mathrm{C}_{2}$ have tolerances of $\pm 10 \%$ on their nominal capacitance values. If the bus voltage $V_{\text {bus }}$ is 100 kV rms, the maximum rms output voltage $\mathrm{V}_{\text {out }}$ (in kV ), considering the capacitor tolerances, is $\qquad$ .


Ans. range [1.90 to 12.00]

Sol.

$V_{\text {bus }}$ is $100 \mathrm{kV}_{\text {rms }}$
$C_{2}=9 \mu \mathrm{~F} \pm 10 \%$
To get maximum output voltage we need minimum $\mathrm{C}_{2}$ and maximum $\mathrm{C}_{1}$.
So, $\mathrm{C}_{2}=8.1 \mu \mathrm{~F}$ and $\mathrm{C}_{1}=1.1 \mu \mathrm{~F}$
So, $V_{\text {out rms }}=\left(\frac{C_{1}}{C_{1}+C_{2}}\right) V_{\text {Bus }_{\text {rms }}}$
$V_{\text {out }}($ rms $)=11.95 \mathrm{kV}$.
68. The volume of cylinder between $r=2 \mathrm{~m}$ and $\mathrm{r}=4 \mathrm{~m}$ contains charge having a uniform charge density $\rho\left(c / m^{3}\right)$. The electric charge density in region between $2 m \leq r \leq 4 m$ is
A. $\frac{\rho}{r} \hat{a}_{r}\left(c / m^{2}\right)$
B. $\frac{6 \rho}{r} \hat{a}_{r}\left(c / m^{2}\right)$
C. $\frac{\rho}{2 r}\left(r^{2}-4\right) \hat{a}_{r}\left(c / m^{2}\right)$
D. $\frac{\rho}{r}\left(r^{2}-4\right) \hat{a}_{r}\left(c / m^{2}\right)$

Ans. C
Sol. According to Gauss's law
$\int D \cdot d s=Q=\int \rho \cdot d v$
$D \times 2 \pi r L=\rho \pi\left(r^{2}-2^{2}\right) L$
$D=\frac{\rho}{2 r}\left(r^{2}-4\right) \hat{a}_{\mathrm{r}}\left(C / m^{2}\right)$
69. A free response LTI system is represented by:
$\left[\begin{array}{l}\dot{x}_{1} \\ \dot{x}_{2}\end{array}\right]=\left[\begin{array}{cc}-1 & 0 \\ 0 & -2\end{array}\right]\left[\begin{array}{l}x_{1} \\ x_{2}\end{array}\right]$
Initial conditions are $x_{1}(0)=1$ and $x_{2}(0)=-1$. Then solution of state equation is
A. $x_{1}(t)=-e^{-t}, x_{2}(t)-2 e^{-t}$
B. $x_{1}(t)=e^{-t}, x_{2}(t)-2 e^{-2 t}$
C. $x_{1}(t)=-1, x_{2}(t)=2$
D. $x_{1}(t)=-e^{-t}, x_{2}(t) 2 e^{-t}$

Ans. B
Sol. Free response means zero input or unforced response.
So, $x(t)=\phi(t) \cdot x(0)$
$\phi(\mathrm{t}) \rightarrow$ state transition matrix $=\mathrm{L}^{-1}\left[(\mathrm{SI}-\mathrm{A})^{-1}\right]$
$S I-A=\left[\begin{array}{cc}s+1 & 0 \\ 0 & s+2\end{array}\right]$
$(s I-A)^{-1}=\frac{1}{(s+1)(s+2)}\left[\begin{array}{cc}s+2 & 0 \\ 0 & s+1\end{array}\right]=\left[\begin{array}{cc}\frac{1}{s+1} & 0 \\ 0 & \frac{1}{s+2}\end{array}\right]$
$\therefore \phi(\mathrm{t})=\left[\begin{array}{cc}\mathrm{e}^{-\mathrm{t}} & 0 \\ 0 & \mathrm{e}^{-2 \mathrm{t}}\end{array}\right]$
$x(t)=\left[\begin{array}{cc}e^{-t} & 0 \\ 0 & e^{-2 t}\end{array}\right]\left[\begin{array}{l}1 \\ -1\end{array}\right] \therefore\left[\begin{array}{l}x_{1} \\ x_{2}\end{array}\right]=\left[\begin{array}{l}1 \\ -1\end{array}\right]$
$x(t)=\left[\begin{array}{l}e^{-t} \\ -e^{-2 t}\end{array}\right]$
$\therefore \mathrm{x}_{1}(\mathrm{t})=\mathrm{e}^{-\mathrm{t}}, \mathrm{x}_{2}(\mathrm{t})=-\mathrm{e}^{-2 \mathrm{t}}$
70. A full wave rectifier with an RL load where $L$ tends to infinite

Given firing angle $120^{\circ}$ then the output average voltage is $\qquad$ .
Source voltage is given as $V_{s}(\mathrm{t})=120 \pi \sin \omega \mathrm{t}$
A. -120 V
B. 120 V
C. 60 V
D. None

Ans. D
Sol. Load impedance angle $\theta_{z}=\tan ^{-1}\left(\frac{L}{R}\right)=\tan ^{-1}(\infty)=90^{\circ}$
Firing angle $\alpha=120^{\circ}$
$\alpha>\theta_{z} \Rightarrow$ Its discontinuous mode of conduction.
So, we can't find by given data.
We need extinction angle to find average output voltage.
71. Suppose $I_{A}, I_{B}$ and $I_{C}$ are a set of unbalanced current phasors in a three-phase system. The phase $B$ zero-sequence current $I_{B 0}=0.1 \angle 0^{\circ}$ p.u. If phase $A$ current $I_{A}=1.1 \angle 0^{\circ}$ p.u. and phase $C$ current $I_{C}=\left(1 \angle 120^{\circ}+0.1\right)$ p.u., then $I_{B}$ in p.u. is
A. $1 \angle-120^{\circ}+0.1 \angle 0^{\circ}$
B. $1.1 \angle 240^{\circ}-0.1 \angle 0^{\circ}$
C. $1.1 \angle-120^{\circ}+0.1 \angle 0^{\circ}$
D. $1 \angle 240^{\circ}-0.1 \angle 0^{\circ}$

