

Answer Keys

1	B	2	B	3	C	4	B	5	B	6	D	7	A
8	B	9	B	10	A	11	B	12	C	13	75	14	14.93
15	A	16	2.38	17	B	18	62.5	19	40	20	10	21	35
22	C	23	D	24	337.5	25	B	26	D	27	D	28	D
29	C	30	D	31	519.5	32	C	33	D	34	A	35	2
36	B	37	C	38	13.82	39	0.5	40	2.5	41	B	42	A
43	A	44	A	45	D	46	976	47	C	48	0.459	49	0.45
50	14.66	51	8	52	B	53	A	54	B	55	B	56	D
57	C	58	C	59	A	60	C	61	D	62	C	63	C
64	C	65	C										

Explanations:-

1. Given D.E is Bernoulli's D.E

Multiplying with ' y^{-2} '

$$y^{-2} \frac{dy}{dx} + y^{-1} = \cos^2 x$$

$$\boxed{y^{-1} = t}$$

Differentiating w.r.t 'X'

$$\Rightarrow -y^{-2} \frac{dy}{dx} = \frac{dt}{dx}$$

$$\Rightarrow -\frac{dt}{dx} + t = \cos^2 x$$

$$\Rightarrow \frac{dt}{dx} - t = -\cos^2 x \quad \text{which is linear D.E in 't'}$$

2. $P = \frac{\partial f}{\partial x} = 4x^3 + 4y$

$$q = \frac{\partial f}{\partial y} = 4y^3 + 4x - 4y$$

$$r = 12x^2; s = 4; t = 12y^2 - 4$$

$$r \text{ at } (\sqrt{2}, -\sqrt{2}) = 24$$

$$s \text{ at } (\sqrt{2}, -\sqrt{2}) = 4$$

$$t \text{ at } (\sqrt{2}, -\sqrt{2}) = 20$$

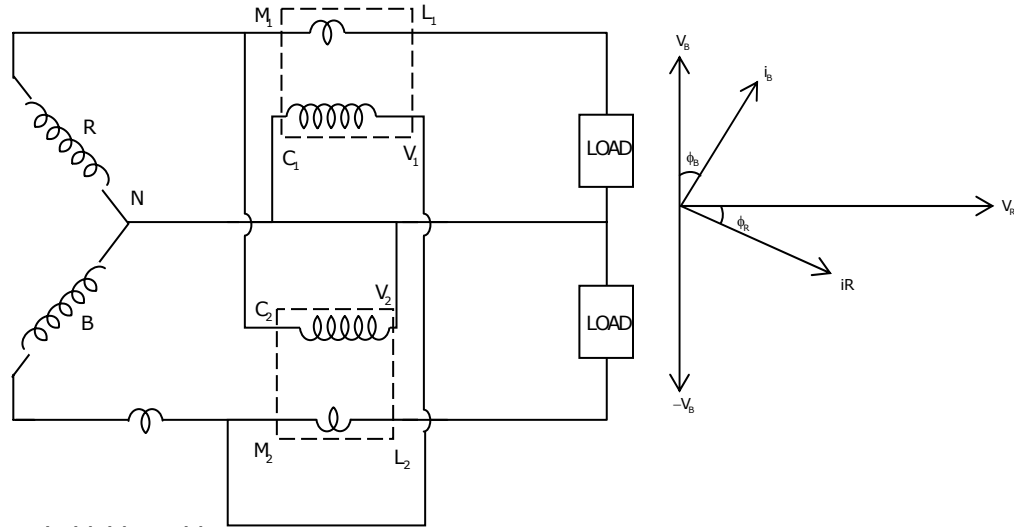
$$\therefore rt - s^2 = 464 > 0 \quad \text{and } r > 0$$

minimum value exists at $(\sqrt{2}, -\sqrt{2})$

$$\text{minimum is } f(\sqrt{2}, -\sqrt{2}) = -8$$

3. $\phi(x, y) = x^2y + yz$
normal vector = $\text{grad}\phi = \nabla\phi$
 $= i \frac{\partial\phi}{\partial x} + j \frac{\partial\phi}{\partial y} + k \frac{\partial\phi}{\partial z} = i2xy + j(x^2 + z) + ky$
normal vector at $(1, 1, 1) = 2i + 2j + k$

5. Pressure coil of meter connected to R-phases connected in between neutral and B phase.



$$i_{M1L1} = i_R V_{C1} V_1 = -V_B$$

$$i_{M2L2} = i_B V_{C2} V_2 = V_R$$

$$\begin{aligned} \therefore \text{reading of meter 1} &= V_B \times i_R \times \cos(\angle -V_{B1} i_R) \\ &= V_B \times i_R \times \cos(90 - \phi_R) = V_B i_R \sin \phi_R \dots\dots(1) \end{aligned}$$

