Branch: Electrical Engineering

Mock- E - Solutions

GATE-2020 General Aptitude (GA)

01. Ans: (C)

Sol: (passive voice - verb in past participle form).

02. Ans: (C)

Sol: 'between.... to' is wrong. 'between.......and'.

03. Ans: (D)

Sol: Suggestion is friendly/ smooth

Demand is unfriendly/Rough

Take is smooth

Grab is Rough

04. Ans: (C)

Sol: Let the four numbers be x, x + 2, x + 4, and x + 6.

$\Rightarrow x + x + 2 + x + 4 + x + 6 = 36$

$\Rightarrow 4x + 12 = 36$

$\Rightarrow x = 6$

Therefore, the numbers are 6, 8, 10 & 12.

Therefore, the sum of their squares = $6^2 + 8^2 + 10^2 + 12^2 = 36 + 64 + 100 + 144 = 344$.

05. Ans: (A)

Sol: We know that an ordinary year has 1 odd day and a leap year has 2 odd days.

During this period, namely 2005, 2006, 2007, 2008, 2009, 2010.

Total number of odd days = (1 + 1 + 1 + 2 + 1 + 1) days = 7 = 0 odd days.

Hence, the calendar for 2005 will serve for the year 2011 too.

06. Ans: (D)

Sol: The solution to this problem can be obtained only with more information like ratio of the length of the rectangle to its breadth.

07. Ans: (B)

Sol: Amount = $\left[7500\times\left(1+\frac{4}{100}\right)^2\right]$

$$= \left(7500\times\frac{26}{25}\times\frac{26}{25}\right)$$

$$= 8112$$

So, compound interest = (8112 – 7500)

= 612

08. Ans: (C)

Sol: Let their present ages be 6x and 7x respectively. Then, their age difference = 'x' years

i.e. 4 = 'x' years

$\therefore$ Their present ages are 24 & 28 respectively

Ratio of ages after 4years = 24 + 4 : 28 + 4 = 7 : 8

09. Ans: (B)

Sol: Expenditure in year 2016 (in 000') = 3800

Expenditure in year 2015 (in 000') = 3075

$\Rightarrow$ Required % increase

$$= \frac{(3800 - 3075)}{3075} \times 100$$

$$= \frac{725}{30.75} = \frac{29}{1.23} = 23.57\%$$

10. Ans: (B)

Specialization (EE)

01. Ans: 120 (No Range)

Sol: For fan load, $T \propto N_r^2$; $P \; \alpha \; N_r^3$

$$N_r \propto N_s \propto \frac{1}{P_{ok}}$$

$$P \propto \left(\frac{1}{P_{ok}}\right)^3$$

$\Rightarrow 15 \times (8)^3 = P_2 (4)^3$

$P_2 = 120$ kW

02. Ans: (A)

Sol: $P_{max} = \frac{|V_s||V_r|}{X_L} = \frac{1\times1}{0.1} = 10\text{p.u}$

For P_{max} $\delta = 90°$

$$(Q_r)_{pmax} = \frac{-V_r^2}{X_L} = \frac{-1^2}{0.1} = 10\text{p.u}$$

Line expecting reactive power from receiving end. So receiving end power factor is leading

$$P.f_r = \cos\tan^{-1}\left(\frac{Q_r}{P_{r\max}}\right)$$

$$Pf_r = \cos\left(\tan^{-1}\left(\frac{10}{10}\right)\right)$$

$= 0.707$ lead

03. Ans: (B)

Sol: $R_1 = 100\ \Omega \pm 10\% = 100 \pm 10\ \Omega$

$R_2 = 200\ \Omega \pm 10\% = 200 \pm 20\ \Omega$

If two resistances are connected in series,

Total resistance $R_T = R_1 + R_2$

$= 300 \pm 30\ \Omega$

04. Ans: 0 (Zero)

Sol: $V_0 = \sum_{n=1,3,5}^{\infty} \frac{2V_s}{n\pi}.\sin(n\omega t)$

$V_{04} = 0$

05. Ans: (A)

Sol: Here, element cannot be resistor as V and i are not proportional. Required element is inductor

For 0 < t < 2 ms

$\frac{di}{dt} = 5 \times 10^3$ A/s and V = 15 V

$\therefore L = \frac{V}{\frac{di}{dt}} = 3\,mH$

06. Ans: (C)

Sol: $\rho_v = \nabla.\vec{D}$

$$= \frac{1}{r^2 \sin\theta}\left[\frac{\partial}{\partial r}\left[r^2 \sin\theta\left(\frac{3r}{r^2+1}\right)\right]\right]$$

$$= \frac{1}{r^2}\left[\frac{(r^2+1)9r^2 - 3r^3(2r)}{(r^2+1)^2}\right]$$

$$= \frac{3(r^2+3)}{(r^2+1)^2}\ C/m^3$$

ρ_v at $\left(1, \frac{\pi}{3}, \frac{\pi}{2}\right) = 3\ C/m^3$

07. Ans: 2

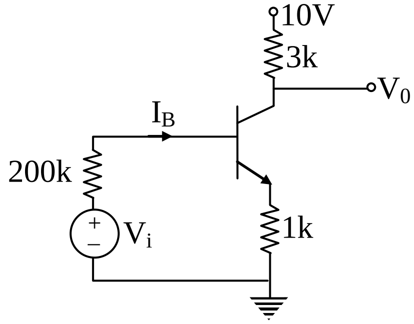
Sol: p = 3, z = 1

No. of asymptotes

= |p – z| = 2

08. Ans: 5.7 (5.5 to 6.0)

Sol:



$$I_B = \frac{V_i - V_{BE}}{[200 + 1(1+\beta)] \times 10^3}$$

$= 14.28\mu A$

$I_C = \beta I_B = 1.428mA$, $I_E = (1+\beta)I_B$

$= 1.4428mA$

$V_0 = 10 - 3\,I_C = 5.716V$

$\therefore V_0 = 5.716V$

09. Ans: (D)

Sol: $\overline{\overline{X + \overline{Y} + \overline{X}}} = \overline{\overline{X}Y + \overline{X}} = X$

10. Ans: (A)

Sol: It is a finite duration signal extending from 0 to 4.

