ACE Engineering Academy

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Mock-D - Solutions

GATE-2020 General Aptitude (GA)

01. Ans: (B)

Sol: (so) is wrong because they mean the same.

02. Ans: (C) **03. Ans: (A)**

04. Ans: (D)

Sol: Capacity of the tank = (12×13.5)=162 litres

Capacity of each bucket = 9 litres.

Number of buckets needed = 162/9 =18

05. Ans: (D)

Sol: Volume of Cuboid = length × breadth × height

Number of cuboids

$$= \frac{(Volume\ of\ cuboids)\ formed\ from}{(Volume\ of\ cuboids)\ taken}$$

$$\frac{18\times15\times12}{5\times3\times2} = 108$$

06. Ans: (B)

Sol: **At the most case:** Let the numbers be {–45, 1, 1, 1, ……, 1}.

Average is 0. So, at the most 44 numbers may be > 0.

At the least case: Let the numbers be {45, –1, –1, –1, …., –1}.

Average is 0. So, at the least 1 number may be > 0.

07. Ans: (B)

Sol: Perimeter = Distance covered in 8 min. = $12000 \times \frac{8}{60}$ m = 1600 m.

Let length = $3x$ metres and breadth = $2x$ metres.

Then, $2(3x + 2x) = 1600$ or $x = 160$.

$\therefore$ Length = 480 m and Breadth = 320 m

$\therefore$ Area = (480 x 320) m^2 = 153600 m^2

08. Ans: B

Sol: Consider CP as 100%.

Loss 15% $\Rightarrow$ So, SP = 85%

Gain 15 % $\Rightarrow$ So, New SP = 115%

Given 115% – 85% = 30% = 450

$$\frac{100}{30}\times450 = 1500$$

09. Ans: (A)

Sol: GDP at the beginning of 2013 is equal to the GDP at the end of 2012

$\Rightarrow$ GDP growth rate in 2012 = 7%

GDP at the end of 2011 = GDP at the beginning of 2012 = \$1 trillion

$\therefore$ GDP at the beginning of 2013 =

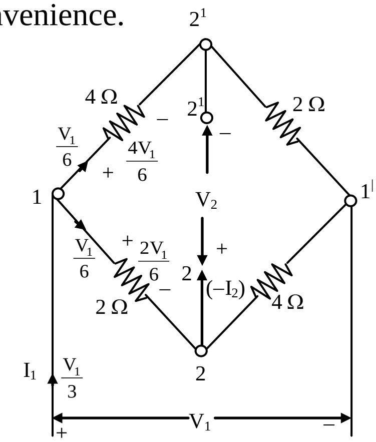
$$\frac{100+7}{100}\times 1\ trillion = \frac{107}{100} = \$1.07\ trillion$$

10. Ans: (A)

Specialization (EE)

01. Ans: (C)

Sol: The circuit is redrawn as a planar circuit for convenience.



We have $V_1 = A\ V_2 + B\ (-I_2)$

$I_1 = C\ V_2 + D\ (-I_2)$

With port 2 open; between 1 & 1′ there is a 6 Ω path (1– 2′ –1′) and another 6 Ω path (1–2–1′).

$\therefore$ Effective resistance between 1 and 1′=3 Ω

$I_1 = V_1/3$

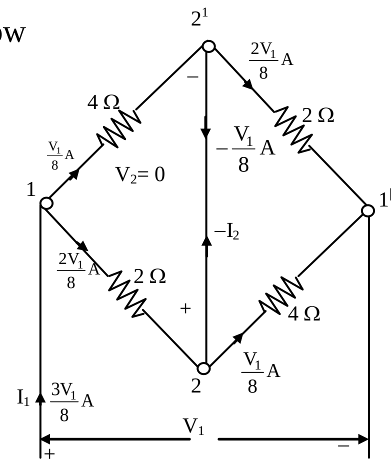
With port 2 open; I_2 = 0. Currents and voltage drops across different resistors are shown in above figure.

By KVL; $\dfrac{4V_1}{6} = \dfrac{2V_1}{6} + V_2$

$$V_2 = \frac{V_1}{3} \qquad \left.\frac{V_1}{V_2}\right|_{I_2=0} = A = 3$$

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

With port 2 shorted, the figure is redrawn below



Between 1 and 1′; we have (4 Ω // 2 Ω) in series with (4 Ω // 2 Ω) = $\dfrac{8}{3}\Omega$

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

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

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

02. Ans: (B)

Sol: $\nabla\times\vec{A} = \frac{1}{r}\frac{\partial}{\partial\phi}(5r\sin\phi)\,\hat{a}_r - \frac{\partial}{\partial r}(5r\sin\phi)\,\hat{a}_\phi$

$= 5\cos\phi\,\hat{a}_r - 5\sin\phi\,\hat{a}_\phi$

At (4, π, 0)

$\nabla\times\vec{A} = -5\hat{a}_r$

03. Ans: (A)

Sol: The efficiency at any load is given by,

$$\%\,\eta = \frac{n\times VA\ \cos\phi}{n\times VA\ \cos\phi + n^2(P_{cu})_{F.L} + P_i}\times 100$$

Where n = Fraction of full load

$1\frac{1}{4}$th of full load, n = 1.25 at power factor $\cos\phi = 1$

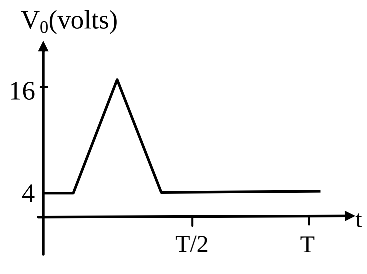
$$\%\eta = \frac{1.25\times100\times10^3\times1}{1.25\times100\times10^3\times1 + (1.25)^2\times1000 + 1000}\times 100$$

$= 97.991\%$

04. Ans: (D)

Sol: For V_i < 4V, the diode is ON and the output V_0 = 4V

For V_i > 4V, the diode is OFF and the output $V_0 = V_i$



05. Ans: (A)

Sol: For first wire, resistivity of conducting material is

$$\rho = \frac{RA}{\ell} = \frac{0.56\times2\times10^{-6}}{50} = 2.24\times10^{-8}\,\Omega-m$$

∴ Cross-sectional area of second wire is

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

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

$= 1.19\times10^{-3}$ m ≃ 1.2 mm

06. Ans: 2 no range

Sol: The probability density function of uniform distribution is

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

$E(y) = E[-2\log_e x]$

$$= \int_0^1 -2\log_e x\ f(x)\,dx$$

$$= -2\int_0^1 \log_e x\,dx$$

$$= -2\{x\log_e x - x\}_0^1$$

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

07. Ans: (C)

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

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

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

08. Ans: (B)

09. Ans: (C)

Sol: Option (a):- Due to multiplication of input terms it is nonlinear, but it is TIV.