$$\text{reading of meter 2} = V_R \times i_B \times \cos(\angle V_{B1} i_B)$$

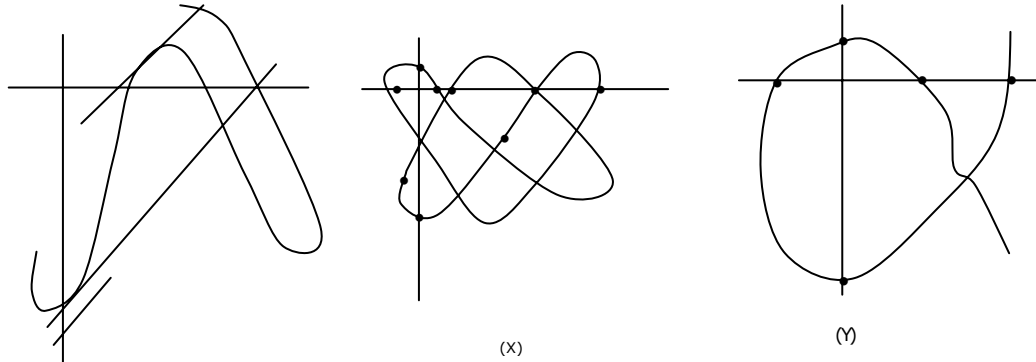
$$= V_R \times i_R \times \cos(90 - \phi_B) = V_R \times i_B \times \sin \phi_B$$

$$\therefore V_R = V_B = V$$

$$\text{total reading of meter 1 + meter2} = V \times i_R \sin \phi_R + V \times i_B \times \sin \phi_B$$

so the meter reads reactive power

6. We can obtain the frequency ratio as following



For x $\frac{f_y}{f_x} = \frac{\text{meeting points of horizontal tangents}}{\text{meeting points of vertical tangents}}$

$$\frac{f_y}{f_x} = \frac{6}{4} = \frac{3}{2}$$

For Y $\frac{f_y}{f_x} = \frac{\text{meeting points of horizontal tangents}}{\text{meeting points of vertical tangents}}$

$$\frac{f_y}{f_x} = \frac{3}{2}$$

8. Power factor = $\frac{R}{Z} = \frac{R_{eq}}{\sqrt{R_{eq}^2 + X_{eq}^2}} = \frac{R_{eq}}{\sqrt{R_{eq}^2 + (2R_{eq})^2}} = \frac{R_{eq}}{R_{eq}\sqrt{5}} = \frac{1}{\sqrt{5}}$

9. $V = \frac{KQ_1}{R_1} + \frac{KQ_2}{R_2}$

$$V = K \left[\frac{10}{\sqrt{6}} + \frac{9}{6} \right] \times 10^{-6}$$

$$V = 9 \times 10^9 [5.5824]$$

$$V = 50.24 \text{ KV}$$

10. Chopper input = $110 - 10 \times 0.5 = 105 \text{ V}$

Battery voltage = $120 \text{ V} = (1-D)^{-1} \cdot 105$

$$\Rightarrow D = 0.125$$

11. $G_2 = \frac{\pi E}{\ln \frac{D}{\sqrt{1 + [(D)^2 / 4h^2]}}} = \frac{\pi \times 10^{-9}}{36\pi \ln \frac{1.5 \times 1000}{2.5 \left(1 + \frac{2.25}{196} \right)^{\frac{1}{2}}}} = 4.35 \text{ pF / m}$

$$\text{For } 40 \text{ km} = 4.35 \times 10^{-12} \times 40 \times 1000 = 0.174 \mu\text{F}$$

12. Since K is negative angle of asymptotes = $\frac{2i}{P-Z}$ $0 \leq i \leq (P-Z-1)$

So if $i = 0$, angle = 0 ; $i = 1$, angle = $\frac{\pi}{2}$; $i = 2$, angle = π ; $i = 3$, angle = $\frac{3\pi}{2}$

13. Let the total voltage be x.

Voltage across bottom most unit is $\frac{1}{3}x$

$$\text{String efficiency} = \frac{\text{Voltage across string}}{n \times \text{Voltage across bottom most unit}} \times 100$$

$$= \frac{x}{4 \times \frac{1}{3}x} \times 100 = 75\%$$

14. $R_T = R_1 + R_2 = 0.12 \Omega$; $X_T = X_1 + X_2 = 0.32 \Omega$

$$Z_{01} = \sqrt{0.12^2 + 0.32^2} = 0.3418 \Omega$$

$$S = \frac{R_2}{R_2 + Z_{01}} = 14.93\%$$

15. 11KV, 50 Hz, 200 kW @ 0.8 pf

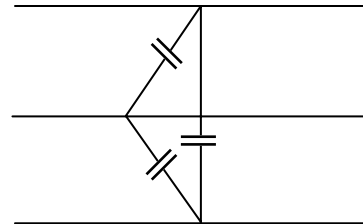
$$Q = \frac{200}{0.8} \times 0.6 = 150 \text{ kVAR}$$

$$Q \text{ supplied by each capacitor} = \frac{1}{3} \times 150 = 50 \text{ kVAR}$$

$$\therefore Q_c = (\omega) \times C \times V_L^2$$

$$= 2\pi \times 50 \times C \times (11)^2 = 50 \times 10^3$$

$$\therefore C = 1.316 \mu\text{F}$$



This is the capacitance of each capacitor in Δ - conneciton.

The capacitance per phase = $3 \times C = 3 \times 1.316 = 3.948 \mu\text{F}$.