All finite duration signals are energy signals but not vice-versa.

11. Ans: (D)

12. Ans: (D)

Sol:

- Closed loop systems accuracy is very high due to correction of any arising error.
- Closed loop systems have high bandwidth, i.e., high operating frequency zone.
- Tendency towards oscillations if feedback is not properly utilised.

13. Ans: (B)

Sol: $\because\ L^{-1}\left\{\frac{\bar{f}(S)}{S}\right\} = \int_0^t L^{-1}\{\bar{f}(S)\}dt$

Now,

$$L^{-1}\left\{\frac{1}{S(S-1)}\right\} = L^{-1}\left\{\frac{\frac{1}{S-1}}{S}\right\} = \int_0^t L^{-1}\left\{\frac{1}{S-1}\right\}dt$$

$$\Rightarrow L^{-1}\left\{\frac{1}{S(S-1)}\right\} = \int_0^t e^t dt$$

$$\therefore L^{-1}\left\{\frac{1}{S(S-1)}\right\} = \left(e^t\right)_0^t = e^t - 1$$

14. Ans: (C)

Sol: Given x(t) = 3 sin(2t)

Input frequency is ω = 2

$$H(2) = \frac{4}{2+j2} = 1.4142\angle -45°$$

If input is the form x(t) = Asin(ω_0t +ϕ). Then output is the form

y(t) = A|H(ω_0)| sin(ω_0t + ϕ + ∠H(ω_0))

y(t) = (3) (1.4142)sin(2t – 45°) = 4.2426 sin(2t – 45°)

15. Ans: 125 no range

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

$\because\ |adj(A_{n\times n})| = |A|^{n-1}$

$\Rightarrow |adj(A_{4\times4})| = |A|^{4-1}$ for n = 4

$\therefore |adj(A_{4\times4})| = |A|^3 = 5^3 = 125$

16. Ans: (A)

Sol: At normal excitation, no load condition δ = 0, E = V

As load increases ‘δ’ increases then

Ecosδ < V ⇒ under excitation

∴ Lagging pf, absorb Reactive power.

17. Ans: 1.8

$$H_{eq} = \frac{KE_1 + KE_2}{G_{base}} = \frac{500+400}{500} = 1.8MJ/MVA$$

18. Ans: (B)

Sol: Given

$$(4)\frac{\partial^2 u}{\partial x^2} + (-3)\frac{\partial^2 u}{\partial x\partial y} + (1)\frac{\partial^2 u}{\partial y^2} + (5)u = 0$$

If we compare the given partial differential equation with general partial differential equation

$$A\frac{\partial^2 u}{\partial x^2} + B\frac{\partial^2 u}{\partial x\partial y} + C\frac{\partial^2 u}{\partial y^2} + D\frac{\partial u}{\partial x} + E\frac{\partial u}{\partial x} + Fu = Q$$

then

we get A = 4, B = – 3 and C = 1

If $B^2 - 4AC < 0$ then the partial different equation is said to be elliptic type.

Here, $B^2 - 4AC = (-3)^2 - 4(4)(1) = -7 < 0$

∴ The given partial differential equation is elliptic type.

19. Ans: 10 A

Sol: for t ≥ 0

$$i_c = V_{co}\sqrt{\frac{C}{L}}\sin\frac{t}{\sqrt{LC}}$$

$I_c = 10 \sin(10^4 t)$

Peak value = 10 A

20. Ans: (D)

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

$$= -V_0\left[\left(\frac{\pi}{4}\right)e^{-z}\cos\left(\frac{\pi y}{4}\right)\hat{a}_y + (-1)e^{-z}\sin\left(\frac{\pi y}{4}\right)\hat{a}_z\right]$$

$$= V_0\left[-e^{-z}\left(\frac{\pi}{4}\right)\cos\left(\frac{\pi y}{4}\right)\hat{a}_y + e^{-z}\sin\left(\frac{\pi y}{4}\right)\hat{a}_z\right]$$

$\therefore$ Electric field intensity at (0, 1, 1) is given by

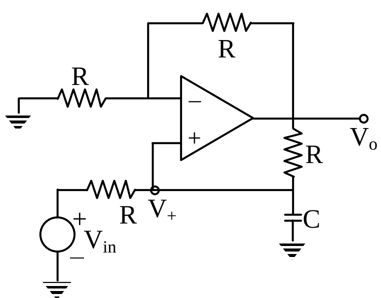
$$\vec{E} = \frac{V_0}{\sqrt{2}\,e}\left[\hat{a}_z - \frac{\pi}{4}\hat{a}_y\right] \text{ V/m}$$

21. Ans: 0.38 (Range: 0.37 to 0.39)

Sol: $\frac{C}{R} = \left(\frac{8}{1+8(2)}\right)\left(\frac{4}{1+4}\right) = \frac{32}{85} = 0.376$

22. Ans: (C)

Sol:



$$V_- = V_+ = \frac{V_o}{2}$$

KCL

$$\frac{(V_+) - V_{in}}{R} + \frac{V_+}{\frac{1}{SC}} + \frac{(V_+) - V_o}{R} = 0$$

$$\rightarrow \frac{V_o}{V_{in}} = \frac{2}{SCR}$$

This is a non inverting integrator

23. Ans: (D)

Sol: $\omega_0 = \frac{3\pi^2}{4}$

$$\frac{\omega_0}{2\pi} = \frac{3\pi}{8}$$

It is a irrational number.

So, non periodic signal.

24. Ans: (C)

Sol: Given that $u = \frac{x^{3/2} + y^{3/2}}{4x - y}$

$\Rightarrow$ u(x, y) is a homogenous function with degree $n = \frac{3}{2} - 1 = \frac{1}{2}$

By Euler's theorem for homogeneous functions, we have the following result.

