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Branch: Electrical Engineering
Mock-B - Solutions

GATE-2020 General Aptitude (GA)

01. Ans: (D)

Sol: (PART AND THE WHOLE) A fragment is a piece of broken bone; a shard is a piece of broken pottery. (D)

02. Ans: (A)

03. Ans: (D)

Sol: irretrievably means impossible to recover or get back, so irrevocably is the correct synonym, which means not capable of being changed : impossible to revoke.

04. Ans: (B)

Sol: Indiscriminate (adj.) means not discriminating or choosing randomly; haphazard; without distinction.

05. Ans: (A)

Sol: $a_0 = 1$; $a_n = 2a_{n-1}$ if n is odd

$a_n = a_{n-1}$ if n is even

$a_{100} = a_{100-1} = a_{99} = 2.a_{99-1} = 2.a_{99} = 2.a_{98-1} = 2a_{97}$

$= 2.2a_{97-1} = 2^2.a_{96} \ldots\ldots\ldots 2_{50}.a_0 = 2^{50}$

06. Ans: (C)

Sol: A = 1; B = 1

(a) B = B + 1 = 2

(b) & (c) A = A × B = 1 × 2 = 2

Step 2: B = 2 + 1 = 3; A = A × B = 2 × 3 = 6

Step 3: B = 3 + 1 = 4; A = A × B = 6×4 = 24

Step 4: B = 4 + 1 = 5; A = 24 × 5 = 120

Step 5: B = 5 + 1 = 6; A = 120 × 6 = 720

07. Ans: (A)

Sol: Ratio of efficiency (P & Q) = 2 : 1

Ratio of efficiency (P + Q, R) = 3 : 1

If R does 1 unit work, then P& Q together do 3 units.

Out of 3 units, P does 2 units and Q does 1 unit.

∴ Ratio of efficiency (P, Q & R) = 2 : 1 : 1

Hence, earnings should be divided in the ratio is 2 : 1 : 1

08. Ans: (C)

Sol: In 1972, A was as old as the number formed by the last two digits of his year of birth.

So, A was born in 1936 (as in 1972, he is 36 yrs older also, last two digits of 1936 are 36).

Hence, B was born in 1936 + 15 = 1951

so, he is 21 yrs old in 1972

09. Ans: (B)

Sol: Difference (in thousands) between the numbers of customers in the 2 complexes in:

January: 22 – 20 = 2

February: 25 – 24 = 1

March: 20 – 15 = 5

April: 28 – 25 = 3

May: 20 – 14 = 6 [Max]

June: 20 – 15 = 5

10. Ans: (B)

Sol: The issue is more about punishing criminals, and so punishment is more important than crime prevention (correct answer B).

Specialization (EE)

01. Ans: 24

Sol: Given that F(x) = f(g(x))

$\Rightarrow F^1(x) = f^1(g(x)).\ g^1(x)$ ($\because$ by chain rule)

$\Rightarrow F^1(5) = f^1(g(5)).\ g^1(5)$

$\Rightarrow F^1(5) = f^1(-2)\ .6$

$\therefore F^1(5) = (4)\ (6) = 24$

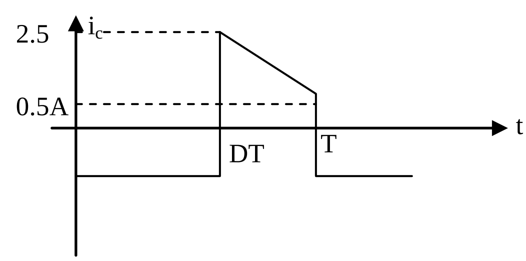
02. Ans: 16.5 to 16.7

Sol: $\frac{V_0}{V_{dc}} = \frac{1}{1-D} \Rightarrow \frac{15}{5} = \frac{1}{1-D}$, hence $D = \frac{2}{3}$

$\Delta V_0 = 0.01\times 15 = 0.15$ V

As $\Delta I_L = 2$ A given, the capacitor current waveform is redrawn as shown below:

$\Delta V_o = \frac{\Delta Q}{C} \Rightarrow 0.15 = \frac{2.5\times10^{-6}}{C}$, hence C = 16.67μF



03. Ans: (D)

Sol: We know that,

$P(A \cap B) \le$ min of $\{P(A), P(B)\}$

$\Rightarrow P(A \cap B) \le 0.25$ .... (1)

we have, $P(A \cup B) \le P(S)$

$\Rightarrow \{P(A) + P(B) - P(A \cap B)\} \le 1$

$\Rightarrow \{0.25 + 0.8 - P(A \cap B)\} \le 1$

$\Rightarrow 0.05 \le P(A \cap B)$ .... (2)

From (1) and (2), we have

$0.05 \le P(A \cap B) \le 0.25$

04. Ans: (A)

Sol: $|adjA| = |A|^{n-1}$

$\Rightarrow \quad -11(4-6) + 3(4-6) = |A|^2$

$\Rightarrow \quad 22 - 6 = |A|^2$

$\therefore |A| = \pm 4$

05. Ans: (B)

Sol: Mod-n ring counter is designed by using 'n' flipflops

Mod-2n Johnson counter is designed by using 'n' flipflops.

So, mod-8 ring counter requires 8 flipflops and mod-8 Johnson counter requires 4 flipflops.

06. Ans: 1

Sol: If rank of A is 2, then |A| = 0

$\Rightarrow (x-1)\ (x^2 + x + 1) = 0$

$\Rightarrow x = 1,\ \dfrac{-1 \pm \sqrt{3}\,i}{2}$

$\therefore x = 1$

07. Ans: (c)

Sol: The slip at 415 V is,

$s = \dfrac{N_s - N_r}{N_s} = \dfrac{1000 - 950}{1000} = 0.05$

When the voltage rise to 440 V, the load torque and rotor resistance remains the same, consequently

We have, $s_{new} = s_{old}\left(\dfrac{E_{2(old)}}{E_{2(new)}}\right)^2$

$E_{2(new)} = \dfrac{440}{\sqrt{3}}$ and $E_{2(old)} = \dfrac{415}{\sqrt{3}}$

$s_{new} = 0.05\left(\dfrac{415/\sqrt{3}}{440/\sqrt{3}}\right)^2 = 0.0444$

$N_r = N_s(1 - s_{new})$

$= 1000(1 - 0.0444)$

$= 955.5$

08. Ans (d)

Sol: Energy consumed in 100 seconds, by a load of 450W

$= \dfrac{P \times hours}{1000} = \dfrac{450 \times 100}{1{,}000 \times 3600} = \dfrac{1}{80} kWh$

Meter constant in revolutions/kWh

$= \dfrac{\text{Revolutions made by disc}}{\text{Energy consumed}} = \dfrac{10}{1/80} = 800$

09. Ans (d)

Sol: We know for dual slope DVM

$\dfrac{V_i \times t_{ON}}{RC} = \dfrac{V_{ref} \times t_{ref}}{RC}$

$\Rightarrow t_{ref} = \dfrac{V_i \times t_{ON}}{V_{ref}} = \dfrac{8}{10} = 0.8 \sec$