16. slip $s_1 = \frac{N_s - N_r}{N_s} = \frac{1500 - 1410}{1500} = 0.06$

$$\text{Rotor input} = \frac{5}{1 - s_1} = \frac{5}{1 - 0.06} = \frac{5}{0.94} = 5.3191 \text{ KW}$$

$$\text{Stator input} = \text{Rotor input} + \text{stator loss} = 5.3191 + 0.5 = 5.819 \text{ KW}$$

$$\text{Slip } s_2 = \frac{1500 - 1250}{1500} = 0.1666$$

$$\text{Rotor input} = \frac{6}{1 - 0.166} = 7.2 \text{ KW}; \text{ Stator input} = 7.2 + 1.0 = 8.2 \text{ KW}$$

$$\therefore \text{ change in stator input} = 8.2 - 5.819 = 2.38 \text{ KW}$$

17. $i_R = \frac{45}{30} = 1.5 \text{ A}$

$$i_p = 45 \times \sqrt{\frac{4}{0.9}} \times 10^{-3} = 3 \text{ A}$$

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{0.9 \times 10^{-3} \times 4 \times 10^{-6}}} = 16666 \text{ rad / sec}$$

$$\text{conduction time} = \frac{\pi}{\omega} + \frac{\sin^{-1}\left(\frac{I_R}{I_p}\right)}{\omega} = 1.98 \text{ msec}$$

18. $V_s = 1 \angle 0^\circ$

$$I_L = \frac{1 \angle 0^\circ}{8j} = -0.125j \text{ A}$$

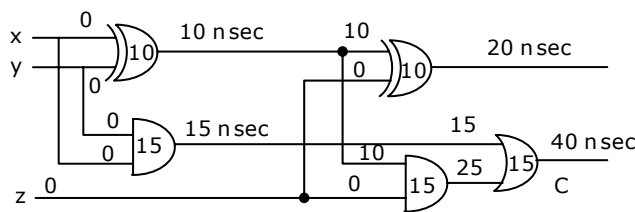
$$I_c = j\omega C 1 \angle 0^\circ \text{ as } \omega = 2 = j2C \text{ A}$$

$$I_s = I_L + I_c = j(2C - 0.125)$$

For V_s and I_s to be in phase, Phase of I_s should be 0, So imaginary term is 0.

$$2C - 0.125 = 0 \Rightarrow C = 0.0625 \text{ F}$$

19.



Carry propagation path is XOR – AND – OR

$$10 + 15 + 15 = 40 \text{ nsec}$$

20. $x(n) = \frac{1}{2\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) e^{j\omega n} d\omega$

$$x(0) = \frac{1}{2\pi} \int_{-\pi}^{\pi} X(e^{j\omega}) e^{j\omega \cdot 0} d\omega$$

$$\Rightarrow x(0) = \frac{1}{2\pi} [20\pi] = 10$$

21. $W = \frac{1}{2} \bar{B} \cdot \bar{H}$
 $B = \mu H$
 $W = \frac{1}{2} \mu H^2 \quad \mu = (\mu_0 \cdot \mu_r)$
 $H^2 = \frac{1}{4\pi} 10^2 + 15^2 + 5^2 = \frac{350}{4\pi}$
 $\mu = 4\pi \times 10^{-7} \times 2$
 $\bar{H} = \frac{4\pi \times 10^{-7} \times 2}{2} \times \frac{1}{4\pi} \times 350$
 $\bar{H} = 35 \mu J / m^2$

22. Under balanced state:

$$\frac{Z_1}{Z_2} = \frac{Z_3}{Z_4}$$

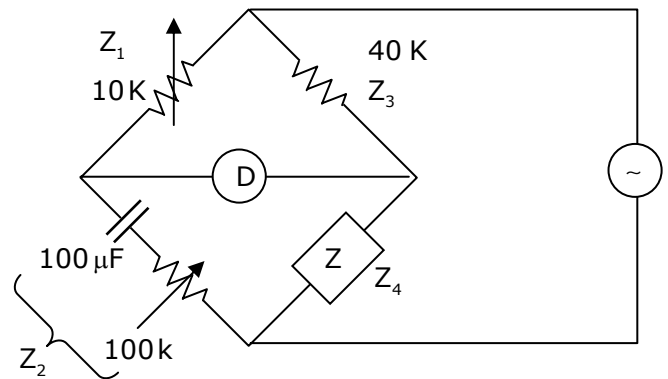
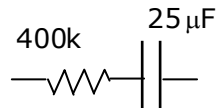
$$\frac{10 \times 10^3}{100 \times 10^3 + \frac{1}{j\omega(100 \times 10^{-6})}} = \frac{40 \times 10^3}{Z}$$

$$\therefore Z = 4 \left[100 \times 10^3 + \frac{1}{j\omega(100 \times 10^{-6})} \right]$$

$$Z = 400k + \frac{1}{j\omega(25 \times 10^{-6})}$$

\therefore the equivalent for z is R in series with 'C'

Figure



23. $\frac{V_1}{f_1} = \frac{V_2}{f_2} = \text{constant} = B_{\max}$. Hysterrys loss is directly Proportional to frequency

Eddy current loss is directly proportional to square of the frequency

$$\frac{P_{e2}}{P_{e1}} = \left(\frac{f_2}{f_1} \right)^2 = \left(\frac{100}{50} \right)^2 = 4 \Rightarrow P_{e2} = 300 \left(\frac{100}{50} \right)^2 = 1200W$$

$$\frac{P_{H2}}{P_{H1}} = \frac{f_2}{f_1} = \frac{100}{50} = 2 \Rightarrow P_{H2} = 2 \times 700 = 1400 W$$

