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ESE- 2020 (Prelims) - Offline Test Series Test- 3

ELECTRICAL ENGINEERING

SUBJECT: ELECTRICAL MACHINES, SYSTEMS & SIGNAL PROCESSING SOLUTIONS

01. Ans: (a)

Sol: Damper winding is made with low resistance copper, Aluminium or Brass. They are inserted in the slots made under the pole shoes. Damper winding also improves the stability.

$\therefore$ Option (a) given is wrong.

02. Ans: (c)

Sol: **Synchronous speed,** $N_s = \dfrac{120f}{P}$

$\therefore N_s \propto f \Rightarrow$ Linear

03. Ans: (b)

Sol: In alternator the field poles leads the air gap field and air gap field leads the armature field.

04. Ans: (b)

Sol: At $I_f = 1A \Rightarrow I_{sc} = 5A$

At $I_f = 2A \Rightarrow I_{sc} = 10\ A$

$Z_s = \dfrac{E_{oc}}{I_{sc}}$ (I_f is same both for E_{oc} & I_{sc})

$= \dfrac{220}{10} = 22\Omega$

05. Ans: (a)

Sol: synchronizing power coefficient P_{sy} gives the change in power delivered or received by the machine per unit change in the torque angle or load angle. A large P_{sy} means more power for a given change in the angle. The coupling between the stator and rotor magnetic fields is called stiffer if a small change in the angle between the axes of these fields leads to a large change in power delivered or received. Thus, synchronizing power coefficient and the stiffness of coupling are the same.

06. Ans: (b)

Sol: $E = 4.44\, K_p\, K_d\, \phi\, f.T$

$E \propto f \propto N$

$N\uparrow$ by 10% , So E_2 also Increases by 10%

I_{SC} is independent of speed. So I_{SC} remains constant.

07. Ans: (b)

Sol: For motor

$$\text{Reactive Power} = \frac{V_t}{X_s}\left(V_t - E_f \cos\delta\right)\ldots\ldots(1)$$

And given,

Terminal voltage = V_t = 1.0 p.u

Synchronous reactance = X_s = 1.25

Excitation Emf = E_f = 2.0 pu

By substituting above values in (1) we get

$$Q = \frac{V_t}{X_s}\left(V_t - E_f \cos\delta\right)$$

$$= \frac{1}{1.25}\left(1 - 2\times\cos\delta\right)$$

As the motor is on no load take $\delta = 0° \Rightarrow \cos\delta = 1$

$$Q = \frac{1}{1.25}\left(1 - 2\times 1\right) = \frac{-1}{1.25} = -0.8$$

08. Ans: (c)

Sol: Synchronous speed of motor $N_s = \dfrac{120f}{f}$

For motor-generates set,

$$N_{set} = \frac{120(50)}{P_m} = \frac{120(60)}{P_G}$$

$$\frac{P_G}{P_m} = \frac{6}{5} = \frac{12}{10}$$

$\therefore$ A 10-pole synchronous motor must be coupled to a 12-pole alternator.

09. Ans: (d)

Sol: Disadvantages of synchronous motor:

1. The requirement of dc supply for field excitation. (DC field to be excited nearer to synchronous speed of motor)
2. The starting synchronizing and control devices are more expensive.
3. The motor is more sensitive to system disturbances.

Advantages:

1. An over excited synchronous motor can generate reactive power to improve the system power factor and at the same time drive a constant speed load.
2. It has high operating efficiency and constant speed.
3. For operating speeds less than about 500 rpm and for power requirements from 35 kW upto about 2500 kW size, weight and cost of synchronous motor are much less those of induction motors of the same speed and kW rating.