Option (b):-Due to multiplication of time variant term (n – 2) it is TV., but linear

Option (c): - It is linear and TIV.

Option (d):- $2^{x_1(n)+x_2(n)} \neq 2^{x_1(n)} + 2^{x_2(n)}$. So, nonlinear and TIV system

10. Ans: 0.0625 (no range)

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

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

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

By Time shifting property,

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

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

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

Put n = 5

$g(5) = \left(\dfrac{1}{4}\right)^{5-3} = \left(\dfrac{1}{4}\right)^2$

$g(5) = \dfrac{1}{16} = 0.0625$

11. Ans: 5.6568 (Range: 5.5 to 5.75)

Sol: $\overline{E} = -\nabla V$

$= -\left[\dfrac{\partial V}{\partial x}\hat{a}_x + \dfrac{\partial V}{\partial y}\hat{a}_y\right]$

$= -\left[2xy\,\hat{a}_x + x^2\,\hat{a}_y\right]$

$\therefore\ \overline{E}$ at x = 2, y = 1 is = – $[4\hat{a}_x + 4\hat{a}_y]$

$\therefore$ Magnitude of $\overline{E} = \sqrt{16+16} = 4\sqrt{2}$

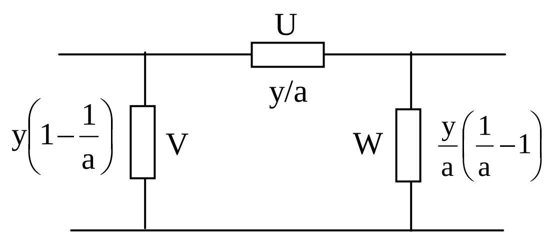
= 5.6568 V/m

12. Ans: (A)

Sol: 1: a tap changing transformer has Y_{Bus} as,

$$Y_{Bus} = \begin{matrix}(1)\\(2)\end{matrix}\begin{bmatrix} y & -\dfrac{y}{a} \\ -\dfrac{y}{a} & \dfrac{y}{a^2} \end{bmatrix}$$

The equivalent – π model from Y_{Bus} will be



As a > 1,

'U' is inductive nature

'W' is capacitive nature

'V' is inductive nature.

13. Ans: 1280 no range

Sol: Given that $|A_{4\times4}| = 5$

$\because |K A_{n\times n}| = K^n |A_{n\times n}|$

$\Rightarrow |(-4) A| = (-4)^4 |A_{4\times4}|$ for n = 4

$\Rightarrow |(-4) A_{4\times4}| = (256)(5)$

$\therefore |(-4) A_{4\times4}| = 1280$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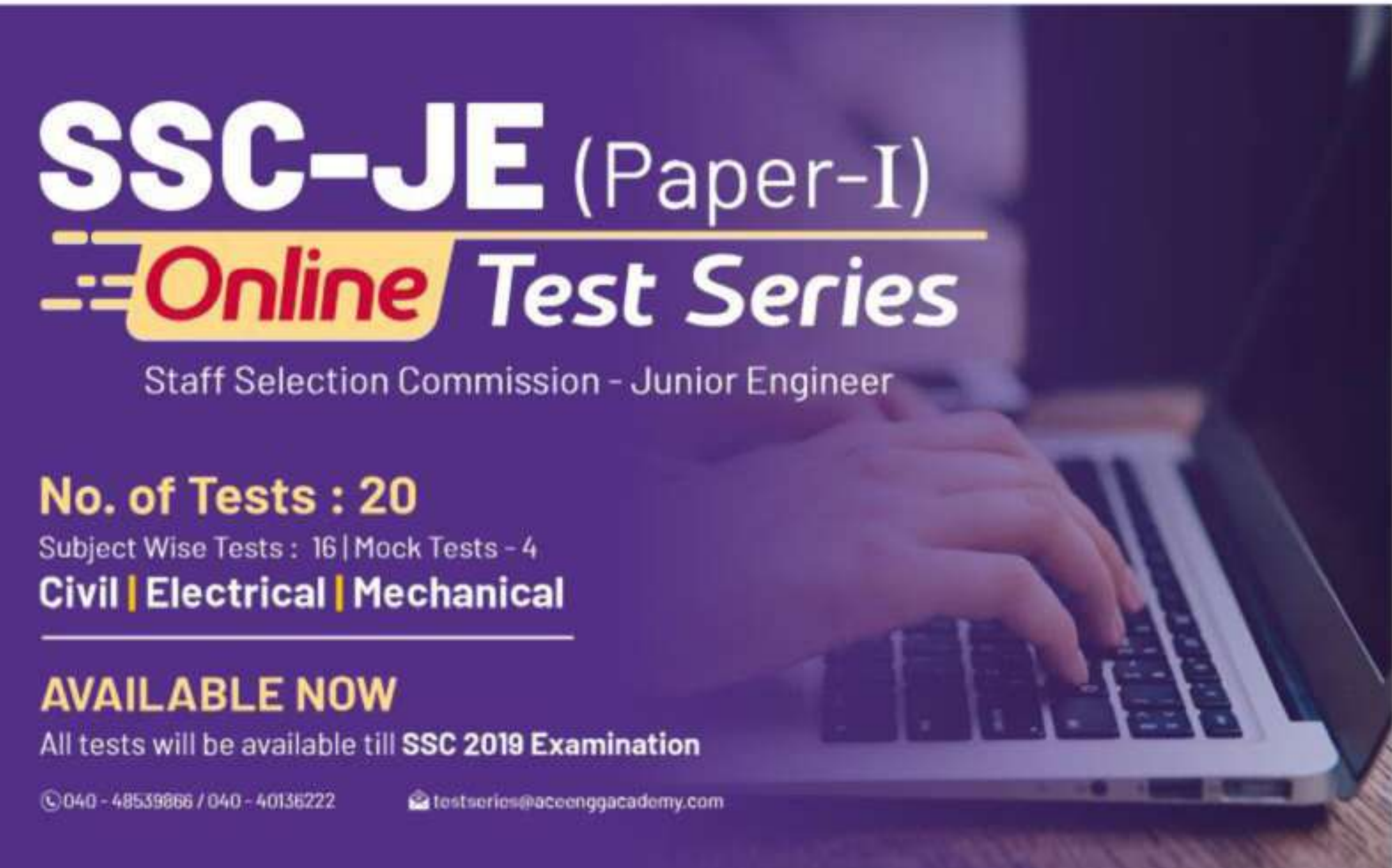
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14. Ans: (C)