10. Ans: 388.488 (Range 387 to 390)

Sol: $i(t) = 4 + 3\cos(10t - 30°) + 4\sin(10t + 30°)$

$= 4 + 3\cos(10t - 30°) + 4\cos(10t + 30° - 90°)$

$= 4 + 3\cos(10t - 30°) + 4\cos(10t - 60°)$

$= 4 + 3\angle -30° + 4\angle -60°$

$= 4 + 3\cos30° - j3\sin30° + 4\cos60° - j4\sin60°$

$= 4 + \left[\frac{4+3\sqrt{3}}{2} - j\frac{3+4\sqrt{3}}{2}\right]$

$= 4 + 6.766\angle -47.24°$

$= 4 + 6.76\angle -47.24$

$i(t) = 4 + 6.76\cos(10t - 47.24)$

$I_{rms} = \sqrt{4^2 + \left(\frac{6.76}{\sqrt{2}}\right)^2} = \sqrt{38.84}$

Power dissipated in 10Ω is $P = I_{rms}^2 \times R$

$= \left(\sqrt{38.84}\right)^2 \times 10$

$= 38.84 \times 10$

P = 388.4 watts

11. Ans :(B)

Sol: Given: $\rho_s = \frac{1}{9\pi} nC/m^2$ located at z= 5m

Field point (1,1,–1)

z-coordinate of field point (z = –1) is less than z-coordinate of source point (z = 5), hence

$$\vec{E} = \frac{\rho_s}{2\varepsilon_0}(-\hat{a}_z) = \frac{\frac{1}{9\pi}\times 10^{-9}}{2\times\frac{10^{-9}}{36\pi}}(-\hat{a}_z)$$

$\therefore \quad \vec{E} = -2\hat{a}_z V/m$

12. Ans: 397.5 range(396 to 398)

Sol: G_1: Full load voltage drop = $400 \times \frac{3}{100} = 12\,V$

G_2:Full load voltage drop = $400 \times \frac{6}{100} = 24\,V$

G_1: $I_{f1} = \frac{250\times10^3}{400} = 625\,A$

G_2: $I_{f2} = \frac{150\times10^3}{400} = 375\,A$

Voltage of G_1 at load current I_1

$V_1 = 410 - \left(\frac{12}{625}\right)I_1$

$V_2 = 420 - \left(\frac{24}{375}\right)I_2$

Load on generation in parallel $I_L = I_1 + I_2 = 1000$ A

Bus voltage = V

$V_1 = V_2 = V$

$410 - \left(\frac{12}{625}\right)I_1 = 420 - \left(\frac{24}{375}\right)I_2$

$0.064I_2 - 0.0192I_1 = 10$

$I_1 + I_2 = 1000$

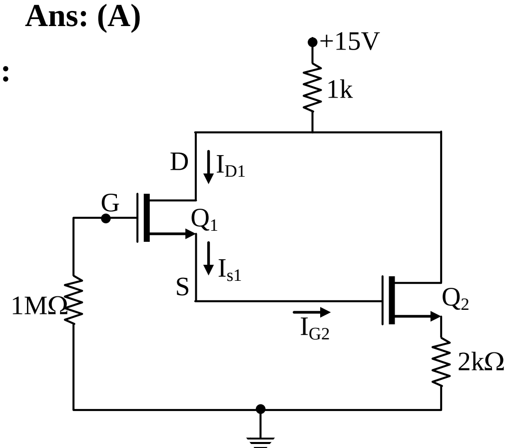
$I_1 = 649$ A, $I_2 = 351$ A

Bus voltage V = $410 - \left(\frac{12}{625}\right)\times 649$

=397.5V

13. Ans: (A)

Sol:

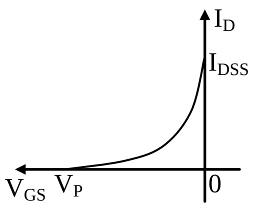


Step(1): From the circuit,

$I_{S1} = I_{G2} = 0$ ___(1) [$\because$ $I_G = 0$ in MOSFETs]

$\Rightarrow$ $I_{D1} = I_{S1} = 0$ ___(2) [$\because$ $I_D = I_S$ in MOSFETs

Step(2): Consider the transfer characteristics of a DMOSFET



Case (i): $I_D = I_{DSS}$ at $V_{GS} = 0$ ___(3)

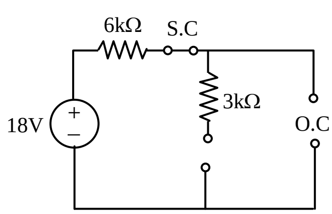
Case (ii): $I_D = 0$ at $V_{GS} = V_P$ ____(4)

$$\Rightarrow V_{GSQ1} = V_P = -4V \_\_(5)$$

$\because$ $I_{D1} = 0$ in the ckt given

14. Ans: – 60 V/sec (No Range)

Sol: At time $t = 0^-$ switch is in open condition



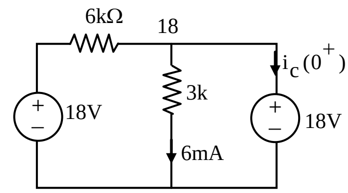
So, L is short circuit, C is open circuit

$$i_L(0^-) = 0$$

$$V_C(0^+) = V_C(0^-) = 18V$$

At $t = 0^+$ switch is closed

$$I_C(0^+) = C\frac{dv(0^+)}{dt}$$



$$\frac{dv(0^+)}{dt} = \frac{i_C(0^+)}{C}$$

$$i_C(0^+) = -6\times10^{-3}A$$

$$\frac{dv(0^+)}{dt} = \frac{-6\times10^{-3}}{100\times10^{-6}}$$

$$\frac{dv(0^+)}{dt} = -60V/sec$$

15. Ans: (B)

Sol: In 180° mode, $(I_{sw})_{rms} = \left[\frac{V_{dc}\sqrt{2}}{3R}\right]$

$$70 = \frac{V_{dc}\sqrt{2}}{3R}$$

$$\frac{V_{dc}}{R} = \left(\frac{210}{\sqrt{2}}\right)$$

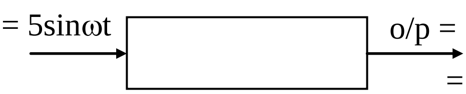
In 120° mode, $(I_{sw})_{rms} = \left[\frac{V_{dc}}{\sqrt{6}R}\right]$

$$\Rightarrow \frac{210}{\sqrt{12}} = 60.62A$$

16. Ans: (D)

Sol:

i/p = 5sinωt



o/p = 10cosωt

= 5A sin(ωt+ϕ)

10cosωt = 5Asin (ωt + ϕ)

A = 2, $\phi = 90^\circ$

If input = 10cosωt

Output = (10) (2) cos (ωt + 90°)

= –20sinωt

17. Ans: (D)

Sol: $(1+t)\frac{dy}{dt} = 4y$

$$\int \frac{1}{y}dy = \int \frac{4}{1+t}dt$$

Log y = 4 log (1+t) +logc

$y = c(1+t)^4$

$y(0) = 1 \Rightarrow 1 = c(1+0)^4 \Rightarrow c = 1$

$\Rightarrow y = (1+t)^4$

18. Ans: 224 (No range)

Sol: Number of P specified = 124

Number of Q specified = 100

∴ Total number of equation

= size of Jacobian matrix

= 124 + 100

= 224

19. Ans: (D)

Sol: $$\frac{E}{R} = \frac{1}{1-\left[-\frac{4}{s+1}-\frac{4}{s+1}\right]} = \frac{s+1}{s+9}$$