10. Ans: (a)

Sol: $E = 4.44\, K_P\, K_d\, \phi fT$

Therefore, E α $K_d fT$

$$\frac{E_A}{E_B} = \frac{K_{d(3-\phi)}}{K_{d(2-\phi)}} \times \frac{T_{ph(3-\phi)}}{T_{ph(2-\phi)}} \times \frac{f_{(3-\varphi)}}{f_{(2-\phi)}}$$

$$= \frac{\sin\frac{60}{3}}{\sin\frac{90}{2}} \times \frac{90}{60} \times \frac{\frac{T}{3}}{\frac{T}{2}} \times \frac{50}{25}$$

= 1.414

11. Ans: (c)

Sol: Slip S = $\frac{1500-1425}{1500} = 0.05$

$R_2 = 7.8\ \Omega$

$$R'_b = R_2 | 2(2-s)$$

$$= \frac{7.8}{2(1.95)} = \frac{7.8}{3.9} = 2\,\Omega$$

12. Ans: (c)

Sol: Since the I.M is fitted with Y-Δ starter, the motor is designed to develop 5 kW with its stator winding in Δ.

$P_1 = 3V_1I_1\cos\theta_1 = 5$kW ……… (1)

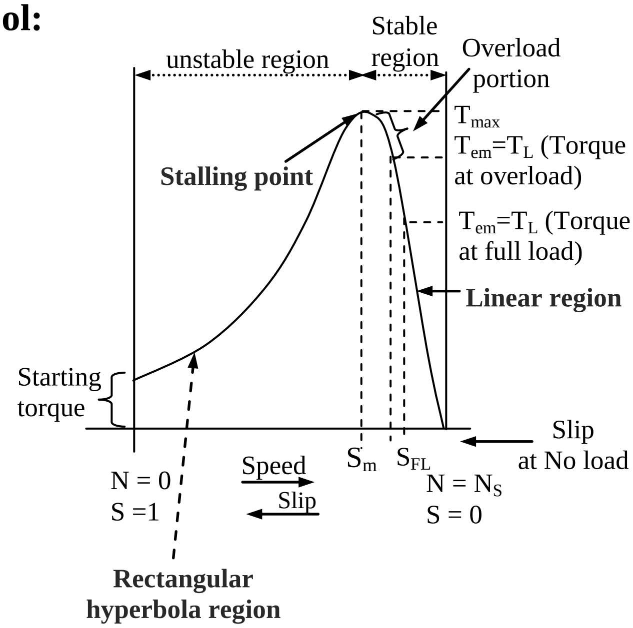
When the motor winding in star, per phase voltage is $\frac{V_1}{\sqrt{3}}$ and per phase current is I_1.

(1) becomes, $3 \times \frac{V_1}{\sqrt{3}} \times I_1 \cos\theta_1 = 5\text{kW}$

$$P_2 = \frac{5}{\sqrt{3}} = 2.9\text{kW}$$

13. Ans: (d)

Sol:



The maximum torque developed under running condition is higher than starting torque as well as full load torque. This can observed in figure as shown above.

14. Ans: (d)

Sol: Even though induction generator delivers active power it draws lagging reactive power from the grid for the establishment of rotating magnetic field. i.e it delivers leading reactive power to grid. So statement-1 is correct.

An over excited synchronous motor draws current at leading p.f. So statement-2 is correct.

Statement -3 is correct

Load angle of a synchronous machine is the angle between the excitation voltage and the terminal voltage. So statement - 4 is wrong.

15. Ans: (a)

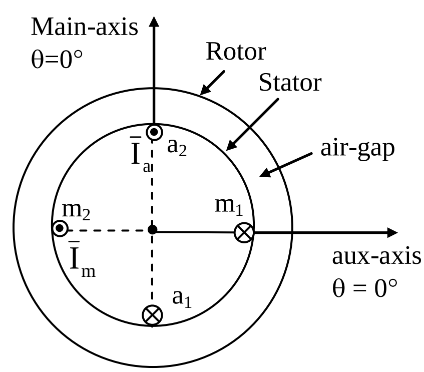
Sol: 1. The tendency of squirrel cage induction motor to run at one seventh of the synchronous speed when connected to supply mains is called crawling. This is due to the space harmonics in the air gap flux wave. **(1- wrong)**