Sol: Given $R_{ds} = 0.15\ \Omega$, $V_{ON} = 0.6$ V

$$I_{RMS} = I^2_{RMS\,1} + I^2_{RMS\,2}$$

$$I^2_{RMS\,1} = \frac{10^2}{3}\times\frac{2}{8} = \frac{25}{3}$$

$$I^2_{RMS2} = 10^2\times\frac{2}{8} = 25$$

$$I^2_{RMS} = \frac{25}{3}+25 = \frac{100}{3}\text{A}$$

$$I_{avg} = \frac{\frac{1}{2}\times 2\times 10+2\times 10}{8} = \frac{30}{8}\text{ A}$$

$$P_{loss} = I^2_{RMS}R_{ds}+I_{avg}V_{ON} =$$

$$\frac{100}{3}(0.15)+\frac{30}{8}(0.6)$$

= 5 + 2.25 = 7.25 W

15. Ans: (B)

Sol: The condition for exactness of a differential equation

M(x, y) dx + N(x, y) dy = 0 is $\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$

Given that $M(x, y) = 3xy^2 + k^2x^2y$ and $N(x, y) = kx^3 + 3x^2y$

Consider $\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$

$\Rightarrow 6xy + k^2x^2 = 3kx^2 + 6xy$

$\Rightarrow k^2 = 3k$ (or) $k^2 - 3k = 0$

$\Rightarrow k = 0, 3$

$\therefore$ The non zero value of k is 3

16. Ans: 0.25 no range

Sol: Given

$$\int_0^x f(t)\,dt = -2+\frac{x^2}{2}+4x\sin(2x)+2\cos(2x)$$

Differentiating both sides of above w.r.t 'x', we get

$$\frac{d}{dx}\left[\int_0^x f(t)\,dt\right] = -0+\frac{2x}{2}+4\sin(2x)$$
$$+8x\cos(2x)-4\sin(2x)$$

$$\Rightarrow \left(\frac{d}{dx}(x)\right)[f(x)]-\left(\frac{d}{dx}(0)\right).[f(0)]$$

$$= x+8x\cos(2x)$$

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

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

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

17. Ans: 10 (no range)

Sol: Resolution = ΔV_i = 5mV

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

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

$2^n - 1 = 1000$

$2^n = 1001$

$n \approx 10$

18. Ans: (B)

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

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

$$\Rightarrow A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

$$= \begin{bmatrix} 15 & 0 & 0 \\ 0 & 14 & 0 \\ 0 & 0 & 13 \end{bmatrix}_{3\times3} \quad \text{for } n = 3$$

$\Rightarrow A_{3\times3}$ is a diagonal matrix & its eigen values are its diagonal elements 15, 14, 13.

If $\lambda_1, \lambda_2, \lambda_3$ are the eigen values of $A_{3\times3}$ matrix then the eigen values of matrix $A^2_{3\times3}$ are λ_1^2, λ_2^2 *and* λ_3^2.

$\therefore$ The eigen values of a required matrix A^2 are $(15)^2$, $(14)^2$ and $(13)^2$ (i.e., 225, 196, 169)

19. Ans: (D)

Sol: Frequency of rotor currents and voltages = sf = –0.01×50 = –0.5 Hz. Rotating magnetic field produced by the rotor currents rotates at a speed of 120 (sf)/P = 15 RPM (in magnitude) with respect to the rotor.

The field due to stator currents rotates at 120 × 50/4 = 1500 RPM with respect to stator say in clock – wise direction.

Rotor field rotates at 1500 RPM with respect to stator.

Rotor field rotates at 15 RPM with respect to rotor.

20. Ans: (C)

Sol: Given data:

$$i(t) = \left[-6\sqrt{2}\sin(100\pi t) + 6\sqrt{2}\cos\left(300\pi t + \frac{\pi}{4}\right) + 6\sqrt{2}\right] A$$

A true rms ammeter measures I_{rms} of i(t)

$$I_{rms} = \sqrt{\left(6\sqrt{2}\right)^2 + \frac{\left(-6\sqrt{2}\right)^2}{2} + \frac{\left(6\sqrt{2}\right)^2}{2}} A$$

$$= \sqrt{36\times2+36+36} A$$

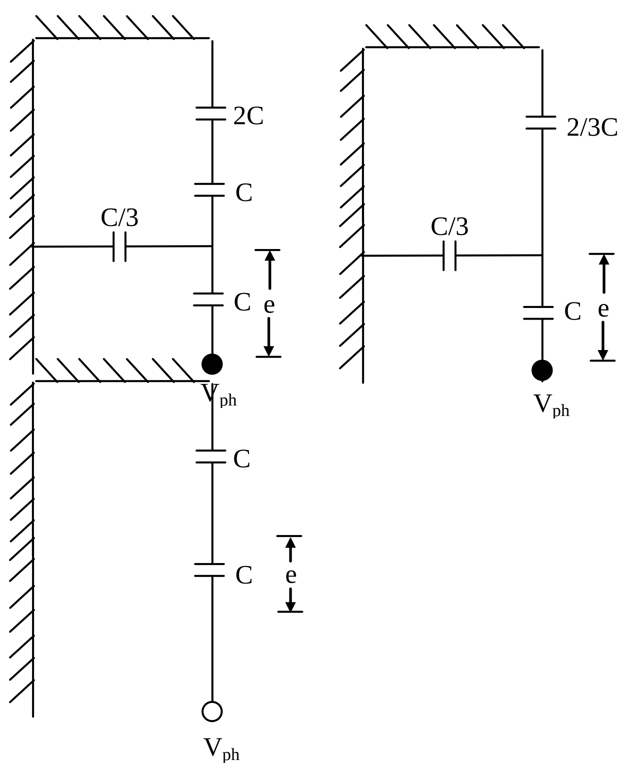
$$= \sqrt{36\times4} A = 12A$$

21. Ans: (B)

Sol: Conductor voltage, $V_{ph} = \frac{33}{\sqrt{3}} kV$

=19.052 kV

Equivalent capacitor arrangement will be



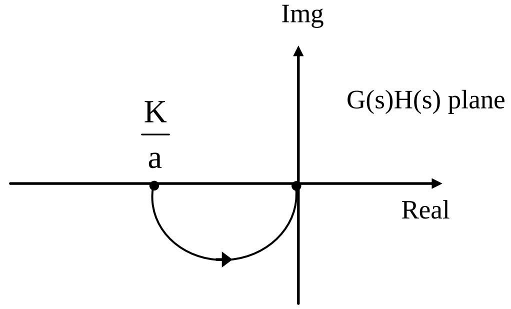
$$e = \frac{V_{ph}}{2} = 9.53\, kV$$

22. Ans: (C)

Sol: OLTF $= \dfrac{K}{s-a}$ (a > 0)

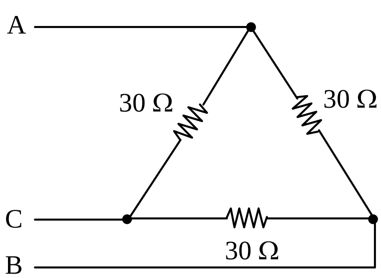
$$= \frac{K}{j\omega - a} = \frac{K}{\sqrt{\omega^2 + a^2}} \angle -\left(180^o - \tan^{-1}\frac{\omega}{a}\right)$$

The Polar plot is

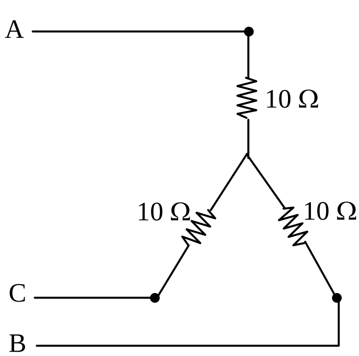


23. Ans: (B)

Sol: onvert delta connected load into star connected load.