Ans. A
Sol. Facilitate per phase analysis of a complex 3-phase unbalanced system.
Given,
$\mathrm{I}_{\mathrm{B} 0}=0.1 \angle 0^{\circ}$ p.u. $=0.1$
$\mathrm{I}_{\mathrm{A}}=1.1 \angle 0^{\circ}$ p.u. $=1.1$
$\mathrm{I}_{\mathrm{C}}=1 \angle 120^{\circ}+0.1$ p.u.
$\mathrm{I}_{\mathrm{B}}=$ ?

$$
\begin{aligned}
& {\left[\begin{array}{c}
\mathrm{I}_{\mathrm{A} 0} \\
\mathrm{I}_{\mathrm{A} 1} \\
\mathrm{I}_{\mathrm{A} 2}
\end{array}\right]=\frac{1}{3}\left[\begin{array}{ccc}
1 & 1 & 1 \\
1 & \alpha & \alpha^{2} \\
1 & \alpha^{2} & \alpha
\end{array}\right]\left[\begin{array}{l}
\mathrm{I}_{\mathrm{A}} \\
\mathrm{I}_{\mathrm{B}} \\
\mathrm{I}_{\mathrm{C}}
\end{array}\right]} \\
& \mathrm{I}_{\mathrm{BO}}=\mathrm{I}_{\mathrm{AO}}=\frac{1}{3}\left(\mathrm{I}_{\mathrm{A}}+\mathrm{I}_{\mathrm{B}}+\mathrm{I}_{\mathrm{C}}\right) \\
& \alpha=1 \angle 120^{\circ}, \alpha^{2}=1 \angle 240^{\circ} \\
& \mathrm{I}_{\mathrm{AO}}=\mathrm{I}_{\mathrm{CO}}(\text { Cophesal })
\end{aligned}
$$

$$
\begin{aligned}
& I_{B}=0.1+1 \angle 240^{\circ} \text { p.u. } \\
& I_{B 0}=\frac{1}{3}\left(I_{A}+I_{B}+I_{C}\right) \\
& I_{B}=3 I_{B 0}-I_{A}-I_{C}=3 \times 0.1-1.1-1 \angle 120^{\circ}-0.1=0.3-1.1-0.1-1 \angle 120^{\circ} \\
& =-0.9-1 \angle 120^{\circ}=-0.9-\left(-\frac{1}{2}+j \frac{\sqrt{3}}{2}\right) \\
& I_{B}=-0.9+0.5-j \frac{\sqrt{3}}{2} \\
& =-0.4-j \frac{\sqrt{3}}{2}=0.4+0.5+\left[-\frac{1}{2}-j \frac{\sqrt{3}}{2}\right]=0.1+1 \angle 240^{\circ} \text { or } 0.1+1 \angle-120^{\circ}
\end{aligned}
$$

72. Find the sum of rms value of $i_{1}$ and rms value of $i_{3}$ in $\qquad$ amp in the below circuit.


Ans. range [66.5 to 67.5]

$\mathrm{i}_{1}=3 \mathrm{i}_{\mathrm{A}}$
$\mathrm{i}_{2}=3 \mathrm{ic}$
$\mathrm{i}_{3}=\mathrm{i}_{1}-\mathrm{i}_{2}=3\left[\mathrm{i}_{\mathrm{A}}-\mathrm{i}_{\mathrm{C}}\right]$
$\left(\mathrm{i}_{1}\right)_{\mathrm{rms}}^{2}=30^{2} \times \frac{120^{\circ}}{180^{\circ}} \Rightarrow\left(\mathrm{i}_{1}\right)_{\mathrm{rms}}=30 \sqrt{\frac{2}{3}}=24.49 \mathrm{Amp}$

$\left(\mathrm{i}_{3}\right)_{\mathrm{rms}}^{2}=30^{2} \times \frac{120}{180}+60^{2} \times \frac{60}{180}$
$=30^{2} \times \frac{2}{3}+60^{2} \times \frac{1}{3}$
$\left(\mathrm{i}_{3}\right)_{\mathrm{rms}}=\sqrt{1800}=42.426 \mathrm{Amp}$
$\mathrm{i}_{1, \mathrm{rms}}+\mathrm{i}_{3, \mathrm{rms}}=66.92 \mathrm{Amp}$
73. A thin soap bubble of radius $R=1 \mathrm{~cm}$ and thickness $\mathrm{a}=3.3 \mu \mathrm{~m}(\mathrm{a} \ll \mathrm{R})$ is at a potential of 1 V with respect to a reference point at infinity. The bubble bursts and becomes a single spherical drop of soap (assuming all the soap is contained in the drop) of radius $r$. The volume of the soap in the thin bubble is $4 \pi R^{2}$ a and that of the drop is $\frac{4}{3} \pi r^{3}$. The potential in volts, of the resulting single spherical drop with respect to the same reference point at infinity is $\qquad$ . (Give the answer up to two decimal places.)