If u = f(x, y) is a homogeneous function with degree 'n' in x and y then

$$x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = n.u$$

$$\therefore\ x\frac{\partial u}{\partial x} + y\frac{\partial u}{\partial y} = \frac{1}{2}u$$

25. Ans: (B)

Sol: P(x = 2) = P(x = 3)

$$\frac{\lambda^2 e^{-\lambda}}{2!} = \frac{\lambda^3 e^{-\lambda}}{3!}$$

$$\frac{\lambda^2 e^{-\lambda}}{2} = \frac{(\lambda^2)(\lambda)e^{-\lambda}}{6}$$

$\Rightarrow \lambda = 3$

$P(x \neq 0) = 1 - P(x = 0)$

$$= 1 - \frac{\lambda^0 e^{-\lambda}}{0!} = 1 - e^{-3}$$

26. Ans: 88.29 (Range: 88 to 89)

Sol: Torque constant $T_2 = T_1$

$$\phi_2 I_{a_2} = \phi_1 I_{a_1}$$

$$\Rightarrow I_{sh_2} I_{a_2} = I_{sh_1} I_{a_1}$$

$$I_{sh_1} = \frac{V}{R_{sh}} = \frac{250}{250} = 1A$$

$$I_{sh_2} I_{a_2} = 1 \times 20$$

$$I_{a_2} = \frac{20}{I_{sh_2}}$$

$$E_{b_1} = V - I_{a_1} R_a = 250 - 20 \times 0.5 = 240 \text{ A}$$

$$E_{b_2} = V - I_{a_2} R_a = 250 - \frac{20}{I_{sh2}} \times 0.5$$

$$= 250 - \frac{10}{I_{sh_2}}$$

$$\frac{E_{b_2}}{E_{b_1}} = \frac{I_{sh_2} \times N_2}{I_{sh_1} \times N_1} \Rightarrow \frac{250 - \frac{10}{I_{sh_2}}}{240} = \frac{I_{sh_2} \times 800}{1 \times 600}$$

$$= 250 - \frac{10}{I_{sh_2}} = 320\ I_{sh_2}$$

$$\Rightarrow 32\ I_{sh_2}^2 - 25\ I_{sh_2} + 1 = 0$$

$$I_{sh_2} = \frac{25 \pm \sqrt{25^2 - 4 \times 32 \times 1}}{2 \times 32}$$

I_{sh_2} = 0.739 A or (0.0422 A is too low)

$$I_{sh_2} = 0.739 A = \frac{V}{R_{sh_2}} = \frac{250}{R_{sh_2}}$$

$$R_{sh_2} = \frac{250}{0.739} = 338.29\ \Omega$$

Resistance to be added = 338.29 – 250

= 88.29 Ω

27. Ans: (B)

Sol: $$SIL_1 = \frac{V^2}{Z_{c1}} = 640\,MW$$

$$SIL_2 = \frac{V^2}{Z_{c2}} = 640 \times 1.3 MW$$

$$\frac{V^2}{Z_{c1} \cdot \sqrt{\frac{1-k_{se}}{1-k_{sh}}}} = 640 \times 1.3$$

$$\sqrt{\frac{1-k_{se}}{1-k_{sh}}} = \frac{1}{1.3}$$

= 0.769

To meet this equation k_{sh}= 0, $k_{se} \neq 0$

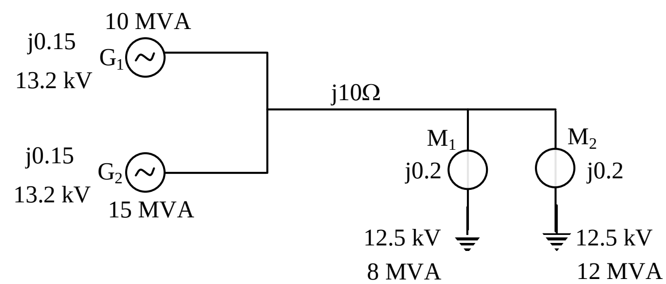
So, $\sqrt{1-k_{se}} = 0.769$

K_{se} = 0.408

% series compensation = 40.8%

28. Ans: (C)

Sol: Base: 50 MVA, 13.8 kV



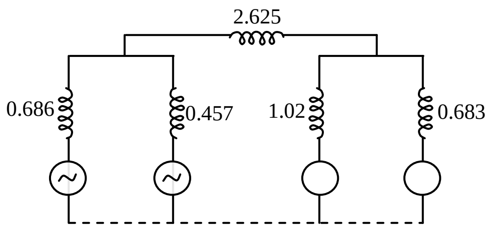
$$X_{G_1} = j0.15 \times \frac{50}{10} \times \left(\frac{13.2}{13.8}\right)^2 = j0.686$$

$$X_{G_2} = j0.15 \times \frac{50}{15} \times \left(\frac{13.2}{13.8}\right)^2 = j0.457$$

$$X_{T.L} = \frac{10 \times 50}{(13.8)^2} = 2.625$$

$$X_{M_1} = 0.2 \times \left(\frac{50}{8}\right) \times \left(\frac{12.5}{13.8}\right)^2 = 1.02$$

$$X_{M_2} = 0.2\times\left(\frac{50}{12}\right)\times\left(\frac{12.5}{13.8}\right)^2 = 0.683$$



29. Ans: 0.36 (Range: 0.2 to 0.5)

Sol: I = 0.3 A, M = $800\sin\left(\theta-\frac{2\pi}{9}\right)$ μH.

$\theta = 100° = \frac{5\pi}{9}$ rad

For EDM instrument, $T_d = I^2\frac{dM}{d\theta}$

$= (0.3)^2\times 800\cos\left(\frac{5\pi}{9}-\frac{2\pi}{9}\right)$

= 36 μNm.