⇓



∴ In 120° conduction scheme,

$$V_{ph} = \frac{V_{dc}}{\sqrt{6}} = 163.3\,V$$

3-ϕ load power

$$P_0 = 3\left[\frac{V_{ph}^2}{R}\right] = 3 \times \frac{163.3^2}{10} = 8kW$$

24. Ans: (C)

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

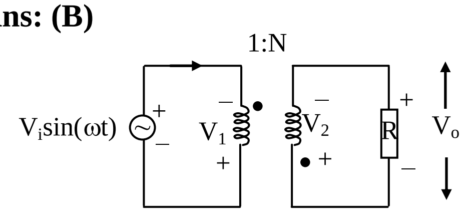
$u(t) = \delta(t) \xrightarrow{LT} U(s) = 1$

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

$y(t) = C\,e^{At}\,B$, as $e^{At} \xrightarrow{LT} (sI - A)^{-1}$

25. Ans: (B)

Sol:



$$\frac{V_2}{V_1} = N$$

$V_2 = NV_1 = NV_i\,\sin\omega t$

So $V_0 = -NV_i\,\sin\omega t$.

(According to dot polarity)

26. Ans: 425.8 (Range: 424 to 426)

Sol: Given,

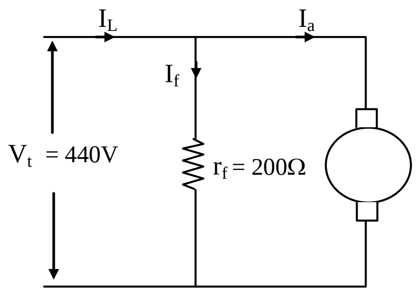
Terminal voltage (V_t) = 440 V

Armature resistance (r_a) = 0.8 Ω

Field resistance = (r_f) = 200 Ω

Efficiency (η) = 85%

Power output (P_o) = 7.46 kW



$$\text{Efficiency } (\eta) = \frac{\text{Power output}(P_o)}{\text{Power input}(P_i)}$$

$$\Rightarrow \quad \frac{85}{100} = \frac{7.46\times10^3}{P_i}$$

$$\Rightarrow \quad P_i = 8776.5 \text{ W}$$

Power input $(P_i) = V_t \times I_L$

$\Rightarrow$ 8776 W = 440 $\times I_L$

$\Rightarrow$ I_L= 19.95 A

$$I_f = \frac{V_t}{r_f} = \frac{440}{200}$$

I_f = 2.2 A

For a shunt motor,

$I_a = I_L - I_f$

I_a = 19.95 – 2.2

I_a = 17.75 A

For a shunt motor

Back emf $(E_a) = V_t - I_a r_a$

E_a = 440 – (17.75) × (0.8)

$\Rightarrow E_a$ = 425.8 V

∴ Back Emf for the given shunt motor is 425.8 V

27. Ans: (A)

Sol: CLTF = $\dfrac{G(s)}{1+G(s)}$

$$= \frac{k(s+4)}{s(s+1)+k(s+4)} \Rightarrow \frac{k(s+4)}{s^2+(k+1)s+4k}$$

By comparing with standard form of second order characteristic equation

$2\omega_n = (k + 1)$ and $\omega_n = \sqrt{4k}$

$2\omega_n = k + 1 \qquad \because \zeta = 1$

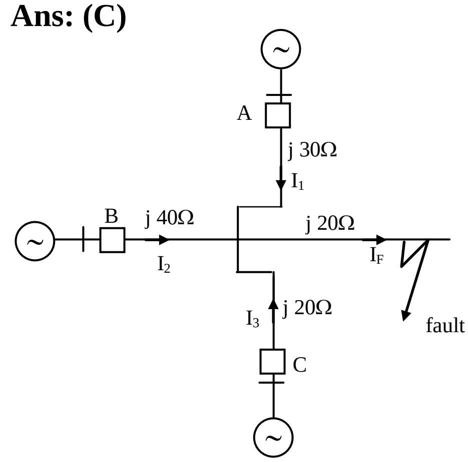
$2\times\sqrt{4k} = k+1 \Rightarrow 16\,k = k^2 + 2\,k + 1$

$\Rightarrow k^2 - 14\,k + 1 = 0$

$\Rightarrow k = 0.071 \;\&\; 13.92$

28. Ans: (C)

Sol:



I_1 = 1540 A, I_2 = 1150 A, I_F = 5000 A

Now, $I_3 = I_F - I_1 - I_2$

= 2310 A

∗ Voltage at 'A' ,

$V_A = I_1 \times j30 + I_F \times j20$

Impedance measured by 'A',

$$Z_A = \frac{V_A}{I_1} = j30 + j20\times\frac{I_f}{I_1}$$

= j30 +j64.92

= j 94.9 Ω

∗ Voltage at 'B',

$V_B = j40\times I_2 + j20\times I_F$

Impedance measured by 'B',

$$Z_B = \frac{V_B}{I_2} = j40 + j86.95$$

$$= j\,126.95\ \Omega$$

∗ Voltage at 'C',

$V_C = I_3 \times j20 + I_F \times j20$

Impedance measured by 'C',

$$Z_C = \frac{V_C}{I_3} = j20 + j43.29 = j\,63.29\ \Omega$$

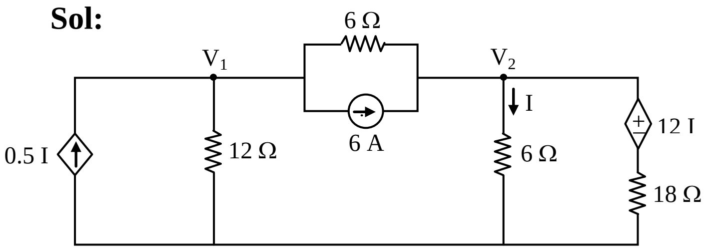
As reach = 100 Ω

Relays 'A' and 'C' operates first after this operation, impedance measured by 'B' will be $Z_B = j60\Omega$ and it is lower than reach.