Soap drop of radius 'r'

Ans. range [10 to 10.20]
Sol. Charge must be same
$\left(4 \pi R^{2} a\right) P_{v}=\left(\frac{4}{3} \pi r^{3}\right) P_{v}$
$r=\sqrt[3]{3 R^{2} a}$
$0.996 \times 10^{-3}$
The potential of thin bubble is 1 V
$1=\frac{Q}{4 \pi \mathrm{E}_{0} \times 1 \times 10^{-2}}$
$\mathrm{Q}=4 \pi \varepsilon_{0} \times 1 \times 10^{-2} \mathrm{C}$
Potential of soap drop
$V=\frac{Q}{4 \pi \varepsilon_{0} r}$
$=\frac{4 \pi \varepsilon_{0} \times 10^{-2}}{4 \pi \varepsilon_{0} \times 0.9966 \times 10^{-3}}$
$=10.03 \mathrm{~V}$
74. A belt-driven DC shunt generator running at 300 RPM delivers 100 kW to a 200 V DC grid. It continues to run as a motor when the belt breaks, taking 10 kW from the DC grid. The armature resistance is $0.025 \Omega$, field resistance is $50 \Omega$, and brush drop is 2 V . Ignoring armature reaction, the speed of the motor is $\qquad$ RPM. (Round off to 2 decimal places.)
Ans. 275.18
Sol. $\mathrm{P}_{0}=100 \times 10^{3}$
$\mathrm{I}_{\mathrm{L}}=\frac{100 \times 10^{3}}{200}$
$\mathrm{IL}=500 \mathrm{~A}$
$\rightarrow I_{\text {sh }}=\frac{200}{50}=4 \mathrm{~A}$
$\mathrm{I}_{\mathrm{a}}=500+4=504 \mathrm{~A}$
By KVL
$E_{g}-I_{a} R_{a}-V_{B}=V_{\text {Bus }}$
$E_{g}-V_{B u s}+I_{a} R_{a}+B . D$.
$=200+504 \times 0.025+2$
$\mathrm{E}_{\mathrm{g}}=214.6 \mathrm{~V}$


The machine starts consuming 10 kW Power due to absence of mechanical input.

$P=10 \times 10^{3}$
$\mathrm{I}_{\mathrm{L}}=\frac{10 \times 10^{3}}{200}=50 \mathrm{~A}$
$\rightarrow I_{\text {sh }}=\frac{200}{50}=4 \mathrm{~A}$
$\mathrm{I}_{\mathrm{a}}=\mathrm{I}_{\mathrm{L}}-\mathrm{I}_{\text {sh }}=50-4=46 \mathrm{~A}$
By KVL
$V-I_{a} R_{a}-B . D=E_{b}$
$200-46 \times 0.025-2=E_{b}$
$\mathrm{E}_{\mathrm{m}}=\mathrm{E}_{\mathrm{b}}=196.85$ Volts
$N \propto \frac{E_{b}}{\phi}$
' $\phi$ ' is constant since current through shunt field winding is constant.
$\therefore \frac{N_{m}}{N_{g}}=\frac{E_{m}}{E_{g}}$
$\mathrm{N}_{\mathrm{m}}=\frac{196.85}{214.6} \times 300$
$\mathrm{N}_{\mathrm{m}}=275.18 \mathrm{rpm}$
75. A $500 / 5 \mathrm{~A}, 50 \mathrm{~Hz}$ current transformer has a bar primary. The secondary burden is pure resistance of $1 \Omega$ and it draws a current of 5A, if magnetic core requires 250 AT for magnetisation, the percentage of ratio error is?
Ans. range [10.2 to 10.8]
Sol. Nominal ratio $=\frac{\text { Primary current }}{\text { Secondary current }}=\frac{500}{5}=100$
Primary turns $=1$, Magnetizing current $=250 \mathrm{~A}$
Primary current $=\sqrt{500^{2}+250^{2}}=559.016 \mathrm{~A}$
Actual ratio $=\frac{\text { Primary current }}{\text { Secondary current }}=\frac{559.016}{5}=111.8$
Percentage error $=\frac{\text { Nominal ratio }- \text { Actual ratio }}{\text { Actual ratio }} \times 100$
$=\frac{100-111.8}{111.8} \times 100 \%=-10.5 \%$
76. The closed loop line integral

$$
\oint_{|z|=5} \frac{z^{3}+z^{2}+8}{z+2} d z
$$

Evaluated counter-clockwise, is
A. $+4 \mathrm{j} \pi$
B. $-4 \mathrm{j} п$
C. $+8 \mathrm{j} \pi$
D. $-8 \mathrm{j} п$

Ans. C
Sol. $\oint_{|z|=5} \frac{z^{3}+z^{2}+8}{z+2} d z=2 \pi j$ (sum of residues)

$$
\begin{aligned}
& =2 \pi j \times\left[\lim _{z \rightarrow 2}(z+2) \frac{\left(z^{3}+z^{2}+8\right)}{z+2}\right] \\
& =2 \pi j\left[\frac{-8+4+8}{1}\right]=8 \pi j
\end{aligned}
$$

77. Two buses i and j are connected with a transmission line of admittance $=\mathrm{Y}$, at the two ends of which there are ideal transformers with turns ratios as shown. Bus admittance matrix for the system is

A. $\left[\begin{array}{cc}t_{i}^{2} Y & -t_{i} t_{j} Y \\ -t_{i} t_{j} Y & t_{j}^{2} Y\end{array}\right]$
B. $\left[\begin{array}{cc}t_{i} t_{j} Y & -t_{j}^{2} Y \\ -t_{i}^{2} Y & t_{i} t_{j} Y\end{array}\right]$
C. $\left[\begin{array}{cc}-t_{i} t_{j} Y & t_{j}^{2} Y \\ t_{i}^{2} Y & -t_{i} t_{j} Y\end{array}\right]$
D. $\left[\begin{array}{cc}t_{i} t_{j} Y & -\left(t_{i}-t_{j}\right)^{2} Y \\ -\left(t_{i}-t_{j}\right)^{2} Y & t_{i} t_{j} Y\end{array}\right]$