Now, controlling torque $T_C = K\theta$

At balance condition, $T_d = T_C$

$K = \frac{36}{100}$ μNm/degree

= 0.36μNm/degree

30. Ans: 30 Amp

Sol: $\Rightarrow V_0 = \frac{2V_m}{\pi}\cos\alpha = \frac{2\times 200\pi}{\pi}\cos120°$

$V_0 = -200$ volt

$P_0 = V_0I_0 = 6000$ W

$$I_0 = \frac{6000}{200} = 30\,\text{Amp}$$

31. Ans: (D)

Sol: Let f(z) = $\frac{e^z+\sin(z)}{\left(z-\frac{\pi}{2}\right)^4} = \frac{\phi(z)}{(z-z_o)^{n+1}}$

Then the singular point of f(z) is $z=\frac{\pi}{2}$

Here, the singular point $z=\frac{\pi}{2}$ lies in the given region $\left|z-\frac{\pi}{2}\right| = 4$

Now, we can evaluate the given integral by using Cauchy's integral formula

i.e $\oint_C f(z)\,dz = \oint_C \frac{\phi(z)}{(z-z_o)^{n+1}}dz = \frac{2\pi i}{n!}\phi^{(n)}(z_o)$

$\Rightarrow \oint_C f(z)dz = \oint_c \frac{e^z+\sin(z)}{\left(z-\frac{\pi}{2}\right)^{3+1}}dz$

$\Rightarrow \oint_c f(z)dz = \frac{2\pi i}{3!}\phi'''\left(\frac{\pi}{2}\right) = \frac{2\pi i}{6}(e^z-\cos z)_{z=\frac{\pi}{2}}$

$\therefore \oint_c f(z)dz = \frac{\pi i}{3}e^{\pi/2}$

32. Ans: (A)

Sol: Given that $\bar{f} = x^2\,\bar{i}+y^2\,\bar{j}+z^2\,\bar{k}$

New, (W.D) Work done

$= \int_c \bar{f}.d\bar{r}$ where $\bar{f} = f_1\,\bar{i}+f_2\,\bar{j}+f_3\,\bar{k}$ &

$\bar{r} = x\,\bar{i}+y\,\bar{j}+z\,\bar{k}$

$\Rightarrow$ W.D = $\int_A^B [f_1dx+f_2dy+f_3dz]$

$\Rightarrow$ W. D = $\int_{(0,0,0)}^{(3,6,10)}[x^2dx+y^2dy+z^2dz]$

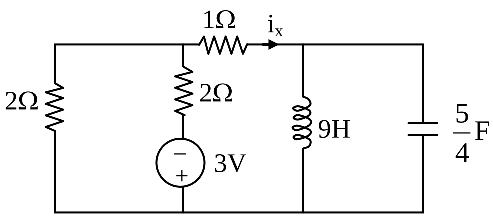
$$\Rightarrow \text{W.D} = \left(\frac{x^3}{3} + \frac{y^3}{3} + \frac{z^3}{3}\right)_{(0,0,0)}^{(3,6,10)}$$

$$= \frac{(3)^3}{3} + \frac{(6)^3}{3} + \frac{(10)^3}{3}$$

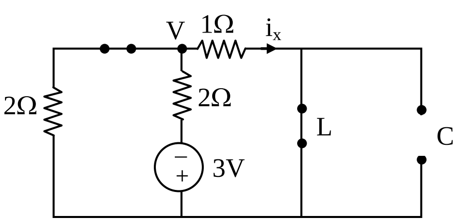
$$\therefore \text{W.D} = \frac{1243}{3}$$

33. Ans: (D)

Sol: At t = 0^-, the circuit is as shown below



Assume up to t = 0^-, the circuit is in steady state then the equivalent circuit is



Applying nodal analysis,

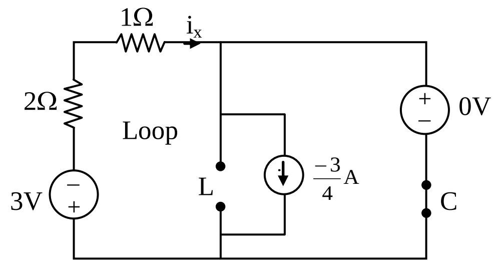
$$\Rightarrow \frac{V}{2} + \frac{V+3}{2} + \frac{V}{1} = 0$$

$$\Rightarrow V = \frac{-3}{4} V$$

$$\therefore i_x = \frac{V}{1} = \frac{-3}{4} A$$

$$\Rightarrow i_L(0^-) = i_x = \frac{-3}{4} A \text{ and } V_c\,(0^-) = 0V$$

At t = 0^+ the circuit becomes



Applying kVL for the outer loop

$\Rightarrow$ 3+3i_x +0 = 0

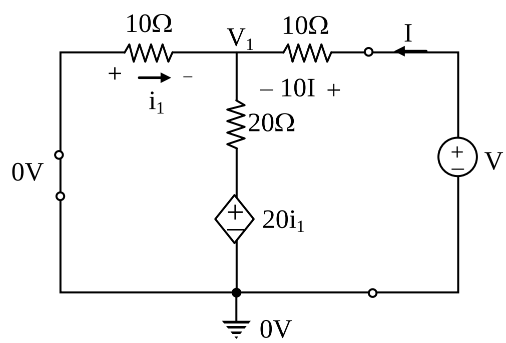
$\Rightarrow i_x$ = – 1A

$\therefore$ i_x at t = 0^+ is –1A

34. Ans: 14

Sol: $\tau = R_{eq}$ C sec

Evaluation of R_{eq}:



By KVL $\Rightarrow$ 0 – 10i_1 –V_1 = 0 $\Rightarrow V_1 = -10i_1$ …… (1)

By KVL $\Rightarrow V_1$ +10I –V=0$\Rightarrow V_1$ = V–10I…… (2)

$$\text{Nodal} \Rightarrow -i_1 + \frac{V_1 - 20i_1}{20} - I = 0$$

$\Rightarrow -40i_1 + V_1 = 20I$

$\Rightarrow V_1 = 4I$

$$\Rightarrow V - 10I = 4I \Rightarrow V = 14I \Rightarrow \frac{V}{I} = R_{eq} = 14$$