⇒ Later on 'B' also operates.

29. Ans: 3 (2.9 t0 3.1)

Sol:



Here, $I = \frac{V_2}{6}$

Dependent current source supplies current of 0.5I

i.e., $0.5\left(\frac{V_2}{6}\right) = \frac{V_2}{12}$

dependent voltage source supplies voltage of

12I i.e., $12\left(\frac{V_2}{6}\right) = 2V_2$

Apply KCL at Node (1)

$$-\frac{V_2}{12} + \frac{V_1}{12} + \frac{V_1 - V_2}{6} = -6$$

$\Rightarrow 3V_1 - 3V_2 = -72$ ....(1)

Apply KCL at Node (2),

$$\frac{V_2 - V_1}{6} + \frac{V_2}{6} + \frac{V_2 - 2V_2}{18} = 6$$

$-3V_1 + 5V_2 = 108$ ....(2)

Adding (1) & (2), we get

$V_2 = 18$ V

$$I = \frac{V_2}{6} = \frac{18}{6} = 3\text{A}$$

30. Ans: k = 10

Sol: Put s = z –1

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

$z^3 + 4z^2 + z + k - 6 = 0$

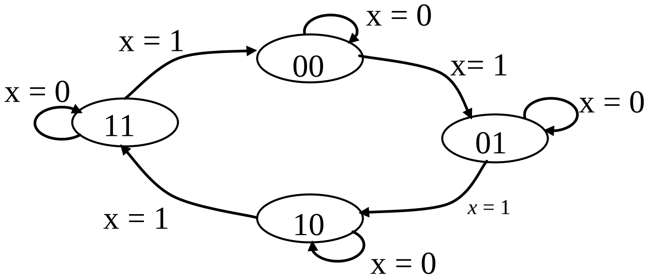
$$\begin{array}{c|cc} z^3 & 1 & 1 \\ z^2 & 4 & k-6 \\ z^1 & \frac{10-k}{4} & \\ z^0 & k-6 & \end{array}$$

$10 - k = 0 \Rightarrow k = 10$

31. Ans: (C)

Sol:

P.S	i/p	FF i/ps	N.S
Q_1 Q_2	x	J_1 K_1 J_2 K_2	Q_1Q_2
0 0	0	0 0 0 0	0 0
0 0	1	0 0 1 1	0 1
0 1	0	0 0 0 0	0 1
0 1	1	1 1 1 1	1 0
1 0	0	0 0 0 0	1 0
1 0	1	0 0 1 1	1 1
1 1	0	0 0 0 0	1 1
1 1	1	1 1 1 1	0 0



32. Ans: 2 no range

Sol: Given that $f(x, y) = x^2 + 2y^2$ .... (1)

with $y - x^2 + 1 = 0$ .... (2)

From (2), we write $y = x^2 - 1$ .... (3)

Put (3) in (1), we get

$f(x, y) = x^2 + 2y^2 = x^2 + 2(x^2 - 1)^2$

$= x^2 + 2[x^4 - 2x^2 + 1]$

Let $g(x) = 2x^4 - 3x^2 + 2$

Then $g'(x) = 8x^3 - 6x$ and $g''(x) = 24x^2 - 6$

Consider $g'(x) = 0$

$\Rightarrow 8x^3 - 6x = 0$

$\therefore x = 0, \dfrac{\sqrt{3}}{2}, \dfrac{-\sqrt{3}}{2}$ are stationary points.

At $x = 0$, $g''(0) = -6 < 0$

At $x = \pm\dfrac{\sqrt{3}}{2}$, $g''\left(\pm\dfrac{\sqrt{3}}{2}\right) = 12 > 0$

$\therefore$ x = 0 is a local point of maxima.

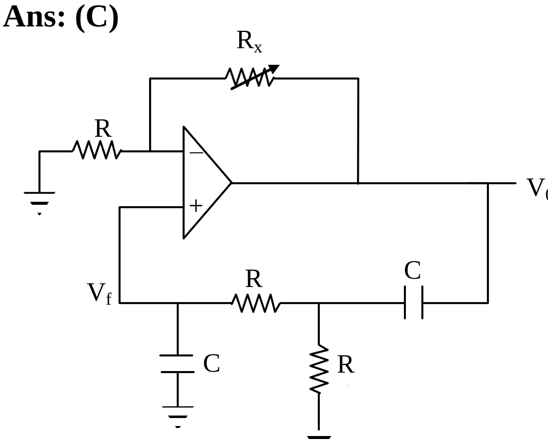
Hence, the maximum value of the function f(x, y) at x = 0 is

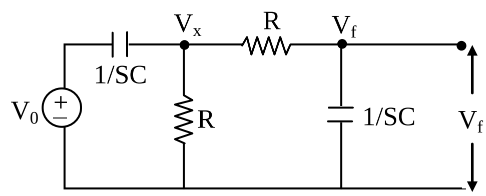
$f(x, y) = f(x, x^2 - 1) = f(0, -1)$

$= 0 + 2[0 - 0 + 1] = 2$

33. Ans: (C)

Sol:





KCL at node V_x.

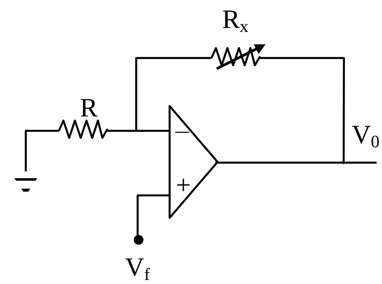
$$\frac{V_0 - V_x}{\frac{1}{SC}} = \frac{V_x}{R} + \frac{V_x - V_f}{R} \quad \ldots\ldots\ (1)$$

and $$\frac{V_x - V_f}{R} = \frac{V_f}{\frac{1}{SC}} \quad \ldots\ldots\ (2)$$

$\therefore V_x = (1+SRC)\,V_f$ --------(3)

$\Rightarrow \beta = \dfrac{V_f}{V_0} = \dfrac{SCR}{S^2C^2R^2 + 3SCR + 1}$ [$\because$ from equation (1), (2) & (3)]

$$\therefore \beta = \frac{1}{3 + j\left[\omega CR - \dfrac{1}{\omega CR}\right]}$$



$$\frac{V_0}{V_f} = 1 + \frac{R_x}{R}$$

Since for sustained oscillations $\beta A = 1$

$$\Rightarrow A = \frac{1}{\beta}$$

$$\therefore 1 + \frac{R_x}{R} = 3 + j\left[\omega CR - \frac{1}{\omega CR}\right]$$