$$P_{C2} = P_{H2} + P_{e2} = 1200 + 1400 = 2600 W(\text{total})$$

24. Stored energy = $100 \times 8 = 800$ MJ

$$P_a = 80 - 50 = 30 \text{ MW} = \frac{M d^2 \delta}{dt^2}$$

$$M = \frac{\text{stored energy}}{180 f}$$

$$M = \frac{800}{180 \times 50} = \frac{4}{45} \text{ MJ s / elect deg}$$

$$\frac{4}{45} \frac{d^2 \delta}{dt^2} = 30$$

$$\alpha = \frac{d^2 \delta}{dt^2} = 337.5 \text{ elect deg / s}^2$$

25.
$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

For the symmetric lattice network

$$Z_{11} = Z_{22} = \frac{1}{2} [4 + 2] = 3$$

$$Z_{21} = Z_{12} = \frac{1}{2} [2 - 4] = -1$$

$$\begin{bmatrix} 3 & -1 \\ -1 & 3 \end{bmatrix}$$

26. Using Laplace transform of derivatives

27. Spectral matrix is the resultant diagonal matrix obtained by $D = P^{-1} A P$. P is modal matrix consisting eigen vectors

But the spectral matrix consists always the eigen values as its principal diagonal elements

$$\therefore D = \begin{bmatrix} -2 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 6 \end{bmatrix}$$

28.
$$P(x \leq \frac{1}{2}) = \int_0^{1/2} f(x) dx = \int_0^{1/2} 3x^2 dx = 3 \left(\frac{x^3}{3} \right)_0^{1/2} = \frac{1}{8} = 0.125$$

29. $z = 1$ is a singularity, which is a pole of order 2

$$[\text{Res } f(z)]_{z=1} = \lim_{z \rightarrow 1} \frac{d}{dz} \left[(z-1)^2 \frac{e^{-z}}{(z-1)^2} \right] = \lim_{z \rightarrow 1} (-e^{-z}) = -e^{-1} = -\frac{1}{e}$$

30. Here op-amp works as a comparator so at output terminal of op-amp only two values possible, +20 or -20 (Saturation values).

When $V_o = +20V$ Zener is in reverse breakdown. So it can be replaced as +4V.

In this case voltage at 2Ω resistor = UTP = $\frac{2}{8} \times (20 - 4) = +4V$

So voltage drop across positive terminal will be $=4+4=8V$

When $V_o = -20V$ Zener is in forward bias and it behaves as short circuit

At this time voltage at positive terminal of op-amp = LTP = $\frac{2}{10} \times (-20) = -4V$

Hence hysteresis width = $8 - (-4) = 12V$

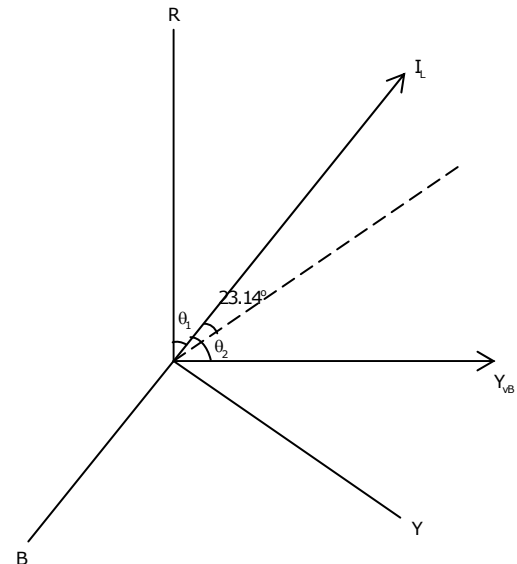
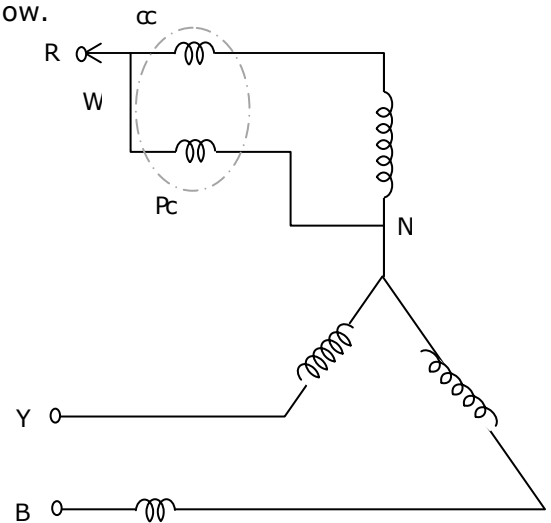
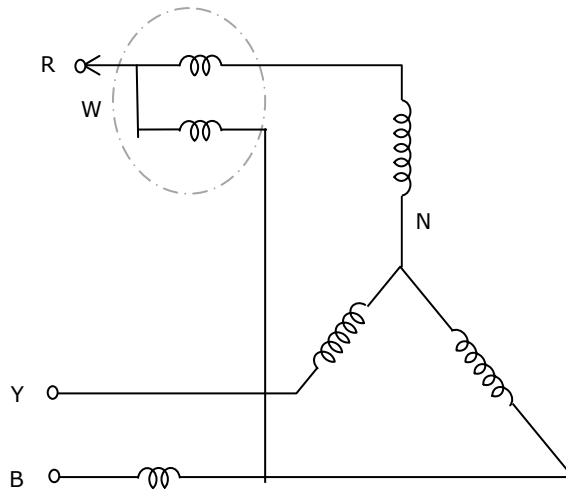
31. First the current coil is connected is R-phase and pressure coil is connected between this phase and the neutral as shown below.