20.Ans:(c)

Sol: Given $y(n) - \frac{1}{4}y(n-1) = x(n)$

Apply z transform

$$Y(z) - \frac{1}{4}z^{-1}Y(z) = X(z)$$

$$Y(z) = \frac{X(z)}{1-\frac{1}{4}z^{-1}}$$

$x(n) = \delta(n-1)$

$X(z) = z^{-1}$

$$Y(z) = \frac{z^{-1}}{1-\frac{1}{4}z^{-1}}$$

Apply inverse z transform

$$\left(\frac{1}{4}\right)^n u(n) \leftrightarrow \frac{1}{1-\frac{1}{4}z^{-1}}$$

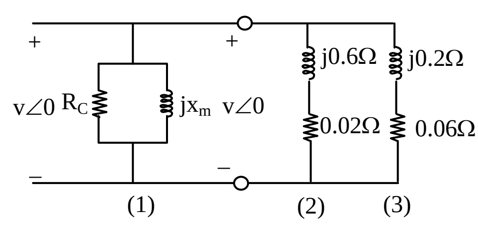
From time shifting property

$$\left(\frac{1}{4}\right)^{n-1} u(n-1) \leftrightarrow \frac{z^{-1}}{1-\frac{1}{4}z^{-1}}$$

So, $y(n) = \left(\frac{1}{4}\right)^{n-1} u(n-1)$

21. Ans: 24.8 (Range: 24 to 25)

Sol: Equivalent-circuit (per ph) of the double-cage motor is as shown.



(1): Magnetizing current & core losses branch.

(2): low resistance, high reactance, inner cage.

(3): High resistance, low reactance, outer cage.

At starting, torque due to inner cage

$$= \frac{3V^2(0.02)}{\omega_s\left[0.02^2+0.6^2\right]}$$

Torque due to outer cage

$$= \frac{3V^2(0.06)}{\omega_s\left[0.06^2+0.2^2\right]}$$

$$\frac{\text{Torque due to outer cage}}{\text{Torque due to inner cage}} = \frac{0.06\left(0.02^2+0.6^2\right)}{\left(0.06^2+0.2^2\right)(0.02)}$$

$$= 3\times\frac{0.3604}{0.0436}$$

$$= 24.8$$

22.Ans: (c)

Sol: $H_1(z) = \frac{z^2+1.5z-1}{z^2}$ and

$H_2(z) = z^2+1.5z-1$

$\therefore$ The zeros of the functions will be identical but not the poles

23. Ans: (D)

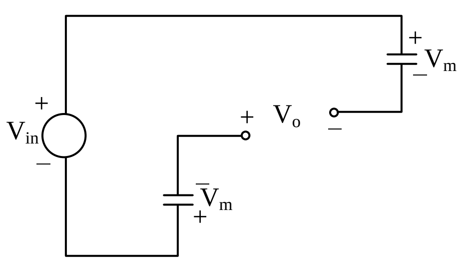
Sol: During positive cycle D_3 is FB, D_4 is RB.

Hence C_1 gets charged to V_m

During Negative cycle D_1 is FB, D_2 is RB.

Hence C_2 gets charged to $-V_m$

After the capacitors are charged, the diodes will remain reverse biased

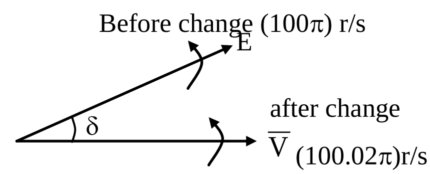


KVL: $-V_{in} + V_m - V_o - V_m = 0$

$V_o = -V_{in}$

24. Ans: 3.6 (No range)

Sol: In figure $\bar{V}$ is the bus voltage and $\bar{E}$ is the induced emf in the machine.



Bus frequency is always fixed at f = 50Hz.

so $\bar{V}$ rotates in the anticlockwise direction at $\frac{2\pi N}{60}$ = 100π r/sec. Before the change in the prime mover input, $\bar{E}$ also rotates in the anticlockwise direction at 100π r/sec. So $\bar{E}$ and $\bar{V}$ are stationary with respective each other, and the torque angle (or) load angle or power angle δ remains constant.

Now, after the change, $\bar{V}$ continues at 100πωr/sec (anticlockwise) but $\bar{E}$ rotates of 100.02π r/s anticlockwise. So relative speed = 0.02π r/s = 0.02×180 = 3.6° elec.

25. Ans: 55 (range 54.90 to 55)

Sol: Compensator $D(s) = \frac{0.4s+1}{0.04s+1} = \frac{1+aTs}{1+Ts}$

aT = 0.4

T = 0.04

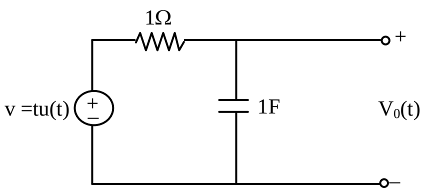
$\therefore$ a = 10

Maximum phase angle,

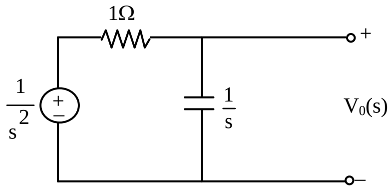
$$\phi_m = \sin^{-1}\left(\frac{a-1}{a+1}\right) = 55^\circ$$

26. Ans: (B)

Sol:



Converting into Laplace domain we get



$$V_0(s) = \frac{\frac{1}{s}\times\frac{1}{s^2}}{1+\frac{1}{s}} = \frac{1}{s^3\left(\frac{s+1}{s}\right)}$$

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

$$V_0(s) = \frac{A}{s}+\frac{B}{s^2}+\frac{C}{s+1}$$

$$B = \left.\frac{1}{s+1}\right|_{s=0} = 1$$

$$A = \left.\frac{dB}{ds}\right|_{s=0} = \left.\frac{(s+1)\times 0-1}{(s+1)^2}\right|_{s=0} = -1$$

$$C = \left.\frac{1}{s^2}\right|_{s=-1} = 1$$

$$V_0(s) = \frac{-1}{s}+\frac{1}{s^2}+\frac{1}{s+1}$$

Apply inverse Laplace transform on both sides

$V_0(t) = -u(t) + tu(t) + e^{-t}\,u(t)$

$V_0(t) = ((t-1)+e^{-t})u(t),\ \ t>0$

27. Ans: (B)

Sol:

- (SP) = 8086H
- (DE) = 8085H
- (HL) exchanged with (DE)

  After execution

  (HL) = 8085H, (DE) = ××××H

  (HL) = 8085H = 1000 0000 1000 0101
  (SP) = 8086H = 1000 0000 1000 0110
  (HL) = 010BH = 0000 0001 0000 1011

- (HL) = 010BH copied into (SP)

  ⇒ (SP) = 010BH

- 8085 microprocessor calls delay subroutine and after execution of subroutine, microprocessor returns to main program.

  SP contents decremented by 2 for CALL operation

  SP contents incremented by 2 for RETURN operation

  i.e., (SP) = 010BH –2+2
  = 010BH

- 8085 microprocessor pushes DE pair contents to stack. SP contents will be decremented by 2 for PUSH operation.