So, $\tau = R_{eq}C = 14 \times 1\mu F = 14\mu sec$

35. Ans: (A)

Sol:

$$\begin{bmatrix} D_x \\ D_y \\ D_z \end{bmatrix} = \varepsilon_0 \begin{bmatrix} 3 & 1 & 1 \\ 1 & 3 & 1 \\ 1 & 1 & 3 \end{bmatrix} \begin{bmatrix} 2 \\ 2 \\ 0 \end{bmatrix}$$

$D_x = \varepsilon_0$ [6+2]

$D_y = \varepsilon_0$ [2+6]

$D_z = \varepsilon_0$ [2+2]

$\Rightarrow D = D_x + D_y + D_z$

$= 8\varepsilon_0 \hat{a}_x + 8\varepsilon_0 \hat{a}_y + 4\varepsilon_0 \hat{a}_z$

36. Ans: 0.43 (range 0.42 to 0.44)

Sol: $\frac{C(s)}{R(s)} = \frac{1}{1+Ts}$

$C(s) = \frac{6}{1+Ts}$

$C(t) = \frac{6}{T} e^{-t/T}$

At t = 0, C (t) = 6/T = 4 $\Rightarrow$ T = 3/2

At t = t_1,

$3 = \frac{6}{T} e^{-t_1/T}$

$3 = \frac{2}{3} \times 6 e^{-t_1/T}$

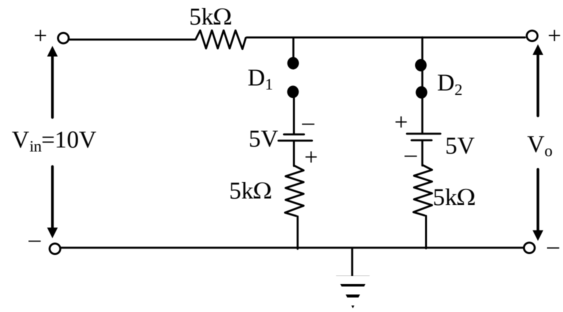
$3 = \frac{2}{3} \times 6 e^{-t_1 2/3}$

$\frac{3}{4} = e^{-2t_1/3}$

$\Rightarrow t_1 = 0.43$ sec.

37. Ans: 0.5

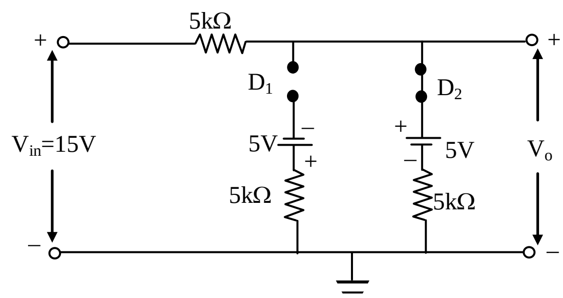
Sol: When V_{in}=10V, 'D_1' OFF & 'D_2' ON



$\therefore I_{D_2} = \frac{10-5}{10k} = 0.5mA$

$\Rightarrow V_0 = 5 + 5\,k.\, I_{D_2} = 5 + 5k\,.(0.5\text{ mA}) = 7.5V$

When V_{in} = 15V, 'D_1' OFF & 'D_2' ON



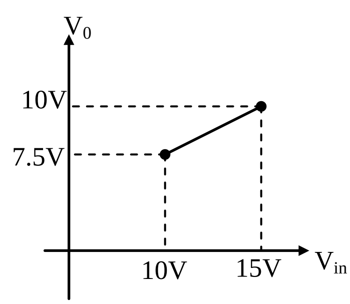
$\therefore I_{D_2} = \frac{15-5}{10k} = \frac{10}{10k} = 1mA$

$\Rightarrow V_0 = 5 + 5k\,(I_{D_2})$

$= 5 + 5k$ (1mA)

$= 5 + 5$

$\therefore V_0 = 10V$



The slope of transfer characteristics

$= \frac{10-7.5}{15-10} = \frac{1}{2}$ =0.5

38. Ans: (D)

Sol: Excess-3 code never depends on BCO, where it was depends only on BCD and was obtained by adding 3 to each BCD digit.

Hence convert $(100\ 101\ 011)_{BCO}$ into BCD & add 3 to each digit.

$(100\ 101\ 011)_{BCO} = (453)_8 = (299)_{10}$

$= (0101\ 1100\ 1100)_{EX-3}$

39. Ans: (A)

Sol: $e^{-a|t|} \leftrightarrow \dfrac{2a}{a^2+\omega^2}$

$e^{-|t|} \leftrightarrow \dfrac{2}{1+\omega^2}$

From multiplication of 't' in time domain property

$tx(t) \leftrightarrow j\dfrac{d}{d\omega}[X(\omega)]$

$te^{-|t|} \leftrightarrow j\dfrac{d}{d\omega}\left[\dfrac{2}{1+\omega^2}\right]$

$te^{-|t|} \leftrightarrow j\left[\dfrac{-2(2\omega)}{(1+\omega^2)^2}\right]$

$te^{-|t|} \leftrightarrow \dfrac{-4j\omega}{(1+\omega^2)^2}$

40. Ans: (A)

Sol: Given $(x^2D^2 - 2xD + 2)\,y = 8$ ----- (1),

where $D = \dfrac{d}{dx}$

Let $x = e^z$ (or) $\log x = z$
and $xD = \theta,\ x^2D^2 = \theta(\theta-1)$ } .... (2)

where $\theta = \dfrac{d}{dz}$

Put (2) in (1), we get

$[\theta(\theta-1) - 2\theta + 2]\,y = 8$

$\Rightarrow (\theta^2 - 3\theta + 2)\,y = 8$

$\Rightarrow f(\theta)\,y = Q(z)$

Where $f(\theta) = \theta^2 - 3\theta + 2$ & $Q(z) = 8$

C.F:

Consider auxiliary equation $f(m) = 0$

$\Rightarrow m^2 - 3m + 2 = 0$

$\Rightarrow m = 1, 2$

$\therefore$ The complementary function is

$y_c = c_1e^z + c_2e^{2z} = c_1x + c_2x^2$

P.I:

$\because Q(z) = 8 = 8e^{0z+0}$ $(\therefore Q(z) = ke^{az+b})$

Here, $f(\theta) = f(a) = f(0) = (0)^2 - 3(0) + 2 = 2 \neq 0$

$\therefore$ The particular integral is

$y_p = \dfrac{1}{f(a)}Q(z) = \dfrac{1}{2}(8) = 4$

Hence, the general solution of the given differential equation is $y = y_c + y_p = c_1x + c_2x^2 + 4$

41. Ans: (A)

Sol: Given $f(x, y) = 4x^2 + 9y^2 + 8x - 36y + 24$

$\Rightarrow p = f_x = 8x + 8$, $q = f_y = 18y - 36$

and $r = f_{xx} = 8$, $s = f_{xy} = 0$, $t = f_{yy} = 18$

consider $p = 0$ and $q = 0$ for stationary points

$\Rightarrow 8x + 8 = 0$ & $18y - 36 = 0$

$\Rightarrow x = -1$ & $y = 2$

$\therefore$ (x, y) = (–1, 2) is a critical point of f(x, y)

At (x, y) = (–1, 2), r = 8 , s = 0 & t = 18

Here, $rt - s^2 = (8)(18) - (0)^2 = 144$

and $r = 8 > 0$

$\therefore$ (x, y) = (–1, 2) is a local point of minima.

Hence, the minimum value of the function f(x, y) at (–1, 2) is f(–1, 2) = –16

42. Ans: 3

Sol: $n = \frac{T_{sweep}}{T_{signal}}$

$$= \frac{Total 10 div \times 3 \frac{ms}{div}}{\frac{1}{100 Hz}}$$

($\because$ 200 πt means f_{signal} =100 Hz)

$$= 10 \text{ div} \times 3 \frac{m\sec}{div} \times 100 \frac{cycles}{\sec}$$

$= 3000 \times 10^{-3}$ cycles

= 3 cycles

43. Ans: (A)

Sol: $P(P) = P(Q) = P(R) = P(S) = \frac{1}{6}$

$P = P(P^C)P(Q^C)P(R^C)P(S) + P(P^C)P(Q^C)P(R^C)P(S^C)P(P^C)P(Q^C)P(R^C)P(S) + \ldots\ldots\ldots\ldots$

$$= \frac{1}{6}\left(\frac{5}{6}\right)^3 + \left(\frac{1}{6}\right)\left(\frac{5}{6}\right)^7 + \ldots\ldots\ldots\ldots$$

$$= \left(\frac{1}{6}\right)\left(\frac{5}{3}\right)^3 \left\{1 + \left(\frac{5}{6}\right)^4 + \left(\frac{5}{6}\right)^8 + \ldots\ldots\ldots\right\}$$

$$= \left(\frac{1}{6}\right)\left(\frac{5}{6}\right)^3 \left\{\frac{1}{1-\left(\frac{5}{6}\right)^4}\right\}$$

$$= \left(\frac{1}{6}\right)\left(\frac{5}{6}\right)^3 \left\{\frac{6^4}{6^4 - 5^4}\right\}$$

$$= \left(\frac{1}{6}\right)\left(\frac{5^3}{6^3}\right) \left\{\frac{6^4}{6^4 - 5^4}\right\}$$

$$= \frac{125}{671}$$

44. Ans: (A)

Sol: MMF balance requires that

$$N_1\bar{I}_1 = N_2\bar{I}_2 + N_3\bar{I}_3$$

$$N_1\bar{I}_1 = N_1\bar{I}_2 + \frac{1}{2}N_1\bar{I}_3$$

Or

$$\bar{I}_1 = \bar{I}_2 + \frac{1}{2}\bar{I}_3 \quad \ldots\ldots\ldots\ldots\ (1)$$

Since the value of flux through all three coils is identical, $\bar{V}_1 = \bar{V}_2 = 2\bar{V}_3$.

By Ohm's law, $\bar{I}_2 = \frac{\bar{V}_2}{R} = \frac{\bar{V}_1}{R}$ ……….. (2)

$$\bar{I}_3 = \frac{\bar{V}_3}{R} = \frac{\bar{V}_1}{2R} \quad \ldots\ldots\ldots\ldots\ (3)$$

Use (2) and (3) in (1) to find

$$\bar{I}_1 = \frac{\bar{V}_1}{R} + \frac{\bar{V}_1}{4R} = \frac{5V_1}{4R}$$

Hence,

$$Z_1 = \frac{\bar{V}_1}{\bar{I}_1} = \frac{4}{5}R$$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45. Ans: 52.35 Range (50 to 55)

Sol: Without capacitor:

Total P_{old} = 150 kW

$$\text{Total } Q_{old} = \frac{100}{0.8}\times 0.6 + \frac{50}{0.707}\times 0.707$$

$$= 125 \text{ kVAr}$$

To make overall pf to be 0.9 lag, after keeping capacitor

$$\cos\phi_{new} = \frac{P}{\sqrt{P^2 + Q_{new}^2}}$$

$$0.9 = \frac{150}{\sqrt{150^2 + Q_{new}^2}}$$

Q_{new}= 72.65 kVAr

Now capacitor bank rating, $Q_c = Q_{old} - Q_{new}$

=52.35kVAr

46. Ans: (B)

Sol: Conduction of FD each time = conduction of each SCR

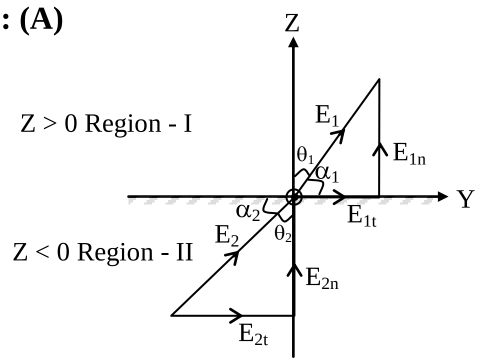
$\alpha - 30 = 150 - \alpha$

$\alpha = 90°$

$$\frac{(i_T)_{rms}}{(i_{FD})_{rms}} = \frac{I_0\sqrt{\frac{150-\alpha}{360}}}{I_0\sqrt{\frac{\alpha-30}{120}}} = \frac{\frac{1}{\sqrt{6}}}{\frac{1}{\sqrt{2}}} = \frac{\frac{1}{\sqrt{2}\sqrt{3}}}{\frac{1}{\sqrt{2}}} = \frac{1}{\sqrt{3}}$$