Ans. A
Sol. Let current $\mathrm{I}_{\mathrm{i}}$

$$
\begin{aligned}
& \mathrm{V}_{1}=\mathrm{V}_{\mathrm{i}} \mathrm{t}_{\mathrm{i}} \text { and } \mathrm{V}_{2}=\mathrm{V}_{\mathrm{j}} \mathrm{t}_{\mathrm{j}} \\
& \mathrm{I}_{1}=\frac{\mathrm{I}_{\mathrm{i}}}{\mathrm{t}_{\mathrm{i}}} \text { and } \mathrm{I}_{2}=\frac{\mathrm{I}_{\mathrm{j}}}{\mathrm{t}_{\mathrm{j}}}
\end{aligned}
$$


$\frac{I_{i}}{t_{i}}=\left(V_{i} t_{i}-V_{j} t_{j}\right) y \quad \Rightarrow I_{i}=V_{i} t_{i}^{2} \cdot y V_{j} t_{j} \cdot y \cdot t_{j}$
Similarly
$\frac{I_{i}}{t_{i}}=\left(V_{i} t_{i}-V_{j} t_{j}\right) y$
$I_{j}=-V_{i} t_{i} t_{j} y+V_{j} t_{j}^{2} \cdot y$
$\therefore \quad[\mathrm{Y}]=\left[\begin{array}{cc}\mathrm{yt}_{\mathrm{i}}^{2} & -\mathrm{yt}_{\mathrm{i}} \mathrm{t}_{\mathrm{j}} \\ -\mathrm{y} \mathrm{t}_{\mathrm{i}} \mathrm{t}_{\mathrm{j}} & \mathrm{yt}_{\mathrm{j}}^{2}\end{array}\right]$
78. Match the following:

| Type of meter |  | Deflection torque |  |
| :--- | :--- | :--- | :--- |
| 1. | EMMC | a. | $\mathrm{I} \times \mathrm{N} \times \mathrm{A} \times \mathrm{B}$ |
| 2. | PMMC | b. | $\mathrm{I}^{2} \times \frac{\mathrm{dM}}{\mathrm{d} \theta}$ |
| 3. | Moving iron | c. | $\frac{1}{2} \mathrm{I}^{2} \frac{\mathrm{dL}}{\mathrm{d} \theta}$ |

A. 1-a, 2-b, 3-c
B. 1-b, 2-c, 3-a
C. 1-a, 2-c, 3-b
D. 1-b, 2-a, 3-c

Ans. D
Sol. $\rightarrow$ EMMC torque expression is given as $I^{2} \times \frac{d M}{d \theta} N-m$
$\rightarrow$ PMMC torque expression is given as INAB $\mathrm{N}-\mathrm{m}$
$\rightarrow$ M.I. torque expression is given as $\frac{1}{2} \mathrm{I}^{2} \frac{\mathrm{dL}}{\mathrm{d} \theta} \mathrm{N}-\mathrm{m}$
79. The steady state output ( $\mathrm{V}_{\text {out }}$ ), of the circuit shown below, will

A. saturate to $+V_{D D}$
B. saturate to $-\mathrm{V}_{\mathrm{EE}}$
C. become equal to 0.1 V
D. become equal to -0.1 V

Ans. B

Sol. Under steady state capacitor acts as open circuit for DC supply.


Op-amp will work as a comparator.
$\mathrm{V}^{-}=0.1 \mathrm{~V}^{2} \mathrm{~V}^{+}=0 \mathrm{~V}$
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}^{+}-\mathrm{V}^{-}=0-0.1=-0.1 \mathrm{~V}$
Op-amp will be in saturation mode, as inverting terminal is greater than the noninverting terminal, hence it will saturates at $-\mathrm{V}_{\mathrm{EE}}$.
Therefore, $\mathrm{V}_{\text {out }}=-\mathrm{V}_{\mathrm{EE}}$
Hence, option $B$ is correct.
80. Statement (I): Negative feedback reduces the gain of the amplifier. But it increases the bandwidth.

Statement (II): Negative feedback increases the output impedance and decreases the input impedance also it makes system less stable.
A. Both statements are true, but statement II is correct explanation of statement I.
B. Both statements are true, but statement II is not correct explanation of statement I.
C. Statement I is true \& statement II is false.
D. Statement II is true \& statement I is false.

Ans. C
Sol. Negative feedback reduces the gain of the amplifier. But it increases the bandwidth, and it makes system more stable.

So, option C is correct.
81. The power input to a $500 \mathrm{~V}, 50 \mathrm{~Hz}$, 6-pole, 3-phase induction motor running at 975 RPM is 40 kW . The total stator losses are 1 kW . If the total friction and windage losses are 2.025 kW , then the efficiency is $\qquad$ \%.

Ans. 90
Sol. $s=\frac{N_{s}-N_{r}}{N_{s}}=\frac{1000-975}{1000}$
$s=0.025$
$\mathrm{P}_{\mathrm{gm}}=(1-\mathrm{s}) \mathrm{p}_{\mathrm{i}}=(1-0.025)\left(\mathrm{P}_{\mathrm{in}}-\right.$ stator loss $)$
$=(0.975)(40-1)$
$\mathrm{P}_{\mathrm{gm}}=38.025 \mathrm{~kW}$

82. Find the highest speed (in rpm) attained by the two different coupled alternators which are running at two different frequencies of 21 Hz and 45 Hz respectively.

Ans. 180
Sol. Both the alternators are coupled, and it should be run at same speed.