  (SP) = 010BH – 2 = 0109H

- 8085 microprocessor executes RST 7 software interrupt where it calls respective ISR and returns to main execution.

(SP) = 0109H – 2+2 = 0109H

- 8085 microprocessor contents of top 2 stack locations back into PSW. SP contents will be incremented by 2 for POP operation.

  (SP) = 0109H + 2 = 010BH

  (SP) = 010BH

28. Ans: (D)

Sol: Given curve 'C' is a closed curve.

So, we have to evaluate the integral by using Green's theorem.

By Green's theorem, we have

$$\oint_C (M\,dx + N\,dy) = \iint_R \left(\frac{\partial N}{\partial x} - \frac{\partial M}{\partial y}\right) dx\ dy$$

Now, $\oint_C [(x-y)dx + (x+3y)\,dy]$

$$= \iint_R \left[\frac{\partial}{\partial x}[x+3y] - \frac{\partial}{\partial y}(x-y)\right] dx\ dy$$

$$= \iint_R [1-(-1)]\,dx\,dy$$

$$= 2\iint_R 1\,dx\,dy = 2(\text{Area of the circle 'C'})$$

$= 2(\pi r^2)_{r=4} = 32\ \pi$

29. Ans: 18

Sol: As $\vec{G}$ is irrotational and hence $\nabla \times \vec{G} = 0$

i.e. $\begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ (axy+bz^3) & (3x^2-cz) & (3xz^2-y) \end{vmatrix} = 0.\hat{a}_x + 0.\hat{a}_y + 0.\hat{a}_z$

So, $-1+c = 0 \Rightarrow c = 1$

$3z^2 - 3bz^2 = 0 \Rightarrow b = 1$

$6x - ax = 0 \Rightarrow a = 6$

$\therefore a = 6, b = 1, c = 1$

$$\nabla.\vec{G} = \frac{\partial G_x}{\partial x} + \frac{\partial G_y}{\partial y} + \frac{\partial G_z}{\partial z}$$

$= ay + 6xz$

$$\nabla.\vec{G}\Big|_{(1,1,2)} = 6\times 1 + 6(1)(2)$$

$\therefore \nabla.\vec{G} = 18$

30. Ans: (B)

Sol: At no load power supplied

$P_{in0} = VI_{L0} = 400\times 2 = 800$ W

Shunt field current $I_{sh} = \dfrac{V}{R_{sh}} = \dfrac{400}{800} = 0.5A$

Armature current $I_{a0} = I_{L0} - I_{sh}$

$= 2 - 0.5 = 1.5A$

No load armature Cu loss

$= I_{a0}^2 R_a + I_{a0} \times$ brush drop

$= (1.5)^2 \times 0.6 + 1.5 \times 2 = 4.35$ W

Constant losses

$P_c = P_{in0}$ – no load armature copper loss

$= 800 - 4.35 = 795.65$W

At full load

Output power $P_{out} = 18000$ W

Let the armature current on full load be 'I_a' amp

$P_{in} = V \times (I_a + I_{sh}) = 400(I_a + 0.5)$

$P_{in} = P_{out}$ + armature Cu loss + constant loss

$400\,(I_a + 0.5) = 18{,}000 + I_a^2\,(0.6) + 795.65 + 2I_a$

$400\,I_a + 200 = 18{,}000 + I_a^2\,(0.6) + 795.65 + 2I_a$

$0.6I_a^2 - 398I_a + 18595.65 = 0$

$I_a = 612.75$ A impractical

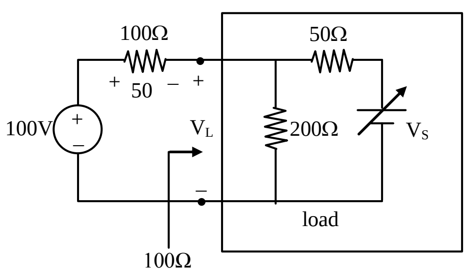
$I_a = 50.579$ A

$$\text{Motor } \eta = \frac{\text{motor output}}{\text{motor input}} \times 100$$

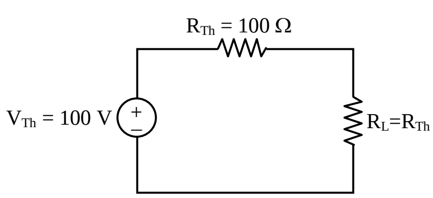
$$= \frac{18000}{20431.6} \times 100 = 88.09$$

31. Ans: 37.5 (Range 37 to 38)

Sol: Applying thevinin's theorem in the source side, the circuit can be redrawn as



We know that for maximum power transform, the load resistance is equal to thevinin's resistance.



Voltage drop across load, $V_L = \dfrac{V_{Th} \times R_{Th}}{R_{Th} + R_L}$

$$\Rightarrow V_L = \frac{V_{Th} \times R_{Th}}{2R_{Th}}$$

$$V_L = \frac{V_{Th}}{2}$$

Consider above figure, for maximum power transferred to load

$$V_L = \frac{V_{TH}}{2} = \frac{100}{2} = 50 \text{ Volts}$$

Applying nodal analysis, we get

$$\Rightarrow \frac{50}{100} = \frac{50}{200} + \frac{50 - V_s}{50}$$

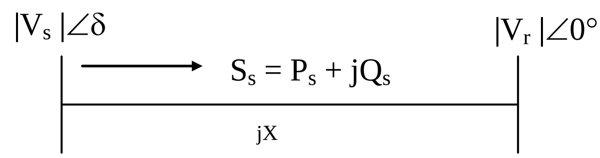
$$\Rightarrow \frac{50 - V_s}{50} = \frac{1}{4}$$

$\Rightarrow 50 - V_s = 12.5$

$\Rightarrow V_s = 37.5$ V

32. Ans: (C)

Sol:



At sending end side, complex power (S_s)

$S_s = V_s \,.\, I_s^*$

$$= |V_s|\angle\delta \left[\frac{|V_s|\angle\delta - |V_r|\angle 0°}{X\angle 90°}\right]^*$$

$$P_s + jQ_s = \frac{|V_s|^2}{X}\angle 90° - \frac{|V_s||V_r|}{X}\angle 90° + \delta$$

Sending end reactive power

$$Q_s = \frac{|V_s|^2}{X}\sin 90° - \frac{|V_s||V_r|}{X}\sin(90° + \delta)$$

$$Q_s = \frac{|V_s|^2}{X} - \frac{|V_s||V_r|}{X}\cos\delta$$

During maximum power transfer $\delta = 90°$

$$\therefore Q_s = \frac{|V_s|^2}{X}$$

$$Q_s = \frac{|V_r|^2}{X} \qquad (\because |V_s| = |V_r|)$$

At receiving end side, complex power (S_r)

$S_r = V_r.\ I_r^*$

$$= |V_r|\angle 0°\left[\frac{|V_s|\angle\delta - |V_r|\angle 0°}{|X|\angle 90°}\right]^*$$

$$P_r + j\,Q_r = \frac{|V_r||V_s|}{|X|}\angle 90° - \delta - \frac{|V_r|^2}{X}\angle 90°$$

Receiving end reactive power

$$Q_r = \frac{|V_r||V_s|}{|X|}\cos\delta - \frac{|V_r|^2}{X}\sin 90°$$

During maximum power transfer $\delta = 90°$

$Q_r = -\frac{V_r^2}{X}$ i.e., load must be able to deliver the reactive power.