47. Ans: (A)

Sol:



The tangential component in region I is

$$\overline{E}_{1t} = 3\hat{a}_x + 5\hat{a}_y$$

The normal component in region I is

$$\overline{E}_{1n} = 2\hat{a}_z$$

The tangential component of the second region is

$$\overline{E}_{2t} = \overline{E}_{1t} = 3\hat{a}_x + 5\hat{a}_y$$

For free of charge $\overline{D}_{2n} = \overline{D}_{1n}$

$$\varepsilon_{r_2}\overline{E}_{2n} = \varepsilon_{r_1}\overline{E}_{1n}$$

$$\overline{E}_{2n} = \frac{\varepsilon_{r_1}}{\varepsilon_{r_2}}\overline{E}_{1n}$$

$$= \frac{2}{4}\times 2\hat{a}_z$$

$$\therefore \hat{E}_{2n} = 1\hat{a}_z$$

$$\tan\theta_2 = \frac{E_{2t}}{E_{2n}} = \frac{\sqrt{3^2+5^2}}{1} = \sqrt{34}$$

$$\therefore \theta_2 = \tan^{-1}\left(\sqrt{34}\right) = 80.27^\circ$$

$$\therefore \alpha_2 = 90 - \theta_2 = 9.73^\circ$$

$$\tan\alpha_1 = \frac{E_{1n}}{E_{1t}} = \frac{2}{\sqrt{3^2+5^2}} = \frac{2}{\sqrt{34}} = 0.343$$

$$\therefore \alpha_1 = \tan^{-1}(0.343) = 18.93^\circ$$

$$\therefore \alpha_1 = 18.93^\circ,\ \alpha_2 = 9.73^\circ$$

48. Ans: (D)

Sol: Select line from ω_2 rise to 100 rad/sec.

$$\text{Slope} = \left(\frac{M_2 - M_1}{\log\omega_2 - \log\omega_1}\right)$$

$$\Rightarrow -20 = \left(\frac{0-6}{\log 100 - \log\omega_2}\right)$$

$$\Rightarrow \log 100 - \log \omega_2 = \frac{-6}{-20} = 0.3$$

$-\log\omega_2 = 0.3 - 2$

$\log\omega_2 = 1.7$

$\omega_2 = 50.11 \approx 50$ rad/sec

$$\Rightarrow \text{TF } G(s)H(s) = \frac{K(1+S/20)}{S(1+S/50)(1+S/100)}$$

$\omega_{gc} = 100$rad/sec [from figure]

$$PM = 180^0 + \angle G(j\omega)H(j\omega)|_{\omega_{gc}}$$

$$= 180^0 + \left[-90^0 + \tan^{-1}\left(\frac{\omega_{gc}}{20}\right) - \tan^{-1}\left(\frac{\omega_{gc}}{50}\right) - \tan^{-1}\left(\frac{\omega_{gc}}{100}\right)\right]$$

$$PM = 180^0 + \left[-90^0 + \tan^{-1}\left(\frac{100}{20}\right) - \tan^{-1}\left(\frac{100}{50}\right) - \tan^{-1}\left(\frac{100}{100}\right)\right]$$

$$= 60^0$$

49. Ans: (B)

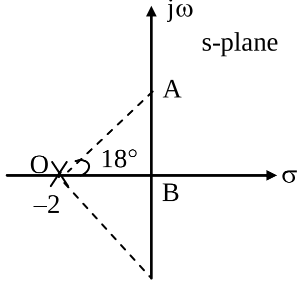
Sol: $G(s)H(s) = \dfrac{k}{(s+2)^{10}}$

$$\text{Centroid} = \frac{\Sigma\text{poles} - \Sigma\text{zeroes}}{p - z}$$

$$= \frac{(-2)10 - 0}{10} = -2$$

$$\text{Angle of asymptotes} = \frac{(2q+1)\pi}{p - z}$$

$$= 18^\circ, 54^\circ \ldots\ldots..$$



$$\cos 18^\circ = \frac{OB}{OA}$$

$$\Rightarrow OA = \frac{OB}{\cos 18^\circ} = \frac{2}{0.95} = 2.105$$

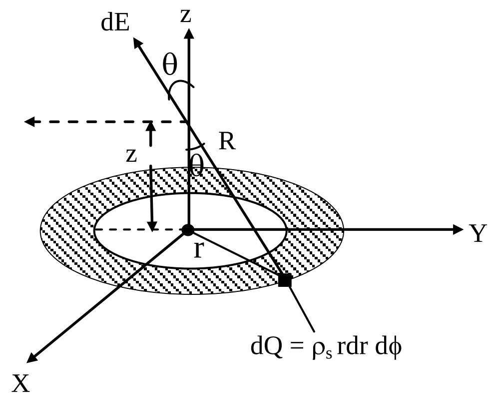
Maximum value of k for stability

$$= \frac{\text{product of distance from poles}}{\text{product of distance from zeroes}}$$

$$= (2.105)^{10}$$

50. Ans: 54.63 (53 to 56)

Sol: From fig. by symmetry only the z-components of the field exists along the z-axis.