As, $\mathrm{N}_{1}=\mathrm{N}_{2}$
$\frac{f_{1}}{P_{1}}=\frac{f_{2}}{P_{2}}$
$\frac{21}{P_{1}}=\frac{45}{P_{2}}$
$\frac{P_{2}}{P_{1}}=\frac{45}{21}=\frac{15}{7}$
Poles should be in pair form:
$\frac{P_{2}}{P_{1}}=\frac{15}{7} \times \frac{2}{2}=\frac{30}{14}$
$P_{2}=30 ; P_{1}=14$
For attaining highest speed $\mathrm{P}=14$.
$\mathrm{N}=\frac{120 \times 21}{14}$
$\mathrm{N}=180 \mathrm{rpm}$
83. A centre-zero ammeter connected in the rotor circuit of a 4 pole 50 Hz SRIM makes 45 complete oscillations in one minute. The speed of rotor field with respect to rotor is
$\qquad$ . (in rpm)

Ans. range [22 to 23]
Sol. $\mathrm{f}_{2}=\frac{\text { Number of oscillations } / \mathrm{min}}{60}$
$=\frac{45}{60}$
$=0.75$
$\mathrm{f}_{2}=\mathrm{sf}$
$s=\frac{0.75}{50}=0.015$
$\mathrm{N}_{\mathrm{s}}=\frac{120 \times 50}{4}$
$\mathrm{N}_{\mathrm{s}}=1500 \mathrm{RPM}$
Rotor speed $=N_{r}=N_{s}(1-s)=1500(1-0.015)$
$\mathrm{N}_{\mathrm{r}}=1477.5 \mathrm{RPM}$
Speed of stator field with respect to rotor, $\mathrm{sN}_{\mathrm{s}}$
$s N_{s}=0.015 \times 1500$
$=22.5 \mathrm{RPM}$
84. The circuit shown below is functionally equivalent to

A. NOR gate
B. OR gate
C. Ex-OR gate
D. NAND gate

Ans. C


Sol.

$$
F=\overline{\overline{\bar{A} B} \cdot \overline{\bar{A} \bar{B}}}=\overline{\overline{\bar{A} B}}+\overline{\overline{A \bar{B}}}=\overline{\bar{A}} B+A \bar{B} \quad \text { (XOR gate })
$$

85. Match the following:

## Instrument Type:

P. Permanent magnet moving coil
Q. Moving iron connected through current transformer
R. Rectifier
S. Electrodynamometer

## Used for:

1) DC Only
2) AC Only
3) AC and DC
A. P-1; Q-2; R-1; S-3;
B. P-1; Q-3; R-1; S-2;
C. P-1; Q-2; R-3; S-3;
D. P-3; Q-1; R-2; S-1;

Ans. C
Sol. Permanent magnet moving coil - DC Only
Moving iron connected through current transformer - AC Only
Rectifier and Electrodynamometer - AC and DC
86. A single-phase inverter is fed from a 100 V dc source and is controlled using a quasisquare wave modulation scheme to produce an output waveform, $\mathrm{v}(\mathrm{t})$, as shown. The angle $\sigma$ is adjusted to entirely eliminate the $3^{\text {rd }}$ harmonic component from the output voltage. Under this condition, for $v(t)$, the magnitude of the $5^{\text {th }}$ harmonic component as a percentage of the magnitude of the fundamental component is $\qquad$ (rounded off to 2 decimal places).


Ans. range [19.9 to 20.2]
Sol. We know that output waveform can be expressed in Fourier series form
From the given wave form,
$V_{o n}(t)=\sum_{n=1,3,5}^{\infty} \frac{4 V_{s}}{n \pi} \sin \left(\frac{n \pi}{2}\right) \sin n d \sin n \omega t$
п- $26=2 d$
$d=\frac{\pi}{2}-6$
for eliminating $3^{\text {rd }}$ harmonics
$\frac{4 V_{s}}{3 \pi} \sin \left(\frac{3 \pi}{2}\right) \sin 3 d=0$
$\sin 3 d=0$
$3 \mathrm{~d}=\pi \quad \Rightarrow \mathrm{d}=\frac{\pi}{3}$
$\left|\frac{\mathrm{V}_{05}}{\mathrm{~V}_{01}}\right|=\left|\frac{\frac{4 \mathrm{~V}_{5}}{5 \pi} \sin \left(\frac{5 \pi}{2}\right) \sin 5 \mathrm{~d}}{\frac{4 \mathrm{~V}_{\mathrm{s}}}{\pi} \sin \left(\frac{\pi}{2}\right) \sin \mathrm{d}}\right|$
$=\frac{1}{5} \times 100 \%=20 \%$
87. The asymptotic Bode magnitude plot of a minimum phase transfer function $\mathrm{G}(\mathrm{s})$ is shown below.


Consider the following two statements.
Statement I: Transfer function $\mathrm{G}(\mathrm{s})$ has three poles and one zero.
Statement II: At very high frequency $(\omega \rightarrow \infty)$, the phase angle $\angle \mathrm{G}(\mathrm{j} \omega)=-\frac{3 \pi}{2}$.
Which one of the following options is correct?
A. Both the statements are true.
B. Both the statements are false.
C. Statement I is false and statement II is true.
D. Statement I is true and statement II is false.

Ans. C
Sol. From the given Bode plot,
$\mathrm{T}(\mathrm{S})=$ Transfer function $=\frac{\mathrm{K}}{\mathrm{s}\left(1+\frac{\mathrm{s}}{1}\right)\left(1+\frac{\mathrm{s}}{20}\right)}$
It has three poles and no zero
So, statement 1 is false
$\angle \mathrm{T}(\mathrm{s})=-90-\tan ^{-1} \mathrm{w}-\tan ^{-1} \frac{\mathrm{w}}{20}$
$\angle \mathrm{T}(\mathrm{jw}) \mid \mathrm{w} \rightarrow \infty=-270^{\circ}$
So, statement 2 is true
88. There are two kind of electrical networks are shown in the figure below. Which of the following relation is true for the given circuit?