So, During maximum power transfer condition, sink of the reactive power is only transmission line.

Total reactive power absorbed by the transmission line is

$Q_{line} = Q_s - Q_r$

$$= \left(\frac{V_r^2}{X}\right) - \left(-\frac{V_r^2}{X}\right)$$

$$Q_{line} = \frac{2V_r^2}{X} \qquad (\therefore |V_r| = |V_s| = V)$$

$$Q_{line} = \frac{2V^2}{X}$$

33. Ans: (B)

Sol: $f(t) = \left(-\frac{t}{T}+1\right)[u(t)-u(t-T)]$

$$f(t) = \left(-\frac{t}{T}\right)[u(t)-u(t-T)] + [u(t)-u(t-T)]$$

$$[u(t)-u(t-T)] \leftrightarrow \frac{1}{s} - \frac{e^{-sT}}{s}$$

From differentiation in s-domain property

$$\left(-\frac{t}{T}\right)[u(t)-u(t-T)] \leftrightarrow \frac{1}{T}\frac{d}{ds}\left(\frac{1}{s}-\frac{e^{-sT}}{s}\right)$$

$$= \frac{1}{T}\left[\frac{-1}{s^2} - \frac{\left(se^{-sT}(-T) - e^{-sT}\right)}{s^2}\right]$$

$$\left(-\frac{t}{T}\right)[u(t)-u(t-T)] \leftrightarrow \frac{1}{T}\left[\frac{-1}{s^2} + T\frac{e^{-sT}}{s} + \frac{e^{-sT}}{s^2}\right]$$

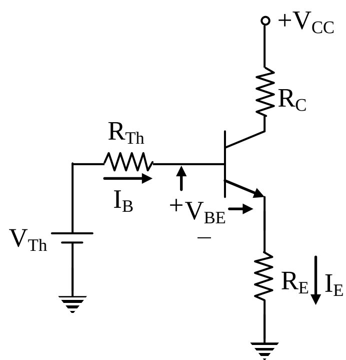
$$= \frac{e^{-sT}}{s} + \frac{e^{-sT}}{Ts^2} - \frac{1}{s^2T}$$

$$F(s) = \frac{1}{s} - \frac{e^{-sT}}{s} + \frac{e^{-sT}}{s} + \frac{e^{-sT}}{Ts^2} - \frac{1}{s^2T}$$

$$= \frac{1}{s} + \frac{e^{-sT}}{Ts^2} - \frac{1}{s^2T} = \frac{1}{s^2T}\left[sT - 1 + e^{-sT}\right]$$

34. Ans: 4.92 (4.5 to 5.5)

Sol:



fig(a): Thevenin equivalent of the given circuit

Step(1):

KVLfor the input loop of circuit shown in fig(a)

$V_{Th} - I_B R_{Th} - V_{BE} - I_E R_E = 0$ ------- (1)

$I_E = \dfrac{V_{Th} - V_{BE}}{R_E + \dfrac{R_{Th}}{1+\beta}}$ ---- (2) $\left[\because I_B = \dfrac{I_E}{1+\beta}\right]$

$V_{Th} = \dfrac{V_{CC} R_2}{R_1 + R_2}$

$R_{Th} = R_1 // R_2$

Step (2):

But $I_E R_E = \dfrac{V_{CC}}{3} = \left[\dfrac{V_{Th} - V_{BE}}{R_E + \dfrac{R_{Th}}{1+\beta}}\right] R_E$ ----- (3)

($\because$ Given that voltage drop across $R_E = \dfrac{V_{CC}}{3}$)

$$\left\{\frac{(V_{Th} - V_{BE})}{R_E\left[1 + \left(\dfrac{R_{Th}}{R_E}\right)\left(\dfrac{1}{1+\beta}\right)\right]}\right\} R_E = \frac{V_{CC}}{3} \text{ ------ (4)}$$

$$V_{Th} = \frac{V_{CC}}{3}\left[1 + \left(5.73 \times \frac{1}{101}\right)\right] + V_{BE} \text{ ---- (5)}$$

$V_{Th} = 4.92693V$ -------- (6)

35. Ans: 0.0045 (Range: 0.004 TO 0.005)

Sol: Let X = number of accidents between 5 P.M and 6 P.M.

For Poisson distribution,

$\lambda = np = (1000)(0.0001) = 0.1$

$P(X = x) = \dfrac{e^{-\lambda}.\lambda^x}{\angle x}$ (x = 0, 1, 2,……..)

Required Probability = $P(X \geq 2)$

$= 1 - P(X < 2)$

$= 1 - \{P(X = 0) + P(X = 1)\}$

$= 1 - e^{-0.1}(1 + 0.1)$

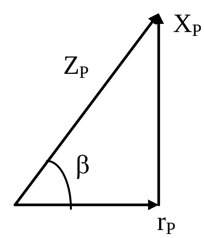
$= 0.0045$

36. Ans: (B)

Sol: Reactance of a pressure coil = 0.2% of its resistance

$\tan\beta = \dfrac{X_P}{r_p}$

$= \dfrac{0.002 r_p}{r_p}$



$\beta = \tan^{-1}(0.002)$

$= 0.1145$ rad

$\cos\phi = 0.707$

$\phi = \cos^{-1}(0.707) = 45^o$

Correction factor $= \dfrac{\cos\phi}{\cos\beta\cos(\phi - \beta)}$

$= \dfrac{0.707}{\cos(6.56).\cos(45^o - 6.56)}$

$= 0.9085$

$\therefore$ Correction factor = 0.9085

37. Ans: 33.66 (33.40 to 33.80)

Sol: Fig.1. Shows the circuit of the transmission line, transformer equivalent circuit referred.

hv and load referred hv. Numerical values are calculated using given data.

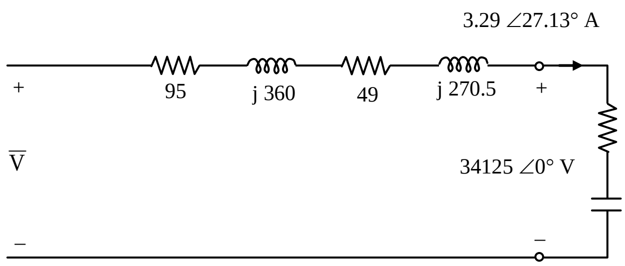


Fig.1

Transformation ratio k = $\left(\frac{35000}{2400}\right) = 14.58$

Equivalent impedance of transformer referred hv = $(0.23 + j1.27)k^2 = 49 + j270.5$