Reading of watt meter

$$W_1 = I_p V_p \cos \theta_1, \cos \theta_1 = 0.8 \Rightarrow \theta_1 = 36.06^\circ$$

$$400 = I_L \frac{V_L}{\sqrt{3}} \cos \theta \Rightarrow 400 = \frac{I_L V_L}{\sqrt{3}} \times 0.8$$

Now when pressure coil is connected Between B and Y phases, the circuit is



$$\text{Angle } \theta_2 = 23.14^\circ + 30^\circ = 54.14^\circ$$

$$\text{Now wattmeter reading } W_2 = V_{YB} I_L \cos \theta_2$$

$$\text{From equation (1) } V_L I_L = \frac{400 \times \sqrt{3}}{0.8}$$

$$\text{so } W_2 = \frac{400}{0.8} \times \sqrt{3} \times \cos 53.14^\circ = 519.5 W$$

32. Nominal ratio $k_{\text{nom}} = \frac{1000}{5} = 200$

Turns ratio $k_t = k_{\text{nom}} = 200$

secondary induced voltage

$$E_s = 5 \times 1.4 = 7\text{V}$$

primary induced voltage

$$E_p = \frac{E_s}{k_t} = \frac{7}{200}\text{V}$$

Loss component of exciting current,

$$I_w = \frac{\text{Iron loss}}{E_p} = \frac{1.4}{7/200} = 40\text{ A}$$

Magnetizing component

$$I_m = \frac{\text{mmf}}{N_p} = \frac{80}{1} = 80\text{ A}$$

As the burden is purely resistive, therefore the secondary load angle is zero $\delta = 0$

Actual ratio

$$k_{\text{act}} = k_t + \frac{I_m \sin \delta + I_w \cos \delta}{I_s} = 200 + \frac{40}{5} = 208\text{V} \therefore \delta = 0$$

$$\text{Ratio error} = \frac{k_{\text{nom}} - k_{\text{act}}}{k_{\text{act}}} = \frac{200 - 208}{208} \times 100 = -3.846\%$$

33. $P_{\text{avg}} = \frac{1}{2} [400 \times 10 \times \cos(60^\circ) + 300 \times 4 \times \cos(30^\circ)] = \frac{3039.23}{2} = 1519.62\text{ W}$

$$V_{\text{ram}} = \frac{1}{\sqrt{2}} \sqrt{(400)^2 + (300)^2} = \frac{500}{\sqrt{2}} = 353.35\text{ V}$$

$$I_{\text{rms}} = \frac{1}{\sqrt{2}} \sqrt{(10)^2 + (4)^2} = 7.62\text{ A}$$

$$\therefore \text{PF} = \frac{\frac{3039.23}{2}}{353.55 \times 7.62} = \frac{1519.615}{2694.1} = 0.564$$

34. The instantaneous value of v_s at which triggering will occur at the SCR trigger point $V_{g(\min)} = 0.5V$ and $I_{g(\min)} = 0.1mA$.

Using KVL around the gate circuit, we have

$$e_s = I_g(R_V + R_{\min}) + V_D + V_g$$

At trigger point

$$e_s(\text{trigger}) = 0.1mA(110k\Omega) + 0.7V + 0.5V = 12.2V$$

Since e_s is a sine wave, it obeys the expression

$$e_s = E_{\max} \sin \omega t = E_{\max} \sin(2\pi ft)$$

Where $2\pi ft$ is the phase angle at any instant of time, this angle is α . Thus $E_{\max} = 24V$

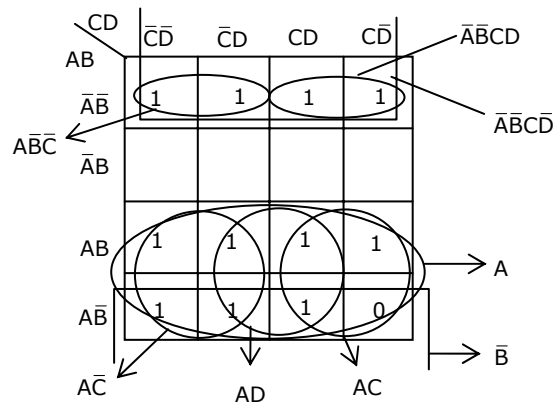
$$e_s = 24 \sin \alpha$$

$$\therefore 12.2 = 24 \sin \alpha$$

$$\sin \alpha = \frac{12.2}{24}$$

$$\therefore \alpha = 30.6^\circ$$

- 35.



Solving $= A + \bar{B}$ so logical operations involved are (NOT) and OR $(A, \bar{B}) = 2$

$$36. \quad H(z) = \sum_{n=0}^{\infty} \left(\frac{1}{4}\right)^n z^{-n} = 1 + \frac{1}{4}z^{-1} + \frac{1}{4}z^{-2}$$

$$Y_2(z) = y_1(z)H(z) = \left(1 + z^{-1} - 5z^{-2}\right) \left(1 + \frac{1}{4}z^{-1} + \frac{1}{16}z^{-2}\right)$$

$$= 1 + z^{-1} - 5z^{-2} + \frac{1}{4}z^{-1} + \frac{1}{4}z^{-2} - \frac{5}{4}z^{-3} + \frac{1}{16}z^{-2} + \frac{1}{16}z^{-3} - \frac{5}{16}z^{-4}$$

$$y_2(z) = \left[1 + \left(1 + \frac{1}{4}\right)z^{-1} + z^{-2} \left[-5 + \frac{1}{4} + \frac{1}{16}\right] + z^{-3} \left[\frac{-5}{4} + \frac{1}{16}\right] + z^{-4} \left[\frac{-5}{16}\right]\right]$$