2. Statement is correct.

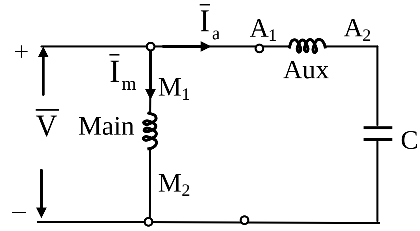
3. Most of the rotor current at starting flows in the top cage having much lower leakage impedance. Since the top cage, sharing most of the rotor current at starting, has higher resistance, it results in higher starting torque. **(3-wrong)**

16. Ans: (d)

Sol:



Cross-section
(Two pole machine assumed)
Fig.1



Electrical connections
Fig.2

Reversing the direction of rotation: Initially, I_a leads I_m by 90^o. Thus direction of rotation is acw (or rotation is from aux-axis to main axis). To reverse this direction,

1. **Connection to the terminals of the capacitor are reversed:** Capacitance is a bilateral element. This does not have any effect on the circuit, and direction of rotation **is not reversed.**

2. **Changing the capacitor position from aux. winding circuit to main winding circuit:**
   Now it is I_m that leads I_a. So direction of rotation is from main-axis towards aux-axis, or cw. Direction of rotation **is reversed.**

3. **Reversing supply connection to main winding (C assumed to be in the aux. circuit):**
   We are interchanging the connections to terminals M_1 and M_2. So I_m now enters main winding at M_2 and leaving at M_1. Hence current entering main winding at M_1 is , $-I_m$.

I_m lags I_a by 90^o. So '$-I_m$' leads I_a by 90^o. Direction of rotation becomes CW and so **is reversed.**

4. **Reversing supply connection to the auxiliary circuit (C assumed to be in the auxiliary circuit):**

   Now auxiliary winding current is '$-I_a$'. I_a leads I_m and so '$-I_a$' lags I_m. Direction rotation becomes CW and so **is reversed.**

17. Ans: (d)

Sol: A induction voltage regulator enables a smooth variation of the output voltage, where as in a tap changer transformer, the output voltage can be controlled only in discrete steps. In induction voltage regulator, the output voltage is controlled by varying the angle between the magnetic axes of primary & secondary windings.

18. Ans: (a)

Sol: The resultant mmf is distributed in both space and time. It can be termed as a rotating magnetic field with sinusoidal space distribution, whose space phase angle changes linearly with time as ωt. Therefore it rotates at a constant angular speed of ω rad(elect.)/sec. This angular speed is called synchronous angular speed (ω_s).

19. Ans: (b)

Sol: Capacitor start, capacitor run motor: This type of motor employs two capacitors: a large one for starting and a smaller one for running. The starting capacitor gets disconnected after starting.

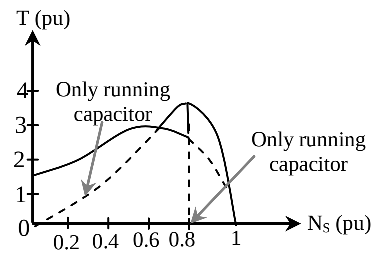
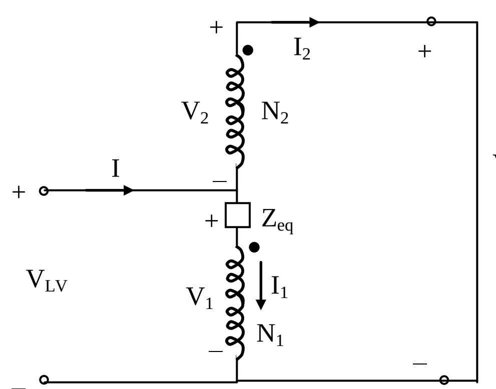


Fig: capacitor-start and run motor torque speed characteristic.

20. Ans: (d)

Sol: In two winding transformer,

$$Z_{eq} = Z_1 + \left(\frac{N_1}{N_2}\right)^2 Z_2$$



When this transformer is connected as an auto transformer, the circuit is shown in figure. If the output winding of the auto transformer is shorted, the voltage V_H (and hence V_1) will be zero.