Load 100 kW at 0.89 leading & 2340 V

Load voltage reffered to hv

= $2340 \times \frac{35000}{2400} = 34{,}125\text{ V}$

P = VI cosϕ

$34125 \times I \times 0.89 = 100 \times 10^3$

$$I = \frac{100 \times 10^3}{34125 \times 0.89} = 3.29\text{A}$$

Phase angle, $\cos^{-1} 0.89 = 27.13$

$\overline{V} = 34125 + 3.29\angle 27.13°[144 + j630.5]$

$\overline{V} = 34125 + [2.92 + j1.5]\,[144 + j630.5]$

= 34125 – 524.28 + j2062.15

= 33600 + j2062

Magnitude = 33663 = 33.66 kV

38. Ans: (B)

Sol: For break point,

$\frac{dk}{ds} = 0$

$\frac{d}{ds}\left(\frac{1}{G(s)H(s)}\right) = 0$

$\frac{d}{ds}(s(s+6)(s^2+4s+13)) = 0$

$(s^2+6s)[2s+4]+(s^2+4s+13)[2s+6]=0$

$2s^3+16s^2+24s+2s^3+6s^2+8s^2+24s+26s+78=0$

$4s^3+30s^2+74s+78=0$

$f(s) = 2s^3+15s^2+37s+39 = 0$ -------(1)

f (–5)= –21

f (–4) = 3

f (–3) = 9

As there is a sign change in between –5, –4, one root is on real axis, which is in between –5, –4. Three real axis break points is not possible

39. Ans: (C)

Sol: $I_a = 1000\angle 0^o\text{ A}, I_b = I_c = 0$

Zero sequence component

$$I_{a0} = I_{b0} = I_{c0} = \frac{1}{3}[I_a + I_b + I_c]$$

$$= \frac{1}{3}[1000\angle 0^o]$$

$= 333.3\ \angle 0^o$

$$I_{a_1} = \frac{1}{3}[I_a + aI_b + a^2I_c] = 333.3\angle 0^o\text{ A}$$

$$I_{b_1} = a^2\,I_{a1} = 333.3\angle 240^o\text{ A}$$

$$I_{c_1} = a\,I_{a1} = 333.3\angle 120^o\text{ A}$$

$$I_{a_2} = \frac{1}{3}[I_a + a^2I_b + aI_c] = 333.3\angle 0^o\text{ A}$$

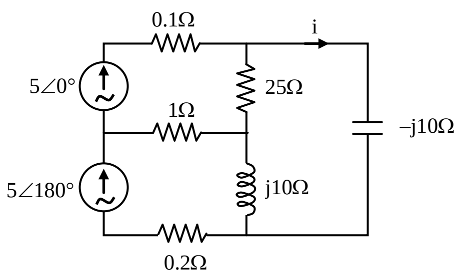
$I_{b_2} = a\, I_{a_2} = 333.3\angle 120^\circ$

$I_{c_2} = a^2\, I_{a_2} = 333.3\angle 240^\circ$

Hence option ‘c’ is correct.

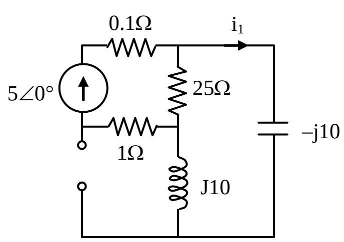
40. Ans: (B)

Sol:

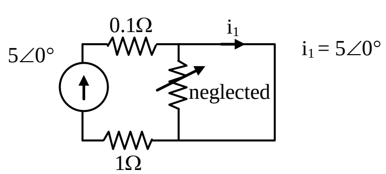


By super position principle $i = i_1 + i_{11}$

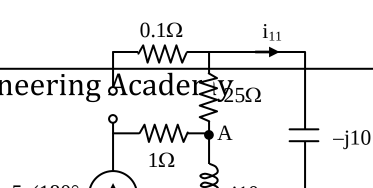
Current i_1: $5\angle 0^\circ$ source acting alone



$-j10 + j10 = 0\ \Omega$ (short circuit)



Current i_{11}: $5\angle 180^\circ$ source acting alone



By current division rule at node A

$$i_{11} = 5\angle 180^\circ \times \frac{j10}{25 + j10 - j10}$$

$$= 2j\angle 180^\circ$$

$$= -2j$$

$\therefore\ i = i_1 + i_{11} = 5 - 2j$ A

41. Ans: 16 (Range: 15.9 to 16.2)

Sol: $G(s)\,H(s) = \dfrac{10}{(s+2)^4}$

$$\angle G(j\omega)\,H(j\omega) = \angle \frac{10}{(j\omega + 2)^4}$$

Gain margin (GM) = 20 log $\dfrac{1}{\left|G(j\omega)H(j\omega)\right|_{\omega=\omega_{PC}}}$

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

$$\angle \frac{10}{(j\omega + 2)^4}\bigg|_{\omega=\omega_{pc}} = -180^\circ$$

$$-4\tan^{-1}\frac{\omega_{pc}}{2} = -180^\circ$$

$\Rightarrow \omega_{PC} = 2$

$$\left|G(j\omega)H(j\omega)\right|_{\omega=\omega_{PC}} = \left|\frac{10}{(j(2)+2)^4}\right|$$

$$= \frac{10}{\left(\sqrt{2^2 + 2^2}\right)^4} = \frac{10}{64}$$

$$\text{Gain margin} = 20\log\frac{64}{10}$$

$= 20[\log 64 - \log 10]$

$= 20\,[6\,(0.3) - 1]$

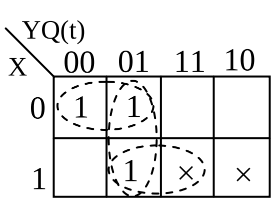
$= 16$ (Range: 15.9 to 16.2)

42. Ans: (C)

Sol: By giving different sets of input values and Q(t) (present state) we have to determine next state Q(t+1)

X	Y	Q(t)	S	R	Q(t+1)
0	0	0	1	0	1
0	0	1	1	0	1
0	1	0	0	1	0
0	1	1	0	1	0
1	0	0	0	0	0
1	0	1	0	0	1
1	1	0	1	1	×
1	1	1	1	1	×

K-map for Q (t + 1)



$\therefore\ Q(t+1) = \overline{X}\,\overline{Y} + \overline{Y}Q(t)$ or

$Q(t+1) = \overline{X}\,\overline{Y} + XQ(t)$

43. Ans: 0.2

Sol: Given that $\frac{dy}{dx} = x^3 - 2y$ $\quad (\because \frac{dy}{dx} = f(x, y))$

with y(0) = 0.25 $\quad (\because y(x_0) = y_0)$

Let $x_0 = 0$, $y_0 = 0.25$ & $h = 0.1$

Then $x_1 = x_0 + h = 0.1$

The formula for Euler's forward method is

$y(x_1) \simeq y_1 = y_0 + h\, f(x_0, y_0)$

$\Rightarrow y(0.1) \simeq y_1 = 0.25 + (0.1)\,(x_0^3 - 2y_0)$

$\Rightarrow y(0.1) \simeq y_1 = 0.25 + (0.1)\,[0 - 2(0.25)]$

$\therefore\ y(0.1) \simeq y_1 = 0.25 - (0.1)\,(0.5) = 0.25 - 0.05 = 0.2$

44. Ans:0 (No range)

Sol: $\delta(t^2 - a^2) = \frac{1}{2|a|}[\delta(t+a) + \delta(t-a)]$

$$I = \int_{-1}^{1} \frac{1}{4}[\delta(t-2) + \delta(t+2)]dt$$

$$I = \frac{1}{4}\int_{-1}^{1}\delta(t-2)dt + \frac{1}{4}\int_{-1}^{1}\delta(t+2)dt$$