Equating img., parts

$$\Rightarrow \omega CR - \frac{1}{\omega CR} = 0$$

$$\Rightarrow f = \frac{1}{2\pi RC}\text{Hz}$$

$$\& \ 1 + \frac{R_x}{R} = 3$$

$$\therefore R_x = 2R$$

34. Ans: 2.22 (Range: 2.15 to 2.25)

Sol: E_2 = stand-still rotor voltage/phase

$$= \frac{60}{\sqrt{3}} = 34.6\text{V}.$$

Rotor impedance at 4% slip

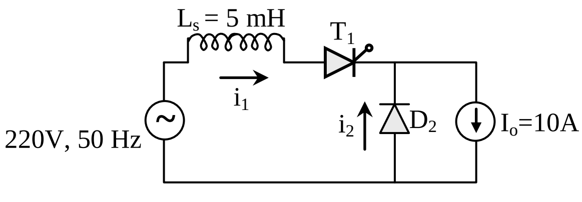
$$= \frac{0.6}{0.04} + j4 = 15 + j4\Omega$$

$$|z| = 15.5\Omega$$

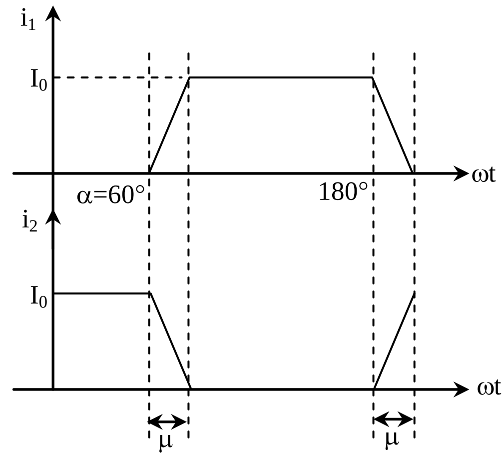
$$\text{current} = \frac{34.6}{15.5} = 2.22\text{Amp}$$

35. Ans: (*)

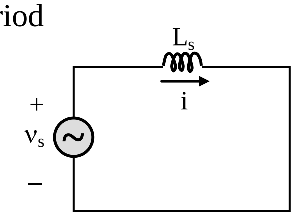
Sol:



$i_1 + i_2 = I_0$



During overlap period



$$v_s = L_s.\frac{di}{dt}$$

$$\int_{-I_0}^{I_0} di = \frac{1}{L_s}\int_{\frac{\alpha}{\omega}}^{\frac{\alpha+\mu}{\omega}} V_m \sin \omega t.dt$$

$$2I_0 = \frac{V_m}{\omega L_S}[\cos\alpha - \cos(\alpha+\mu)]$$

$$I_0 = \frac{V_m}{2\omega L_s}[\cos\alpha - \cos(\alpha+\mu)]$$

$$\cos(\alpha+\mu) = \cos\alpha - \frac{2\omega L_s}{V_m} I_0$$

$$\cos(\alpha+\mu) =$$

$$\cos 60° - \frac{2\times 2\pi\times 50\times 5\times 10^{-3}\times 10}{220\sqrt{2}}$$

$\cos(\alpha + \mu) = 0.399$

$\alpha + \mu = 66.479°$

$\mu = 6.479°$

Conduction angle of $T_1 = 120° + \mu$

$= 120° + (6.48)$

$= 126.48°$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36. Ans: (D)

Sol: Energy consumed $= VI\cos\phi \times t$

$$= \frac{230 \times 40 \times 0.4 \times 1}{1000}$$

$= 3.68$ kWh

Actual number of revolution

$= 3.68 \times 100$

$= 368$ revolutions

$$\% \text{ Error} = \frac{360 - 368}{368} \times 100$$

$= 2.17\%$low

37. Ans: 91 (range: 88 to 93)

Sol: Total energy = $E_{x(t)} = \int_0^{\infty} e^{-2t} dt = \frac{1}{2}$

Given, $x(t) = e^{-t}u(t)$

$$X(\omega) = \frac{1}{1 + j\omega}$$

$$|X(\omega)|^2 = \frac{1}{1 + \omega^2}$$

Using parseval's theorem Energy contained

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

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

$$= \frac{2}{2\pi} \tan^{-1}(7) = 0.4548$$

Percentage of energy

$$= \frac{0.4548}{0.5} = 0.9096 \times 100$$

$= 90.96\% \approx 91\%$

38. Ans: 1.52 no range

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

.... (1)

Given that C: $x = t^2$, $y = t^3$, $0 \le t \le 1$ } .. (2)

$\Rightarrow dx = 2t\, dt$, $dy = 3t^2\, dt$

Using (2), (1) becomes

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

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

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

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

39. Ans: (B)

Sol: Given $\frac{d}{dx}\left(x\frac{dy}{dx}\right) = x$ .... (1)

With $y(1) = 0$ .... (2)

And $y'(1) = 0$ .... (3)

Now, integrating on both sides of (1), we get

$$x\frac{dy}{dx} = \frac{x^2}{2} + C_1$$

$$\Rightarrow \frac{dy}{dx} = \frac{x}{2} + \frac{C_1}{x} \text{ .... (4)}$$

Using (3), (4) becomes

$$0 = \frac{1}{2} + \frac{C_1}{1} \text{ (or) } C_1 = \frac{-1}{2} \text{ .... (5)}$$

Using (5), (4) becomes

$$\frac{dy}{dx} = \frac{x}{2} - \frac{1}{2x}$$

$$\Rightarrow y = \frac{x^2}{4} - \frac{1}{2}\log x + c \text{ .... (6)}$$

Using (2), (6) becomes

$$0 = \frac{1}{4} - \frac{1}{2}(0) + C \text{ (or) } C = \frac{-1}{4} \text{ .... (7)}$$