The voltage V_{LV} will be $V_{LV} = I_1 Z_{eq}$

Z_{eq} is the impedance of ordinary transformer

$I = I_1 + I_2$

$$= I_1 + \left(\frac{N_1}{N_2}\right) I_1$$

$$I = I_1\left[\frac{N_1 + N_2}{N_2}\right]$$

$$I_1 = I\left(\frac{N_2}{N_1 + N_2}\right)$$

$V_{LV} = I_1 Z_{eq}$

$$= I\left[\frac{N_2}{N_1 + N_2}\right] Z_{eq}$$

$$Z'_{eq} = \frac{V_{LV}}{I} = \left(\frac{N_2}{N_1 + N_2}\right) Z_{eq}$$

21. Ans: (a)

Sol: With respect to transformers, by convention we have

Primary $\rightarrow$ winding which receives electrical supply.

Secondary$\rightarrow$ winding to which load is connected.

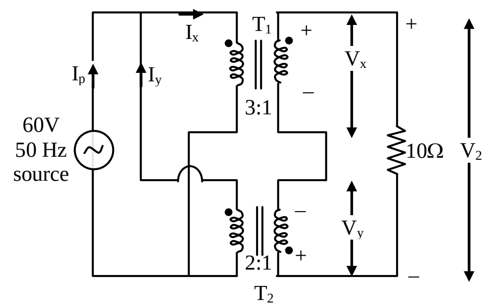
Step up $\rightarrow$ secondary turns > primary turns.

Hence secondary voltage is higher and secondary current is smaller, compared to primary values.

Hence in this question, the primary has a lesser voltage and higher current.

22. Ans: (a)

Sol:



$$\frac{V_x}{60} = \frac{1}{3} \Rightarrow V_x = 20 \text{ V}$$

$$V_y = \frac{1}{2} \times 60 = 30 \text{ V}$$

$$V_2 = 30 - 20 = 10 \text{ V}$$

$$I_2 = \frac{V_2}{R_2} = \frac{10}{10} = 1 \text{ A}$$

$$I_x \times 3 = 1 \times 1 \Rightarrow I_x = \frac{1}{3}$$

$$I_y \times 2 = 1 \times 1 \Rightarrow I_y = \frac{1}{2}$$

$$I_P = I_x - I_y = \frac{1}{3} - \frac{1}{2} = \frac{-1}{6} \text{A}$$

23. Ans (d)

Sol: $3000 = \dfrac{60}{k^2}$

$$3000 = \left(\frac{N_1}{N_2}\right)^2 \times 60$$

$$= \frac{N_1}{N_2} = \sqrt{50}$$

24. Ans: (c)

Sol: Given 20 kVA, single phase transformer

Iron loss, $W_i = 250$ W

Copper loss, W_{cu} = 500 W

Let the maximum efficiency occur at x times of full load. We can write

$$x = \sqrt{\frac{W_i}{W_{cu}}} = \sqrt{\frac{250}{500}} = \sqrt{\frac{1}{2}} = 0.707$$

Maximum efficiency occurs at 70.7% of full load.

Output at unity power factor is

$P_{out} = 0.707 \times 20 \times 1 = 14.14$ kW

25. Ans: (a)

Sol: During open circuit and short circuit tests all the losses do not occur simultaneously, therefore the exact temperature rise can not determined. In order to get exact temperature rise sumpners test should be conducted. In this test core losses and copper losses are obtained, by using these results winding impedance and exciting current can be determined.

26. Ans: (c)

Sol: $P_i = Af + Bf^2$

$\Rightarrow \frac{P_i}{f} = A + Bf$

By using graph, A = 0.01

B = 0.001

Hysteresis Loss at 100 Hz = Af = 1W

Eddy current loss at 100 Hz = Bf^2

$= (0.001)10^4$

= 10 W

27. Ans: (c)

Sol: Let maximum efficiency occur at a fraction x of full load. But at this load, the copper loss is $\left(\frac{x^2}{0.9^2}\right)81 = 100\, x^2$ W. So $100x^2 = 64$ and the fraction x is 0.8.