$$= \delta(n) + \left(1 + \frac{1}{4}\right)\delta(n-1) + \left(-5 + \frac{5}{16}\right)\delta(n-2) + \left(\frac{-5}{4} + \frac{1}{16}\right)\delta(n-3) - \frac{5}{16}\delta(n-4)$$

$$y_2(3) = \frac{-5}{4} + \frac{1}{16} = -\frac{19}{16}$$

37. For impulse response

$$h(t) = \frac{d}{dt}(c(t)) = 0 + 10e^{-10t} - 10e^{-10t} + 100te^{-t}$$

$$\text{For } \tau \text{ or damping ratio find } T(s) = \frac{C(s)}{R(s)}$$

$$\text{Given } R(s) = \frac{1}{s}$$

$$c(s) = \frac{1}{s} - \frac{1}{s+10} - \frac{10}{(s+10)^2} = \frac{(s+10)^2 - s(s+10) - 10s}{s(s+10)^2}$$

$$c(s) = \frac{1}{s} \cdot \frac{100}{(s+10)^2} = \frac{R(s) \cdot 100}{(s+10)^2} \Rightarrow T(s) = \frac{C(s)}{R(s)} = \frac{100}{(s+10)^2}$$

$$T(s) = \frac{100}{s^2 + 20s + 100}$$

$$\omega_n = 100, \quad 2\tau\omega_n = 20 \Rightarrow \tau = 1$$

38. We observe that $R_2 \gg R_1$ so we assume $R_2 \rightarrow \infty$; i.e. the

R_2 is behaving like open circuit. Thus this is not a voltage divider biasing circuit

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (1 + \beta)(R_E)} = 21.7 \mu A$$

$$I_C = \beta I_B = 2.17 \text{ mA}$$

now β increases by 50%, so $\beta = 150$

$$I_B = 16.46 \mu A$$

$$\Rightarrow I_C = \beta I_B = 2.47 \text{ mA}$$

Thus percentage $\Delta I_C = 13.82\%$

39. $V_o = 20k \times 50 i_o = 10^6 i_o$

$$3mV + 4k \times i_o = \frac{V_o}{100}$$

$$\Rightarrow 3mV + 4k \times i_o = 10^4 i_o \Rightarrow i_o = 0.5\mu A \text{ and } V_o = 0.5V$$

40. First of all applying MPTT, power delivered to 10 is maximum when Thevenin's equivalent seen by it is 10Ω .

For that $R=20$, taking value of this R , power delivered to 10 = $\frac{(2.5)^2}{10} = 0.625$

Now R can be varied from 0 to infinite

When $R=0$, $P = \frac{(5)^2}{10} = 2.5W$

When R is open, $P = \frac{\left(\frac{10}{3}\right)^2}{10} = \frac{10}{9} = 1.11W$

Hence maximum = 2.5W

41. Zero = -8

Poles = $-1, -1 \pm j\sqrt{2}, -6$

We can neglect effect of pole at $s = -6$, zero at $s = -8$

During approximation $T(0)$ must be conserved.

$$T(0) = \frac{2|0+8|}{|0+1||3+0||6+0|} = \frac{2 \times 8}{3 \times 6} = \frac{8}{9}$$

After approximation $T(s) = \frac{8}{3(s+1)(s^2+2s+3)}$

at $s = 0$ $T(0) = \frac{8}{3|0+1||0+3|} = \frac{8}{9}$

42. Total current $I_T = I_{D_1} + I_{D_2}$ and $V_{DS_1} + I_{D_1} R_{s_1} = V_{DS_2} + I_{D_2} R_{s_2}$

Also $R_{s_2} I_{D_2} = R_{s_2} (I_T - I_{D_1})$

$\therefore V_{DS_1} + I_{D_1} R_{s_1} = V_{DS_2} + R_{s_2} (I_T - I_{D_1})$

or $V_{DS_1} + I_{D_1} (R_{s_1} + R_{s_2}) = V_{DS_2} + R_{s_2} I_T$

$$I_{D_1} = \frac{V_{DS_2} - V_{DS_1} + R_{s_2} I_T}{R_{s_1} + R_{s_2}} = \frac{4.5 - 4 + 0.3 \times 30}{(0.4 + 0.3)} = 13.57 \text{ A or } 45.23 \%$$

$I_{D_2} = 30 - 13.57 = 16.43 \text{ or } 54.77 \%$

Therefore in current sharing

$\Delta I = I_{D_2} - I_{D_1} = 16.43 - 13.57 = 2.86 \text{ A}$

or $\Delta I = 54.77 - 45.23 = 9.54 \%$

43. $(V_A - V_B) = 255 - 250 = 5 \text{ V}$

Maximum voltage point

$$\begin{aligned} x &= \frac{l}{2} + \frac{(V_A - V_B)}{10 - 1} \\ &= \frac{500}{2} + \frac{5}{1.1 \times 2 \times 10^{-4} \times 500} = \left(\because r = 0.1 \Omega / \text{km} = \frac{0.1}{1000} \Omega / \text{m} \right) \\ &= 295.5 \text{ m} \end{aligned}$$

Drop $= \frac{t_r x^2}{2} = \frac{1.1 \times 2 \times 10^{-4} \times (295.45)^2}{2} = 9.60 \text{ V}$