$\therefore$ The solution of (1) from (6) and (7) is

$$y = y(x) = \frac{x^2}{4} - \frac{1}{2}\log(x) - \frac{1}{4}$$

Hence, $y(2) = 1 - \frac{1}{2}\log(2) - \frac{1}{4}$

$$= \frac{3}{4} - \frac{1}{2}\log(2)$$

40. Ans: 0.672 (Range: 0.66 to 0.68)

Sol: $I_0 = 20$ A

$$V_0 = \frac{3V_{ml}}{2\pi}(1+\cos\alpha)$$

E = 200 V

$$I_0 = \frac{V_0 - E}{R} = \frac{\frac{3V_{ml}}{2\pi}(1+\text{co}\alpha) - E}{R}$$

$$20 = \frac{\frac{3\times 230\times\sqrt{2}}{2\pi}(1+\cos\alpha) - 200}{0.5}$$

$\alpha = 69.37°$

Displacement power factor $= \cos\frac{\alpha}{2}$

$= \cos 34.685$

$= 0.822$

Distortion factor DF $= \frac{I_{S1}}{I_{Sr}}$

$$I_{s1} = \frac{\sqrt{6}}{\pi} I_0 \cos\frac{\alpha}{2}$$

$$= \frac{\sqrt{6}}{\pi}\times 20\times 0.822 = 12.818 \text{ A}$$

$$I_{sr} = I_0\sqrt{\frac{\pi-\alpha}{\pi}} \qquad (\because \alpha \geq 60°)$$

$= 15.679$

$$DF = \frac{I_{s1}}{I_{sr}} = \frac{12.818}{15.679} = 0.817$$

Supply power factor = DPF × DF

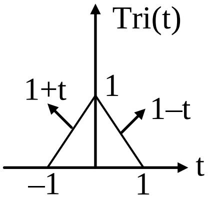
= 0.822 × 0.817

= 0.672

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

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

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



Using parseval's theorem

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

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

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

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

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

42. Ans: (B)

Sol: From Poisson's equation

$$\nabla^2 V = \frac{-\rho_v}{\in}$$

for free space $\in = \in_0$

$$\frac{\partial^2 V}{\partial x^2} = \frac{-1}{\in_0}\frac{x}{6\pi}\times 10^{-9}$$

$$\frac{\partial^2 V}{\partial x^2} = -6x$$

$V(x) = -x^3 + C_1x + C_2$ ....(1)

Given: V (1) = – 50 and

V(4) = 50

Using V(1) = –50 in equation (1), we get

$-50 = -1 + C_1 + C_2$

$C_1 + C_2 = -49$

Using V(4) = 50 in equation (1), we get

$4C_1 + C_2 = 114$

By solving the above equations

$C_1 = 54.33$ and $C_2 = -103.33$

$V(x) = -x^3 + 54.33x - 103.33$

V(2) = – 8 + 108.66 – 103.33

$\therefore V(2) = -2.67$ Volt

43. Ans: (A)

Sol: $\frac{2L}{RT} = \frac{2\times 500\times 10^{-6}}{50\times 50\times 10^{-6}} = 0.4$

1 –D = 1 0.5 = 0.5

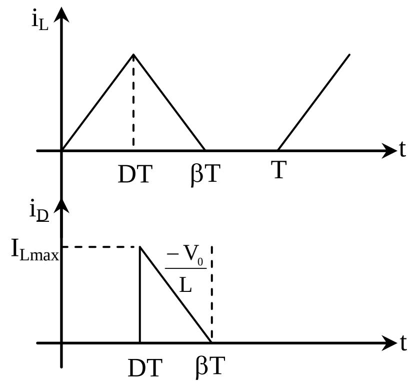
$\frac{2L}{RT} < 1-D$, Circuit is operating in discontinuous mode

$$\frac{2L}{RT} = \beta(\beta - D)$$

$0.4 = \beta(\beta - 0.5)$

$\beta^2 - 0.5\beta - 0.4 = 0$

$\beta = 0.93$



$$\frac{V_0}{L} = \frac{I_{L\max}}{(\beta - D)T}$$

$$I_{L\max} = \frac{V_0}{L}(\beta - D)T$$

$$= \frac{16.128}{500\times 10^{-6}}(0.93 - 0.5)\times 50\times 10^{-6}$$

= 1.6128(0.43)

= 0.693

$$I_{Drms}^2 = \frac{I_{L\max}^2}{3}\times(\beta - D)$$

$$I_{Drms}^2 = \frac{(0.693)^2}{3}\times 0.43$$

= 0.068 A

$I_{Drms} = 0.262$ A

44. Ans: 3.2 (3.1 to 3.3)

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

For 0.9 lagging, angle of admittance must be $\cos^{-1}(0.9) = -25.84°$

Thus, $\frac{1/5}{1/10 + 1/R} = \tan 25.84 = 0.482$

$\Rightarrow R = 3.2\ \Omega$

45. Ans: (B)

Sol: No. of horizontal touches $n_x = 5$

No. of vertical touches $n_y = 3$

$n_x f_x = n_y f_y$

$$\frac{5\times 60}{3} = f_y$$

$\therefore f_y = 100$ Hz

46. Ans: 0.11 Range: 0.1 to 0.2

Sol: Total possible outcomes for both faces even = (2, 2), (2, 4), (2, 6), (4, 2), (4, 4), (4, 6), (6, 2), (6, 4), (6, 6) = 9

Total favorable outcome for sum smaller than 6 = (2, 2)

P (sum is less than 6 given both faces are even) = $\frac{1}{9}$ = 0.11

47. Ans: (C)

Sol: $W_E = \frac{1}{2}\varepsilon E^2$

$$= \frac{1}{2}\times\varepsilon_o\times\varepsilon_r\times E^2$$

Given: $\varepsilon_o = 8.85\times 10^{-12}$ F/m and $\varepsilon_r = 4$

$$\bar{E} = 6\hat{a}_x + 8\hat{a}_y \text{ kV/mm}$$

$$= (6\hat{a}_x + 8\hat{a}_y)\times 10^6 \text{ V/m.}$$

$$|\bar{E}| = 10^7 \text{ V/m.}$$

$$W_E = \frac{1}{2}\times 4\times 8.85\times 10^{-12}\times(10^7)^2$$

$$= 1770 \text{ J/m}^3$$

Energy stored = Energy density × volume

$$= 1770\times 500\times 10^{-3}\times 500\times 10^{-3}\times 0.4$$

$$= 177 \text{ J}$$

48. Ans: 31 (Range: 30 to 32)

Sol: $$Z = \frac{\text{Open circuit voltage}}{\text{Short circuit current}} = \frac{450}{200} = 2.25\,\Omega$$

$$X = \sqrt{Z^2 - R^2} = \sqrt{2.25^2 - 0.2^2} = 2.24\,\Omega$$

Full load current

$$I = \frac{55\times 1000}{550} = 100\text{ A}$$

With I as reference

$\bar{V} = 550\,(0.8 + j0.6) = 440 + j330$ V

$I\bar{Z} = 100\,(0.2 + j2.24) = 20 + j224$

$\bar{E} = \bar{V} + I\bar{Z} = 440 + j330 + 20 + j224$

$= 720\angle 50°$

$$\text{Regulation} = \frac{720-550}{550}\times 100 = 31\%$$

49. Ans: (D)

Sol: Initial energy (W_i)

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

= 0.5J

When connected in parallel, the initial charge $Q_i = C_1V$

= 100 × 10^{-6} × 100 = 10 mC is redistributed in parallel combination of

$C = C_1 + C_2$

= (100+400)μF

∴ Common voltage becomes

$$V = \frac{Q}{C} = \frac{10\times10^{-3}}{500\times10^{-6}} = 20\,V$$

$$W_1 = \frac{1}{2}C_1V^2 = \frac{1}{2}\times100\times10^{-6}\times(20)^2 = 0.02J$$