From sifting property

$$\int_{t_1}^{t_2} x(t)\delta(t-t_0)dt = x(t_0) \quad t_1 \le t_0 \le t_2$$

$= 0$ otherwise

$I = 0 + 0 = 0$

45. Ans: 86.8°

Sol: The given output voltage waveform is having quarter wave symmetry,

$\therefore\ a_n = 0$

And $b_n = \frac{1}{\pi}\int_0^{2\pi} f(t)\sin(n\,\omega t)d\omega t$

$$= \frac{2}{\pi}\int_0^{\pi} f(t)\sin(n\,\omega t)d\omega t$$

For fundamental n = 1

$$\therefore b_1 = \frac{2V_{dc}}{\pi}\left[\int_0^{\alpha}\sin\omega t\,d\omega t - \int_{\alpha}^{\pi-\alpha}\sin\omega t\,d\omega t + \int_{\pi-\alpha}^{\pi}\sin\omega t\,d\omega t\right]$$

$$= \frac{2V_{dc}}{\pi}\left[\left|-\cos\omega t\right|_0^{\alpha} + \left|\cos\omega t\right|_{\alpha}^{\pi-\alpha} - \left|\cos\omega t\right|_{\pi-\alpha}^{\pi}\right]$$

$$= \frac{2V_{dc}}{\pi}[2 - 4\cos\alpha]$$

RMS value of fundamental output voltage can be

$$\Rightarrow \frac{2V_{dc}}{\pi\sqrt{2}}[2 - 4\cos\alpha] = 120\text{ V}$$

$\Rightarrow \cos\alpha = 0.056 \Rightarrow \alpha = 86.8^0$

46. Ans: (D)

Sol: $X(\omega) = \frac{1}{(2+j\omega)^2}$

$$H(\omega) = \frac{1}{4+j\omega}$$

$$Y(\omega) = X(\omega).H(\omega) = \frac{1}{(4+j\omega)(2+j\omega)^2}$$

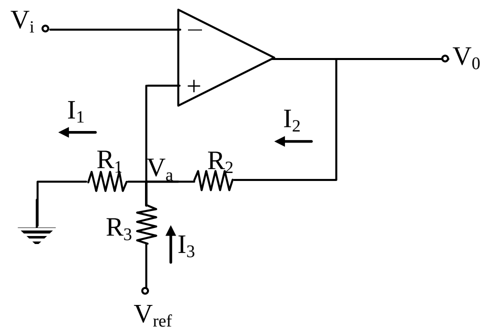
$$= \frac{1/4}{4+j\omega} - \frac{1/4}{2+j\omega} + \frac{1/2}{(2+j\omega)^2}$$

$$y(t) = \frac{1}{4}e^{-4t}u(t) - \frac{1}{4}e^{-2t}u(t) + \frac{1}{2}te^{-2t}u(t)$$

$$y(3) = \frac{1}{4}e^{-12} - \frac{1}{4}e^{-6} + \frac{3}{2}e^{-6} = \frac{1}{4}e^{-12} + \frac{5}{4}e^{-6}$$

47. Ans: 2.19 (2.18 to 2.20)

Sol: Apply KCL at V_a



$I_1 = I_2 + I_3$

$$\frac{V_a}{R_1} = \frac{V_{ref} - V_a}{R_3} + \frac{V_0 - V_a}{R_2}$$

$$V_a\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right] = \frac{V_{ref}}{R_3} + \frac{V_0}{R_2}$$

$V_a = V_{UTP}$ when $V_0 = +V_{sat}$

$V_a = V_{LTP}$ when $V_0 = -V_{sat}$

$$V_a = \frac{\frac{V_{ref}}{R_3} + \frac{V_{sat}}{R_2}}{\left[R_1^{-1} + R_2^{-1} + R_3^{-1}\right]}$$

$$V_{UTP} = \frac{\frac{-10}{10} + \frac{12}{50}}{\left[\frac{1}{10} + \frac{1}{10} + \frac{1}{50}\right]} = -3.4545\text{ V}$$

$V_{LTP} = -5.6363$ V

$V_H = V_{UTP} - V_{LTP}$

$V_H \approx 2.19$

48. Ans: 8021 (Range 8015 to 8030)

Sol: Given data: Number of poles = 12

Reactances of $X_d = 5\Omega$, $X_q = 3\Omega$.

Power factor is unity

$S = \sqrt{3}\, V_L I_L$

$\Rightarrow 20\times 10^6 = \sqrt{3} \times 11\times 10^3\ I_a$

$$I_a = \frac{20\times10^3}{\sqrt{3}\times11\times10^3} = 1049.72 \text{ A}$$

At unity power factor

$V\sin\delta = I_q X_q$

$I_q = I_a\cos\delta$

$I_d = I_a\sin\delta$

$\therefore\ V\sin\delta = (I_a\cos\delta)X_q$

$$\tan\delta = \frac{I_a X_q}{V} = \frac{1049.7\times3}{(11\times10^3)/\sqrt{3}} = 0.49585$$

$\delta = 26.4^o$

$I_q = I_a\cos\delta = 1049.72\cos26.4° = 940.3$

$I_d = I_a\sin\delta = 1049.72\sin26.4^o = 466.7$

Excitation voltage per phase,

$E = V\cos\delta + I_d X_d$

$$= \frac{11\times10^3}{\sqrt{3}}\cos26.4^o + 466.7\times5$$

$= 5688 + 2333.5$

$= 8021.5$ V

49. Ans: (B)

Sol: Given $v = y + e^{-x}\cos y$

$\Rightarrow v_x = -e^{-x}\cos(y)$ and $v_y = 1 - e^{-x}\sin(y)$

Consider $du = (u_x)\,dx + (u_y)\,dy$

$= (v_y)\,dx + (-v_x)\,dy$

$\Rightarrow du = (1 - e^{-x}\sin y)\,dx + (e^{-x}\cos y)\,dy$

$\Rightarrow \int du = \int (1 - e^{-x}\sin y)\,dx + \int 0\,dy + k$

$\Rightarrow u = x + e^{-x}\sin y + k$

Now the required analytic function f(z) is given by $f(z) = u + iv$

$\Rightarrow f(z) = (x + e^{-x}\sin y + k) + i(y + e^{-x}\cos y)$

$\therefore\ f(z) = z + ie^{-z} + k$

50. Ans: (D)

Sol: From Poisson's equation, we have

$$\nabla^2 V = -\frac{\rho_v}{\varepsilon_0}$$

$\rho_v = -\varepsilon_0\nabla^2 V$

$$\frac{\partial V}{\partial r} = \frac{-100\sin\theta}{r^3}$$

$$\frac{dV}{d\theta} = \frac{50\cos\theta}{r^2}, \frac{\partial V}{\partial\phi} = 0$$

So,

$$\overline{\nabla}^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial V}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial V}{\partial\theta}\right) + 0$$

$$= \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\times -\frac{100\sin\theta}{r^3}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\frac{\sin\theta\times50\cos\theta}{r^2}\right)$$

$$= \frac{1}{r^2}\times\frac{100\sin\theta}{r^2} + \frac{1}{r^4\sin\theta}\times50\cos2\theta$$

$$= \frac{100\sin\theta}{r^4} + \frac{50(1-2\sin^2\theta)}{r^4\sin\theta}$$

$$= \frac{50}{r^4\sin\theta}$$

Now, $\rho_v = -\varepsilon_0\ \nabla^2 V = -\varepsilon_0\dfrac{50}{r^4\sin\theta}$

So, $Q = \int \rho_v\, dv$

$$= \int_1^2\int_0^\pi\int_0^{2\pi} -\varepsilon_0\frac{50}{r^4\sin\theta}\times r^2\sin\theta\, dr\, d\theta\, d\phi$$

$$= -50\varepsilon_0 \int_1^2 \frac{dr}{r^2} \int_0^{\pi} d\theta \int_0^{2\pi} d\phi$$

$$= -50\varepsilon_0 \left[\frac{-1}{r}\right]_1^2 [\pi]\ [2\pi]$$

$$= -50\varepsilon_0 \times \frac{1}{2} \times 2\pi^2$$

$$= -50\varepsilon_0\ \pi^2 = -50 \times \frac{10^{-9}}{36\pi} \times \pi^2$$

$$= -\frac{50\pi}{36} \text{nC} = -4.36\text{nC}$$

51. (Range: 608 to 612)

Sol: Given:

Rating of transformers = 100 MVA at 220 kV

Magnetizing current interrupted at 44% of its peak value.