$V_{\min} = 255 - \text{Drop} = 255 - 9.60 = 245.4 \text{ V}$

44. Phase voltage of $x\%$ of generator winding $= \left(\frac{11000}{\sqrt{3}} \right) \frac{x}{100} \text{ V}$

Fault current (out of balance current) for fault

at $x\%$ of winding away from neutral $= \frac{3 \times \frac{11000}{\sqrt{3}} \frac{x}{100}}{3 \times 22}$

Full load current $= \frac{6 \times 10^3}{\sqrt{3} \times 11} = 314.9 \text{ A}$

Minimum out of balance current required for relay operation

$= 0.25 \times 314.9 = 78.7 \text{ A}$

Hence $\frac{\sqrt{3} \times 11000 \frac{x}{100}}{3 \times 22} = 78.7 \therefore x = 27.3 \%$

45. Given that $R_a = 0.11 \Omega$ and $R_s = 0.08 \Omega$
 Let $V_a = 230V$ and $n_1 = 975$ rpm, then generated voltage is
 $E_{a1} = V_t - I_{a1}(R_a + R_s) = 230 - 90(0.11 + 0.08) = 212.9 V$
 Similarly, the generated voltage at $I_a = 30 A$ is
 $E_{a2} = 230 - 30(0.11 + 0.08) = 224.3 V$
 We know that

$$E_a \propto n\phi \Rightarrow \frac{E_{a1}}{E_{a2}} = \left(\frac{n_1}{n_2}\right)\left(\frac{\phi_1}{\phi_2}\right) \therefore \phi_2 = 0.48 \phi_1$$

 So, $n_2 = n_1 \left(\frac{\phi_1}{\phi_2}\right) \left(\frac{E_{a2}}{E_{a1}}\right) = 975 \left(\frac{1}{0.48}\right) \left(\frac{224.3}{212.9}\right) = 2140 \text{ r / min}$

46. At no load $I_{nL} = 5A$
 Load current $I_{f,nL} = \frac{220}{200} = 1.1 A$
 Field current $I_{f,nL} = \frac{220}{200} = 1.1 A$
 Armature current $I_{a,nL} = I_{nL} - I_{f,nL} = 5 - 1.1 = 3.9 A$
 Back emf $E_{a,nL} = V_t - I_{a,nL}R_a$
 $= 220 - 3.9 \times 0.3 = 218.83 V$
 At load
 Load current $I_L = 40A$
 When the load is connected field current is reduced by 2.5%
 Field current $I_f = 1.0725 A$
 Armature current $I_a = I_L - I_f = 38.9 A$
 back emf $E_a = V_t - I_a R_a$
 $= 220 - 38.9 \times 0.3 = 208.33 V$

$$\frac{E_a}{E_{a,nL}} = \frac{I_f \times n}{I_{f,nL} \times n_L} \Rightarrow n = n_o \times \frac{I_{f,nL}}{I_f} \times \frac{E_{a1}}{E_{a,nL}}$$

 $= 1000 \times \frac{1.1}{1.0725} \times \frac{208.33}{218.83} = 976 \text{ rpm}$

47. If we append 0 on LSB N becomes 2N
 If we append 1 on LSB N becomes 2N+1
 So appending 11 on LSB $2(2N+1)+1=4N+3$

48. Given $E_{dc} = 220V$, $R = 0.1 \Omega$, $L = 10 \text{ mH}$, $E_b = 100$

$$i_o = \frac{E_o - E_b}{R} = \frac{\alpha E_{dc} - E_b}{R}$$

$$\therefore \alpha = \frac{i_o R + E_b}{E_{dc}} = \frac{(10 \times 0.1) + 100}{220}$$

$$\therefore \alpha = 0.459$$

49. Duty cycle to achieve regenerative braking at the rated current

$$\therefore \text{Rated load current, } i_o = \frac{\alpha E_{dc} - E_b}{R}$$

For regeneration this current should be negative

$$\therefore -10 = \frac{(\alpha \cdot 220) - 100}{0.1}, \therefore D = 0.45$$

50. Given $f_{r1} = 2\text{MHz}$ with $C_1 = 400\text{pf}$

$$f_{r2} = 3\text{MHz} \text{ with } C_1 = 160\text{pf}$$

$$f_r = \frac{1}{2\pi\sqrt{L(C + C_d)}} \quad C_d \text{ is the coil capacitance}$$

$$\frac{f_{r1}}{f_{r2}} = \sqrt{\frac{C_2 + C_d}{C_1 + C_d}} \Rightarrow \frac{2}{3} = \sqrt{\frac{160 + C_d}{400 + C_d}}$$

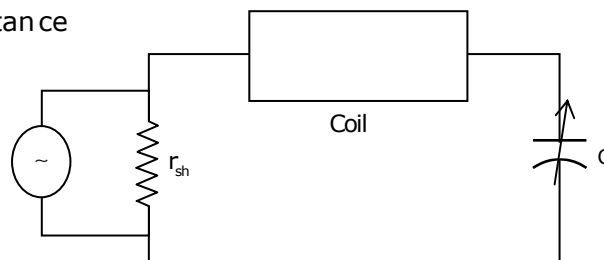
$$\Rightarrow 4 \times 400 - 9 \times 160 = 5C_d$$

$$\therefore C_d = \frac{160}{5} = 32\text{PF}$$

$$\text{with } C_1 = 400\text{ pf } C_d = 32\text{pf } f_{r1} = 2\text{MHz}$$

$$\therefore 2 \times 10^6 = \frac{1}{2\pi \times \sqrt{L(400 + 32) \times 10^{-2}}}$$