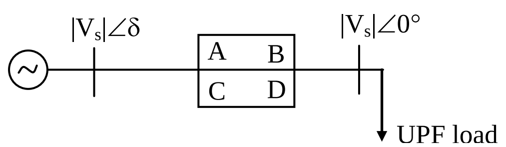
$$W_2 = \frac{1}{2}C_2V^2 = \frac{1}{2}\times400\times10^{-6}\times(20)^2 = 0.08J$$

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

Energy dissipated = $W_i - W_f$ = 0.5–0.1= 0.4J

50. Ans: 592.96 (Range: 592 to 594)

Sol:



$P_r = P_{load}$

$Q_r = 0$

Reactive power equation,

$$Q_r = \frac{|V_s||V_r|}{|B|}\sin(\beta-\delta) - \frac{|A|}{|B|}|V_r|^2\sin(\beta-\alpha)$$

$$= \frac{|V_s||V_r|}{|B|}\sin(90^\circ-\delta) - \frac{|A|}{|B|}|V_r|^2\sin(90^\circ-0^\circ)$$

$|V_s|\cos\delta = |A|.\,|V_r| \Rightarrow |V_r| = \frac{|V_s|\cos\delta}{|A|}$. (1)

Real power,

$$P_r = \frac{|V_s||V_r|}{|B|}\cos(\beta-\delta) - \frac{|A|}{|B|}|V_r|^2\cos(\beta-\alpha)$$

$$P_r = \frac{|V_s||V_r|}{|B|}\cos(90^\circ-\delta) - \frac{|A|}{|B|}|V_r|^2\cos(90^\circ-0^\circ)$$

$$P_r = \frac{|V_s||V_r|}{|B|}\sin\delta$$

$$P_r = \frac{|V_s||V_s|\cos\delta}{|A|.|B|}.\sin\delta$$

$$P_{(3-\phi)} = \frac{(400)^2\times\cos15^\circ\times\sin15^\circ}{0.973\times69.33}\,MW$$

= 592.96 MW

51. Ans: (C)

Sol: Given $\frac{d^2y(t)}{dt^2} + \frac{dy(t)}{dt} - 2y(t) = x(t)$.

Apply L.T

$s^2Y(s) + sY(s) - 2Y(s) = X(s)$

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

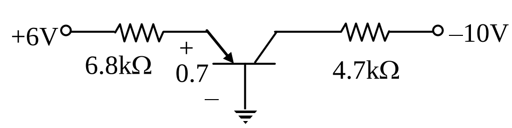
Given that system is stable. So, ROC must include jω axis.

So, ROC $-2 < \sigma < 1$.

$$h(t) = \frac{-1}{3}e^{-2t}u(t) - \frac{1}{3}e^{t}u(-t)$$

52. Ans: 140.4 [Range: 138 to 142]

Sol: DC analysis: Open circuit the capacitor



$$I_E = \frac{6-0.7}{6.8k\Omega} = 0.779mA$$

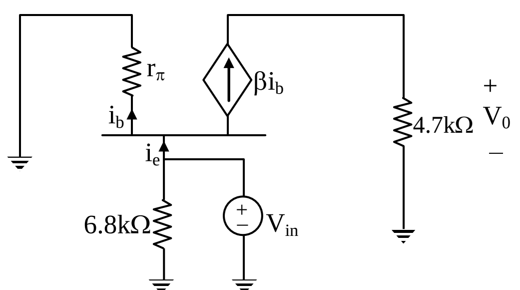
$$\beta = \frac{\alpha}{1-\alpha} = \frac{0.998}{1-0.998} = 499$$

$$I_C = \frac{\beta}{1+\beta} I_E = 0.777 \text{mA}$$

$$g_m = \frac{I_c}{V_T} = \frac{I_c}{26\text{mV}} = \frac{0.777}{26}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{499}{0.777} \times 26 = 16.7\text{k}\Omega$$

AC analysis: short circuit DC voltage source and replace the transistor with its equivalent π-model



$V_0 = \beta i_b\ (4.7\text{k}\Omega)$

$V_{in} = i_b \times r_\pi$

$$A_v = \frac{V_0}{V_{in}} = \frac{\beta i_b (4.7\text{k}\Omega)}{i_b r_\pi} = 140.4 \text{ V/V}$$

53. Ans: 0

Sol: $$TF = K\frac{\left(1+\frac{s}{0.5}\right)^2}{\left(1+\frac{s}{10}\right)^3}$$

It is type 0 system

Velocity error coefficient

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

$= 0$

54. Ans: (C)

Sol:

	MVI B, 0AH	7T
LOOP:	MVI C, 50H	7T
	DCR C	4T
	DCR B	4T
	JNZ LOOP	10T/7T

B register initialized with 0AH i.e., 10d.

Effect on zero flag due to "DCR B" instruction will be verified by "JNZ LOOP" instruction in iteration.

Therefore LOOP gets executed for 10 times.

The only instruction outside the LOOP is MVI B, 0AH which gets executed for only 1 time.

All the instructions inside the loop gets executed for 10 times.

∴ Total T – states

$= 1 \times 7T + 10 \times [7T + 4T + 4T + 10T] - 3T$

$= 7T + 10 \times 25T - 3T$

$= 4T + 250T$

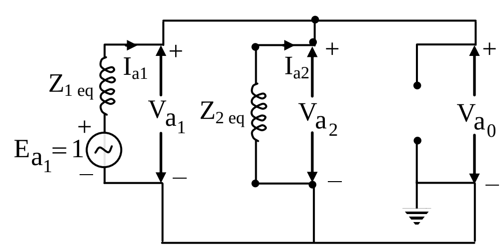
$= 254T$

55. Ans: 1.33 p.u. (Range : 1.2 to 1.4)

Sol: $Z_{1eq} = j0.3 + j0.2 = j0.5$ p.u.

$Z_{2eq} = j0.2 + j0.2 = j0.4$ p.u.

$Z_{0eq} = \infty$



$$I_{a1} = \frac{E_{a1}}{Z_{1eq} + Z_{2eq}}$$

$$= \frac{1}{j0.5 + j0.4}$$

$$= -j1.111 \text{ p.u.}$$

$$V_{a1} = E_{a1} - I_{a1}Z_{1eq}$$

$$= 1-(-j1.111) \times j0.5$$

$$= 0.4445 \text{ p.u.}$$

$$V_a = V_{a1} + V_{a2} + V_{a0}$$

$$= 3V_{a1}$$

$$= 3 \times 0.4445$$

$$= 1.333 \text{ p.u.}$$