Capacitance = 2000 μF

And inductance L = 35 H

Full load transformer current

$$I_{fl} = \frac{100 \times 1000}{\sqrt{3} \times 220} = 262.43 \text{ A}$$

Magnetizing current $I_\mu = \frac{4}{100} \times I_{fl}$

$$= \frac{4}{100} \times 262.43$$

$$= 10.49 \text{ A}$$

Magnetizing current at the moment of interruption $i = \frac{44}{100} \times I_\mu$

$$= \frac{44 \times 10.49\text{A}}{100} = 4.61 \text{ A}$$

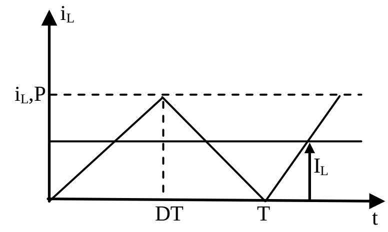
Now if V is the voltage that may appear across the circuit breaker contacts, then

$$V = i\sqrt{\frac{L}{C}} = 4.61\sqrt{\frac{35}{2000 \times 10^{-6}}}$$

$$= 609.8 \text{ V}$$

52. Ans: (D)

Sol: At boundary conditions, inductor current waveform is shown below:



$$I_L = \frac{1}{2} i_{L,p} = \frac{10}{2} = 5\text{A}$$

Average output voltage, $V_o = D \times V_{dc} = 0.2 \times 500 = 100$ V. As average inductor voltage is zero, $E = V_o = 100$ V

Power delivered to the battery = $I_L \times E = 5 \times 100 = 500\text{W}$

From 0 to *DT*, inductor current slope,

$$\frac{V_{dc} - E}{L} = \frac{i_{L,p}}{DT}$$

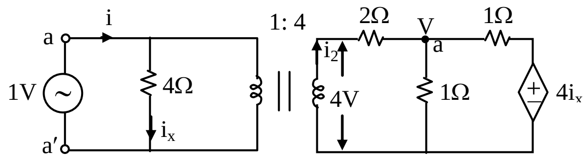
Conduction time of the switch,

$$DT = \frac{0.06 \times 10}{500 - 100} = 1.5\,\text{ms}$$

53. Ans: 171 (Range: 165 to 175)

Sol: Now 1V is applied at primary side a-a′

$R = \frac{1}{i}$



By transformation ratio

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

$\frac{V_2}{V_1} = k = 4$

$V_2 = 4V$

$i_x = \frac{1}{4}A$

Apply KCL at node-a,

$$\frac{V-4}{2} + \frac{V}{1} + \frac{V-4i_x}{1} = 0$$

$V–4+2V + 2V –8i_x = 0$

$5V = 4+8i_x = 4 + 8\frac{1}{4} = 6$

$V = \frac{6}{5}V$

i_2 is current flows through secondary winding then

$$i_2 = \frac{4-\frac{6}{5}}{2} = \frac{14}{10} = 1.4\,A$$

This i_2 transferred to primary then

$i_2' = 1.4 \times 4$

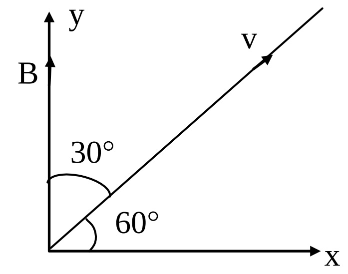
$\therefore\ i = i_x + i_2'$

$= \frac{1}{4} + 1.4 \times 4 = 5.85\ A$

$\therefore\ R = \frac{1}{i} = \frac{1}{5.85} = 171\ m\Omega$

54. Ans: (C)

Sol:



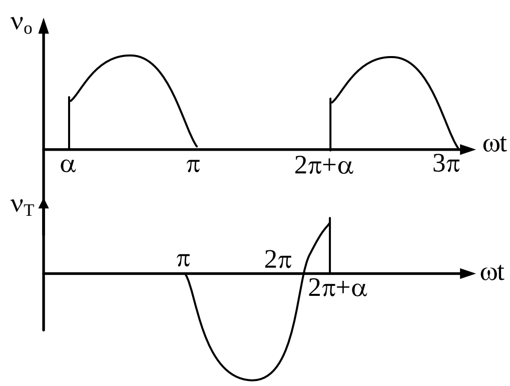
Angle between the B and v is 30°, so the path of the particle is helix.

$$T = \frac{2\pi m}{Bq} = \frac{2\pi \times 1.67 \times 10^{-27}}{0.104 \times 1.6 \times 10^{-19}} = 2\pi \times 10^{-7}\ \text{sec}$$

$$r = \frac{mv\sin\theta}{Bq} = \frac{1.67 \times 10^{-27} \times 2 \times 10^{6}}{1.6 \times 10^{-19} \times 0.104} \times \sin 30^\circ = 0.1m$$

55. Ans: 231.5 to 232.5

Sol: $V_S = 300$ V $R_L = 100\Omega$ $\alpha = 60^o$



Moving Iron voltmeter reads r.m.s value of voltage

When thyristor is ‘ON’ reading is zero

When thyristor is off

$$V_{r.m.s} = \left[\frac{1}{2\pi}\int_{\pi}^{2\pi+\alpha} V_m^2 \sin^2 \omega t \, d\omega t\right]^{\frac{1}{2}}$$

$$= \left[\frac{V_m^2}{2\pi}\int_{\pi}^{2\pi+\alpha} \frac{1-\cos 2\omega t}{2} d\omega t\right]^{\frac{1}{2}}$$

$$= \frac{V_m}{2\sqrt{\pi}}\left[\pi+\alpha-\frac{1}{2}\left(\sin 2(2\pi+\alpha)-\frac{1}{2}\sin 2\pi\right)\right]^{\frac{1}{2}}$$

$$= \frac{V_m}{2\sqrt{\pi}}\left[(\pi+\alpha)-\frac{1}{2}\sin 2\alpha\right]^{\frac{1}{2}}$$

$$= \frac{300\times\sqrt{2}}{2\sqrt{\pi}}\left[(\pi+60^\circ)\times\frac{\pi}{180}-\frac{1}{2}\sin\frac{2\pi}{3}\right]^{\frac{1}{2}}$$

$$= 231.94 \text{ V}$$