28. Ans: (d)

Sol: Back pitch $Y_b = \frac{2C}{P} \pm K$

Where C = Number of coils = 40

P = Number of poles = 6

K is a number (integer or fraction) added to $\frac{2C}{P}$ to make Y_b an odd integer.

$$Y_b = \frac{2\times 40}{6} \pm K = \frac{40}{3} \pm \frac{1}{3}$$

$$\therefore Y_b = \frac{40}{3} - \frac{1}{3} = 13$$

But $Y_b - Y_f = \pm 2$

$Y_f = 13 - 2 = 11$ for progressive winding

= 13 + 2 = 15 for retrogressive winding

29. Ans: (b)

Sol: 1. At the trailing pole tip the armature flux adds main field flux and at the leading pole tip opposes, therefore strengthening effect at trailing at pole tip and weakening effect at leading pole tip.

2. Resistance commutation: This method will be suitable for small fractional kW machines.

   Voltage/EMF commutation: (By using interpoles/commutating poles/compoles) This method is suitable for normal and large rating machines except for fractional kW machines.

3. The polarity of the interpole is same a that of the main field pole ahead in the direction of generator rotation (statement 3 is wrong).

30. Ans: (b)

Sol: The inter poles are tapering in shape i.e., having broad base and less pole shoe area, to reduce the extra air gap flux under trailing pole tip. The air gap under inter poles is more than the air gap under the main field poles to avoid the saturation.

31. Ans: (a)

Sol: When the machine is delivering (generator action) a purely leading current, armature reaction is magnetizing. Thus the armature mmf of 3A (interms of field current) must be added to be actual field current 7A to get an effective field current of 10 A. From graph, with 7 A and 10 A, induced emf/ph is 480 V & 500 V respectively. So, increase in induced emf on load is 20 V or reduction is – 20 V.

32. Ans: (c)

Sol: Separately excited dc machine, means we are supplying field current and we are varying it flow by using separated source

So it's field control operation

For field control machine will operate under constant power conditions

33. Ans: (d)

Sol: Given data, $I_{a1} = 1$ A, $I_{a2} = 0.5$ A

In D.C series motor, $E_b \propto N\phi$ and $\phi \propto I_a$

$$\therefore \frac{N_1}{N_2}\times\frac{\phi_1}{\phi_2} = \text{constant}$$

$$\Rightarrow N_2 = N_1\left(\frac{I_{a1}}{I_{a2}}\right) = N_1\left(\frac{1}{0.5}\right) \Rightarrow 2N_1$$

The percentage increase in speed is

$$= \frac{N_2 - N_1}{N_1}\times 100$$

$$= \frac{2N_1 - N_1}{N_1}\times 100$$

$= 100$ %.

34. Ans: (a)

Sol: from fig, slope, $R_a = \frac{80-60}{80} \Rightarrow 0.25\,\Omega$

Copper loss of the system

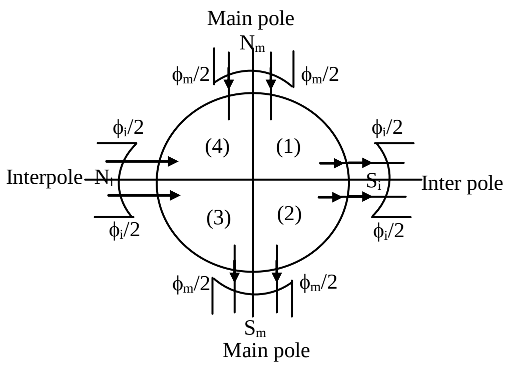
$$= I_a^2 R_a = 40^2 \times 0.25$$

$= 400$ W.

35. Ans: (c)

Sol: For generator operation, the polarity of the inter pole must be the same as that of the main pole ahead of it in the direction of rotation (to help commutation). For a motor operation, the inter pole polarity must be opposite to the above.