A. $R A=R B$
B. $R A=R B=0$
C. $R A<R B$
D. $R A>R B$

Ans. C

Sol.

$\Rightarrow \mathrm{R}_{\mathrm{A}}=\frac{1 \times \mathrm{R}_{\mathrm{B}}}{1+\mathrm{R}_{\mathrm{B}}}$
$R_{A}=\frac{R_{B}}{1+R_{B}}$
$\therefore \mathrm{R}_{\mathrm{A}}<\mathrm{R}_{\mathrm{B}}$
89. A 3 -phase balanced load which has a power factor of 0.707 is connected to a balanced supply. The power consumed by the load is 5 kW . The power is measured by the twowattmeter method. The reading of the two wattmeters are
A. 3.94 kW and 1.06 kW
B. 2.50 kW and 2.50 kW
C. 5.00 kW and 0.00 kW
D. 2.96 kW and 2.04 kW

Ans. A
Sol. p.f. $=0.707, \phi=\cos ^{-1}(0.707)=45^{\circ}$
$\mathrm{P}=5 \mathrm{~kW}$
$W_{1}+W_{2}=5$

$$
\begin{equation*}
\tan \phi=\frac{\sqrt{3}\left(W_{1}-W_{2}\right)}{\left(W_{1}+W_{2}\right)} \tag{i}
\end{equation*}
$$

$\left(W_{1}+W_{2}\right) \times 1=\sqrt{3}\left(W_{1}-W_{2}\right)$
$W_{1}-W_{2}=\frac{5}{\sqrt{3}}$
From equation (i) and (ii)
$\mathrm{W}_{1}=3.94 \mathrm{~kW}$
$\mathrm{W}_{2}=1.06 \mathrm{~kW}$
90. A single-phase full-bridge inverter fed by a 325 V DC produces a symmetric quasi-square waveform across 'ab' as shown. To achieve a modulation index of 0.8 , the angle $\theta$ expressed in degrees should be $\qquad$ (Round off to 2 decimal places.) (Modulation index is defined as the ratio of the peak of the fundamental component of $\mathrm{V}_{\mathrm{ab}}$ to the applied DC value.)



Ans. 51.06
Sol. Supply voltage $=325 \mathrm{~V}$

Amplitude of fundamental component of output voltage can be expressed as:
$\mathrm{V}_{01}=\mathrm{m}_{\mathrm{A}} \times \mathrm{V}_{\mathrm{s}}=0.8 \times 325=260 \mathrm{~V}$
From the given waveform,


Pulse width of output voltage, $2 \mathrm{~d}=\pi-\phi \quad \Rightarrow \mathrm{d}=\frac{\pi}{2}-\phi$
Fourier series expansion of square wave will be:
$V_{0}=\sum_{n=1,3,5}^{\infty} \frac{4 V_{s}}{n \pi} \sin n d \sin n \omega t$
Fundamental voltage, $\mathrm{V}_{01}=\frac{4 \mathrm{~V}_{\mathrm{s}}}{\pi} \sin \mathrm{d}$
$V_{01}=\frac{4 V_{s}}{\pi} \sin \left(\frac{\pi}{2}-\theta\right)=\frac{4 V_{s}}{\pi} \cos \theta$
Equating equation (1) and (2),
$\frac{4 \times 325}{\pi} \cos \theta=260 \Rightarrow \cos \theta=0.628$
$\theta=51.073^{\circ}$
91. Consider the following gate network:


Which one of the following gate is redundant?
A. Gate 1
B. Gate 2
C. Gate 3
D. Gate 4

Ans. B
Sol. $F=\bar{w}+\bar{w} z+\bar{Z} x y$

$$
=\bar{w}(z+1)+\bar{z} x y
$$

$=\overline{\mathbf{w}}+\overline{\mathbf{z}} \mathrm{xy}$
So, gate 2 is redundant
92. A continuous-time input signal $x(t)$ is an eigen function of an LTI system, if the output is
A. $k x(t)$, where is an eigenvalue.
B. $k e^{j \omega j} x(t)$, where is an eigenvalue and is a complex exponential signal.
C. $x(t) e^{j \omega t}$, where $\mathrm{e}^{\mathrm{j} \omega t}$ is a complex exponential signal.
D. $\mathrm{kH}(\omega)$, where k is an eigenvalue and $\mathrm{H}(\omega)$ is a frequency response of the system.

Ans. A
Sol. If the output signal is a scalar multiple of input signal, the signal is refereed as an eigen function (or characteristic function) and the multiplier is referred as an eigen value (or characteristic value).
If $x(t)$ is the eigen function and $k$ is the eigen value, then output, $y(t)=k x(t)$.
Hence, the correct option is (A).
93. Consider a permanent magnet dc (PMDC) motor which is initially at rest. At $t=0$, a dc voltage of 5 V is applied to the motor. Its speed monotonically increases from $0 \mathrm{rad} / \mathrm{s}$ to $6.32 \mathrm{rad} / \mathrm{s}$ in 0.5 sec and finally settles to $10 \mathrm{rad} / \mathrm{sec}$. Assuming that the armature inductance of the motor is negligible, the transfer function for the motor is
A. $\frac{2}{0.5 s+1}$
B. $\frac{10}{s+0.5}$
C. $\frac{2}{s+0.5}$
D. $\frac{10}{0.5 s+1}$