$dQ = \rho_s\, r\, dr\, d\phi$

$$\cos\theta = \frac{z}{R},\ R = \sqrt{r^2 + z^2}$$

Hence

$$dE_z = \frac{dQ}{4\pi \in_o R^2}\cos\theta$$

$$= \frac{\rho_s r\, dr d\phi}{4\pi \in_o (r^2 + z^2)} \cdot \frac{z}{\sqrt{r^2 + z^2}}$$

$$= \frac{\dfrac{100\times 10^{-6}}{r} \times r dr d\phi \times z}{4\pi \times \dfrac{1}{36\pi} \times 10^{-9} (r^2 + z^2)^{3/2}}$$

At z = 10 m

$$E_Z = 9\times10^6 \int_{r=1}^{2}\int_{\phi=0}^{2\pi} \frac{dr d\phi}{(r^2+100)^{\frac{3}{2}}}$$

$$= 18\pi\times10^6 \int_{r=1}^{2} \frac{dr}{(r^2+100)^{3/2}}$$

$$= 18\pi\times10^6 \left.\frac{r}{100\sqrt{r^2+100}}\right|_{r=1}^{2}$$

= 54.63 kV/m

51. Ans: (A)

Sol: T = 1msec

R = 5Ω

L = 0.2 H

$$T_a = \frac{L}{R} = 0.04$$

$$\frac{T_{OFF}}{T_{ON}} = \frac{(1-D)T}{DT} = 1 = D = 0.5$$

$T_{ON} = DT = 0.5$ m

$V_0 = DV_s$

$V_0 = 0.5 \times 100$

$V_0 = 50V$

$$I_{max} = \frac{V_s}{R}\left[\frac{1-e^{\frac{-T_{ON}}{T_a}}}{1-e^{\frac{-T}{T_a}}}\right] = 10.062 \text{ A}$$

$$I_{min} = \frac{V_s}{R}\left[\frac{e^{\frac{T_{ON}}{T_a}}-1}{e^{\frac{T}{T_a}}-1}\right] = 9.938 \text{ A}$$

$\Delta i_0 = I_{max} - I_{min}$

$\Delta i_0 = 0.125$ A

52. Ans: (B)

Sol: $X(z) = \frac{z}{(z-1)^3}$

$\Rightarrow z^{n-1}X(z) = \frac{z^n}{(z-1)^3}$

Poles of z^{n-1} X(z) are given by,

$(z-1)^3 = 0$

z = 1 , z = 1 , z = 1

i.e., 'z = 1' is a repeated pole of index 'm + 1 = 3'

Now,

Residue of z^{n-1} X(z) at repeated pole 'z = a' of index 'm + 1'

$$= \frac{1}{m!}\lim_{z\to a}\frac{d^m}{dz^m}(z-a)^{m+1}z^{n-1}X(z)$$

$\therefore$ Residue of z^{n-1} X(z) at repeated pole 'z = 1' of index '3' = $\frac{1}{2!}\lim_{z\to 1}\frac{d^2}{dz^2}(z-1)^3\frac{z^n}{(z-1)^3}$

$$R = \frac{1}{2}\lim_{z\to 1}\frac{d^2}{dz^2}z^n$$

$$R = \frac{1}{2}\lim_{z\to 1} n.(n-1)z^{n-2}$$

$$R = \frac{1}{2}n(n-1)u(n)$$

Now, By Residue method,

$Z^{-1}\{X(z)\}$ = Sum of all the residues of $z^{n-1}X(z)$

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

53. Ans: 87.6 (Range: 86 to 89)

Sol: $P_s = P_e = 1.0$

$$P_{M_1} = \frac{EV}{X_{1_{eq}}} = (EV)y_{eq} = 2.0\,(1.2\times 1.0) = 2.4$$

$$\delta_0 = \sin^{-1}\left(\frac{P_S}{P_{M_1}}\right)$$

$$= \sin^{-1}\left(\frac{1.0}{2.4}\right)\text{ele.deg ree} \Rightarrow 24.62°$$

$$\delta_{0(rad)} = \delta_0 \times \frac{\pi}{180} = 0.429$$

Fault: $P_{e_2} = 0, P_{m_2} = 0$

$$\delta_m = 180° - \sin^{-1}\left(\frac{P_S}{P_{m_3}}\right)$$

$$P_{m_3} = P_{m_1}$$

$$\delta_m = 180° - \sin^{-1}\left(\frac{1.0}{2.4}\right)$$

$$= 180° - 24.62° = 155.38°$$

$$\delta_{m(rad)} = \delta_m \times \frac{\pi}{180} = 2.711$$

$$\delta_c = \cos^{-1}\left[\frac{P_S(\delta_m - \delta_e) + P_{m_3}\cos\delta_m}{P_{m_3}}\right]$$

$$\delta_C = \cos^{-1}\left[\frac{1.0(\delta_m - \delta_o) + 2.4\cos\delta_m}{2.4}\right]\text{ele.deg ree}$$

$$\delta_c = \cos^{-1}\left[\frac{1.0(2.711 - 0.429) + 2.4\cos(155.38)}{2.4}\right]$$

$= 87.6°$

54. Ans: (A)

Sol: $tu(t) \leftrightarrow \frac{1}{s^2}$

$$(t-2)u(t-2) \leftrightarrow \frac{e^{-2s}}{s^2} \left[\because x(t-t_0) \leftrightarrow e^{-st_o} X(s)\right]$$

$$e^{-t}(t-2)u(t-2) \leftrightarrow \frac{e^{-2(s+1)}}{(s+1)^2} \left[\because e^{s_0 t} x(t) \leftrightarrow X(s-s_o)\right]$$

55. Ans: (D)

Sol: → (HL) = 1000H

→ (A) = 45H

→ (B) = 96H

→ (HL) = 1000H pushed to top of stack

→ (A) = 45H = 0100 0101
(B) = 96H = 1001 0110
(A) = DBH = 1101 1011
CY = 0, P = 0, AC = 0, Z = 0, S = 1

→ (HL) = 1000H–1= 0FFFH

→ (TOS) = 1000H popped into DE pair

(DE) = 1000H

→Decimal Adjust Accumulator After Addition

(A) = DBH = 1101 1011
+ 66H = 0110 0110
(A) = 41H = 0100 0001
CY=1, P=1, AC=1, Z=0, S=0

→ Double Add HL to DE

(HL) = 0FFFH
(DE) = 1000H
(HL) = 1FFFH

→ (flag register) = 00×1 ×1×0 = 0001 0100 = 04H

(HL) = 1FFFH & (PSW) = 4114H