$$\therefore L = \frac{1}{(4\pi)^2 \times (432)} = 14.66\mu\text{H}$$



51. error caused by $r_{sh} = \frac{-r_{sh}}{r_{sh} + R_{coil}} \times 100$

$$\frac{0.1}{100} = \frac{r_{sh}}{r_{sh} + 8}$$

$$\Rightarrow 100 r_{sh} = 0.8$$

$$\therefore r_{sh} = 0.008 \Omega$$

$$52. \quad \phi(S) = L \begin{bmatrix} \cos \sqrt{2} t & \frac{1}{\sqrt{2}} \sin \sqrt{2} t \\ -\sqrt{2} \sin \sqrt{2} t & \cos \sqrt{2} t \end{bmatrix}$$

$$[SI - A]^{-1} = \frac{\text{adj}[SI - A]}{\Delta S} = \begin{bmatrix} S & 1 \\ \frac{S}{S^2 + 2} & \frac{1}{S^2 + 2} \\ -2 & S \\ \frac{S}{S^2 + 2} & \frac{1}{S^2 + 2} \end{bmatrix}$$

$$[SI - A] = \begin{bmatrix} S & -1 \\ 2 & S \end{bmatrix}$$

$$\text{So matrix } A = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix}$$

53. $y(S) = C[SI - A]^{-1} B$

$$A = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix}, \quad C = [0 \quad 1], \quad B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$Y(S) = [0 \quad 1] \begin{bmatrix} S & -1 \\ 2 & S \end{bmatrix}^{-1} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= [0 \quad 1] \begin{bmatrix} S & 1 \\ -2 & S \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$(S^2 + 2)$$

$$= [0 \quad 1] \begin{bmatrix} \frac{S}{S^2 + 2} & \frac{1}{S^2 + 2} \\ \frac{-2}{S^2 + 2} & \frac{S}{S^2 + 2} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$Y(S) = [0 \quad 1] \begin{bmatrix} \frac{S+1}{S^2 + 2} \\ \frac{S-2}{S^2 + 2} \end{bmatrix} = \frac{S-2}{S^2 + 2}$$

$$y(t) = \cos \sqrt{2}t - \sqrt{2} \sin \sqrt{2}t$$

54. $\left(\frac{2}{3}\right)^n u(n) \xrightarrow{z} \frac{z}{z - \frac{2}{3}} = x(z)$

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

$$H(z) = \frac{y(z)}{x(z)} = \frac{\frac{2z/3}{z - 2/3}}{\frac{z}{z - 2/3}} = \frac{2}{3z - 2}$$

So $H = (e^{j\Omega}) = H(z) e^{j\Omega} = \frac{2}{3e^{j\Omega} - 2} = \frac{2e^{-j\Omega}}{3 - 2e^{-j\Omega}}$

55. $H(j\Omega) = \frac{y(e^{j\Omega})}{x(e^{j\Omega})} = \frac{2e^{j\Omega}}{3 - 2e^{-j\Omega}}$

$$3y(n) - 2y(n-1) = 2x(n-1)$$

57. The two verbs of the main clause are in simple past tense and are joined with "and".

58. Sedative induces drowsiness. Likewise anesthetic induces numbness.

59. Veneration is respect and derision is lack of that

60. Given that certain amount becomes five times after 3 years under compound interest. So after next 3 years it will be 5 times of the previous amount and so on.

End of the year	No. of times
3	5
6	$5(5) = 25$
9	$5(25) = 125$
12	$5(125) = 625$
15	$5(625) = 3125$

After 15 years the amount will be 3125 times.

61. Sum of n terms =

$$n^2 + 3n$$

$$\text{sum of } (n-1) \text{ terms} = (n-1)^2 + 3(n-1) = n^2 + n - 2$$

Now we know n^{th} term = sum of n terms – sum of $(n-1)$ terms

$$\text{Therefore } n^{\text{th}} \text{ term in this case} = n^2 + 3n - (n^2 + n - 2) = 2n + 2$$

$$\text{Therefore } 6^{\text{th}} \text{ term is } 2 \times 6 + 2 = 14$$

62. When we write down all the greater number of all distinct 2 element subsets, you will find that 8 gets written 7 times $\{(1, 8), (2, 8), (3, 8), (4, 8), (5, 6), (6, 8), (7, 8)\}$,

7 gets written 6 times and so on. Hence the sum would be

$$8 \times 7 + 7 \times 6 + 6 \times 5 + 5 \times 4 + 4 \times 3 + 3 \times 2 + 2 \times 1$$

$$= 56 + 42 + 30 + 20 + 12 + 6 + 2 = 168$$

63. Every bounce is $\frac{3}{5}$ th of the previous drops in this movement. There are infinite GPs (the GP representing the falling distances and GP representing the rising distances). The required answer is

$$\frac{180}{1 - \frac{3}{5}} + \frac{108}{1 - \frac{3}{5}} = 720\text{m}$$

64. i. $\frac{B \text{ in } 2011}{C \text{ in } 2012} = \frac{15}{55} = \frac{3}{11}$

$$\text{ii. Average} = \frac{10 + 15 + 40 + 40}{4} = \frac{105}{4} = 26.25$$

$$\text{iii. Percentage increase in } C = \frac{30-15}{15} \times 100\% = 100\%$$

65. That baseball injuries definitely *are* a result of weightlifting, might fix it.