Ans. A
Sol. $\mathrm{T}(\mathrm{s})=\frac{\mathrm{K}}{(\tau \mathrm{S}+1)}$

$$
r(t)=5 u(t)
$$

$R(s)=\frac{5}{s}$
$\mathrm{C}(\mathrm{s})=\mathrm{T}(\mathrm{s}) \cdot \mathrm{R}(\mathrm{s})=\frac{\mathrm{K}}{(\tau \mathrm{S}+1)} \times \frac{5}{\mathrm{~s}}$
$C(\infty)=\lim _{s \rightarrow 0} s C(s)=\lim _{s \rightarrow 0} s \frac{5 K}{s(\tau s+1)}$
$=5 \mathrm{~K}$
According to question
$C(\infty)=10$
$5 K=10 \Rightarrow K=2$


Time constant
$\tau=0.5$
$\mathrm{T}(\mathrm{s})=\frac{\mathrm{K}}{(\mathrm{Ts}+1)}$
$=\frac{2}{(0.5 s+1)}$
94. The transfer function of a phase lead compensator is given by $D(s)=\frac{3\left(s+\frac{1}{3 T}\right)}{\left(s+\frac{1}{T}\right)}$

The frequency (in rad/sec), at which $\angle \mathrm{D}(\mathrm{j} \omega$ ) is maximum, is
A. $\sqrt{3 T}$
B. $\sqrt{3 \mathrm{~T}^{2}}$
C. $\sqrt{\frac{1}{3 \mathrm{~T}^{2}}}$
D. $\sqrt{\frac{1}{\mathrm{~T}^{2}}}$

Ans. C
Sol. T (s) $=\frac{1+3 \mathrm{TS}}{1+\mathrm{TS}}$
Frequency at which $\angle \mathrm{T}(\mathrm{j} \omega$ ) is maximum (i)

$$
\omega_{\mathrm{m}}=\frac{1}{\mathrm{~T} \sqrt{\alpha}}
$$

$\mathrm{T}(\mathrm{s})=\frac{1+\alpha \mathrm{TS}}{1+\mathrm{TS}}$ is The general phase lead compensator
$\therefore \mathrm{a}=3$
$\omega_{\mathrm{m}}=\frac{1}{\mathrm{~T} \sqrt{3}}=\frac{1}{\sqrt{3 \mathrm{~T}^{2}}}$
95. A separately excited d.c. motor runs at 1400 rpm under no load with 220 V supply. The voltage is maintained as constant at its rated value. The speed of the motor is 1200 rpm when it delivers a torque of 10 Nm . Find the armature resistance of the motor in $\Omega$. (Assume rotational losses and armature reaction are neglected).
A. 3.417
B. 4.714
C. 5.612
D. 2.232

Ans. B
Sol. At no load: $\mathrm{I}_{\mathrm{a}}=0 \mathrm{~A}$
$E=k f w \Rightarrow$ since $f$ is constant
$E=K^{\prime} N \Rightarrow \frac{E_{2}}{E_{1}}=\frac{N_{2}}{N_{1}}$
Case (i): No load
$\mathrm{E}_{1}=\mathrm{V}=220 \mathrm{~V}$
$\mathrm{N}_{1}=1400 \mathrm{rpm}$
$E_{1}=k \phi \omega=k \phi\left(\frac{2 \pi N_{1}}{60}\right)$
$220=k \phi\left(\frac{2 \pi \times 1400}{60}\right)$
$\mathrm{kf}=1.5$
Case (ii):
$\mathrm{N}_{2}=1200 \mathrm{rpm}, \mathrm{T}=10 \mathrm{Nm}$
$\mathrm{E}_{2}=\frac{\mathrm{N}_{2}}{\mathrm{~N}_{1}} \mathrm{E}_{1}$
$E_{2}=\frac{1200}{1400} \cdot 220$
$\mathrm{E}_{2}=188.571$ volts
$\mathrm{T}=\mathrm{kfI} \mathrm{a}$
$10=\mathrm{kfI}_{\mathrm{a}}$
$\mathrm{I}_{\mathrm{a}}=\frac{10}{\mathrm{k} \phi}$
$=\frac{10}{1.5}$
$\mathrm{I}_{\mathrm{a}}=6.667 \mathrm{~A}$
We know:
$\mathrm{V}=\mathrm{E}+\mathrm{I}_{\mathrm{a}} \mathrm{Ra}_{\mathrm{a}}$
$\mathrm{R}_{\mathrm{a}}=\frac{\mathrm{V}-\mathrm{E}}{\mathrm{I}_{\mathrm{a}}}=\frac{220-188.571}{6.667}=4.714 \Omega$
$\mathrm{Ra}_{\mathrm{a}}=4.714 \Omega$
96. The coils of a wattmeter have resistances $0.01 \Omega$ and $1000 \Omega$; their inductance may be neglected. The wattmeter is connected as shown in the figure, to measure the power consumed by a load, which draws 25 A at power factor 0.8 . The voltage across the load terminals is 30 V . The percentage error on the wattmeter reading is $\qquad$ .
Ans. 0.15
Sol. $\mathrm{P}_{\text {load }}=30 \times 25 \times 8=600 \mathrm{~W}$
Wattmeter measures loss in pressure coil circuit
Loss in $\mathrm{P}_{\mathrm{C}}=\frac{\mathrm{V}^{2}}{\mathrm{R}_{\mathrm{P}}}=\frac{30^{2}}{1000}=0.9 \mathrm{~W}$
Error $=\frac{0.9}{600} \times 100=0.15 \%$
97. Consider the boost converter shown. Switch Q is operating at 25 kHz with a duty cycle of 0.6 . Assume the diode and switch to be ideal. Under steady-state condition, the average resistance $R_{i n}$ as seen by the source is $\qquad$ $\Omega$. (Round off to 2 decimal places.)


Ans. 1.6
Sol. $\mathrm{V}_{0}=\frac{\mathrm{V}_{\mathrm{s}}}{1-\alpha}$

$$
V_{0}=(1-a) I_{s}
$$

$\mathrm{R}_{0}=\frac{\mathrm{R}_{\text {in }}}{(1-\alpha)^{2}}$
$\mathrm{R}_{\text {in }}=(1-\alpha)^{2} \mathrm{R}_{0}$
$R_{\text {in }}=(1-0.6)^{2} \times 10$
$=(1-0.6)^{2} \times 10$
$=1.6 \Omega$
98. What magnetic behaviour is observed in a type I super conductor?
A. perfect diamagnetism
B. perfect paramagnetism
C. perfect ferromagnetism
D. perfect ferrimagnetism

Ans. A
Sol. Perfect diamagnetism behaviour is observed in a type I super conductor.
99. Consider a power system consisting of N number of buses. Buses in this power system are categorized into slack bus, PV buses and PQ buses for load flow study. The number of PQ buses is NL. The balanced Newton-Raphson method is used to carry out load flow study in polar form. H, S, M, and R are sub-matrices of the Jacobian matrix J as shown below:
$\left[\begin{array}{c}\Delta \mathrm{P} \\ \Delta \mathrm{Q}\end{array}\right]=\mathrm{J}\left[\begin{array}{c}\Delta \delta \\ \Delta \mathrm{V}\end{array}\right]$; where $\mathrm{J}=\left[\begin{array}{ll}\mathrm{H} & \mathrm{S} \\ \mathrm{M} & \mathrm{R}\end{array}\right]$
The dimension of the sub-matrix $M$ is:
A. $(\mathrm{N}-1) \times(\mathrm{N}-1-\mathrm{NL})$
B. $\mathrm{N}\llcorner\times(\mathrm{N}-1)$
C. $N_{\llcorner } \times\left(N-1+N_{L}\right)$
D. $(N-1) \times(N-1+N L)$

Ans. B
Sol. $\left[\begin{array}{c}\Delta \mathrm{P} \\ \Delta \mathrm{Q}\end{array}\right]=\left[\begin{array}{ll}\mathrm{I} & \mathrm{m} \\ \mathrm{H} & \mathrm{S} \\ \mathrm{M} & \mathrm{R}\end{array}\right]\left[\begin{array}{l}\Delta \delta \\ \Delta|\mathrm{V}|\end{array}\right]$
$I \rightarrow$ Number of P specified
$\mathrm{m} \rightarrow$ Number of Q specified
$\mathrm{M}_{\mathrm{NL}} \times{ }_{\mathrm{i}}^{\left(\mathrm{N}_{\mathrm{i}}\right)}$
Total buses $=\mathrm{N}$
Slack bus = 1

Number of PQ buses $=N \mathrm{~L}$
Number PV buses $=N-\left(1+N_{L}\right)$
$\mathrm{I} \rightarrow$ Number of P specified $=\mathrm{N} / \mathrm{L}+\mathrm{N}-1-\mathrm{N} / \mathrm{L}$
$\mathrm{m} \rightarrow$ Number of Q specified $=\mathrm{N} \mathrm{L}$
size of $M=N_{L} \times(N-1)$
100. Consider a causal and stable LTI system with rational transfer function $\mathrm{H}(\mathrm{z})$. Whose corresponding impulse response begins at $n=0$. Furthermore, $H(1)=\frac{5}{4}$. The poles of $H(z)$ are $P_{k}=\frac{1}{\sqrt{2}} \exp \left(j \frac{(2 k-1) \pi}{4}\right)$ for $k=1,2,3,4$. The zeros of $H(z)$ are all at $z=0$. Let $g[n]=j^{n h} h[n]$. The value of $g[8]$ equals $\qquad$ -.
Ans. range [0.090 to 0.100]
Sol. The poles of $H(z)$ are $P_{k}=\frac{1}{\sqrt{2}} \exp \left(\frac{j(2 k-1) \pi}{4}\right) k=1,2,3,4$

$$
\begin{aligned}
& P_{1}=\frac{1}{\sqrt{2}} e^{\frac{j x}{4}}=\frac{1}{2}+\frac{j}{2}=\frac{1+j}{2} \\
& P_{2}=\frac{1}{\sqrt{2}} e^{\frac{j 3 \pi}{4}}=\frac{-1}{2}+\frac{j}{2} \\
& P_{3}=\frac{1}{\sqrt{2}} e^{\frac{j 5 \pi}{4}}=-\frac{1}{2}-\frac{j}{2} \\
& P_{3}=\frac{1}{\sqrt{2}} e^{\frac{j 7 \pi}{4}}=\frac{1}{2}-\frac{j}{2} \\
& H(z)=\frac{k z^{4}}{\left(z-P_{1}\right)\left(z-P_{2}\right)\left(z-P_{3}\right)\left(z-P_{4}\right)}=\frac{k z^{4}}{z^{4}+\frac{1}{4}}
\end{aligned}
$$

Given $H(1)=5 / 4$
$\frac{5}{4}=\frac{k}{5 / 4}$
$k=\frac{25}{16}$
$H(z)=\frac{\frac{25}{16} z^{4}}{z^{4}+\frac{1}{4}}$
Given $\mathrm{g}(\mathrm{x})=(\mathrm{j})^{4} \mathrm{n}(\mathrm{x})$
$G(t)=H(z / j)$

$$
\begin{aligned}
& G(z)=\frac{\frac{25}{16}\left(\frac{z}{j}\right)^{4}}{\left(\frac{z}{j}\right)^{4}+\frac{1}{4}}=\frac{\frac{25}{16} z^{4}}{z^{4}+\frac{1}{4}} \\
& G(z)=\frac{25}{16}-\frac{25}{64} z^{-4}+\frac{25}{256} z^{-8}+\ldots \\
& g(8)=\frac{25}{256}=0.097
\end{aligned}
$$