Considering generator operation, a cross-section of the 2-pole machine is shown below.



From the figure we see that flux quadrants 1 & 3 is $(\phi_m - \phi_i)/2$ and flux in quadrants 2 & 4 is $(\phi_m + \phi_i)/2$.

36. Ans: (a)

Sol: $r_{xh}(\tau) = x(\tau)*h(-\tau) = e^{-\tau}u(\tau)*e^{\tau}u(-\tau)$

Apply Fourier transform

Convolution in time domain gives multiplication in frequency domain

$$e^{-\tau}u(\tau) \leftrightarrow \frac{1}{1+j\omega}$$

$$e^{\tau}u(-\tau) \leftrightarrow \frac{1}{1-j\omega}$$

$$S_{xh}(\omega) = \frac{1}{(1+j\omega)(1-j\omega)} = \frac{1}{2}\left[\frac{2}{\omega^2+1}\right]$$

Apply inverse fourier transform

$$e^{-a|t|} \leftrightarrow \frac{2a}{a^2+\omega^2}$$

$$r_{xh}(t) = \frac{1}{2}e^{-|t|}$$

37. Ans: (b)

Sol: $X(f) = 1 - \text{rect}(f - 0.5)$

Apply inverse Fourier transform

$\delta(t) \leftrightarrow 1$

$\text{sinc}(t) \leftrightarrow \text{rect}(f)$

$x(t)e^{j2\pi f_0 t} \leftrightarrow X(f - f_0)$

$e^{j\pi t}\text{Sinc}(t) \leftrightarrow \text{rect}(f - 0.5)$

$x(t) = \delta(t) - \text{sinc}(t)\, e^{j\pi t}$

38. Ans: (c)

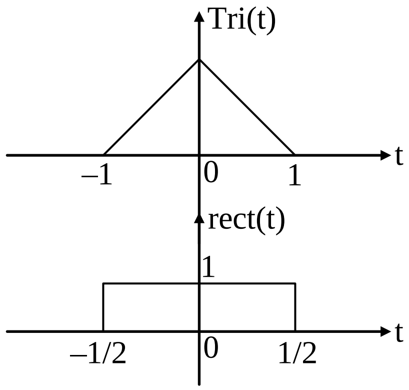
Sol: $\text{Tri}(t) \leftrightarrow \text{sinc}^2(f)$

$\text{rect}(t) \leftrightarrow \text{sinc}(f)$

From plancheral's relation

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

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



$$\text{Tri}(t) = 1 + t \qquad -1 < t < 0$$
$$\qquad\quad 1 - t \qquad 0 < t < 1$$

$$\int_{-\infty}^{\infty} \text{Tri}(t)\,\text{rect}(t)\,dt = \int_{-1/2}^{0} (1+t)\,dt + \int_{0}^{1/2} (1-t)\,dt$$

$$= t + \frac{t^2}{2}\Big|_{-1/2}^{0} + t - \frac{t^2}{2}\Big|_{0}^{1/2}$$

$$= -\left(-\frac{1}{2}+\frac{1}{8}\right) + \left(\frac{1}{2}-\frac{1}{8}\right)$$

$$= \frac{3}{8}+\frac{3}{8}$$

$$= \frac{3}{4}$$

39. Ans: (c)

Sol: Given $x(t) = \sin(10\pi t)$

and $y(t) = x^3(t) = \sin^3(10\pi t)$

$$y(t) = \frac{3}{4}\sin(10\pi t) - \frac{1}{4}\sin(30\pi t)$$

$$\omega_0 = 10\pi$$

$$y(t) = \frac{3}{4}\sin(\omega_0 t) - \frac{1}{4}\sin(3\omega_0 t)$$

So, I & III harmonics are present.

40. Ans: (b)

Sol: The Exponential Fourier series expansion of x(t) is $x(t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega_0 t}$ ....(1)

Given $x(t) = \sum_{n=-\infty}^{\infty} \frac{1}{1+j\pi n} e^{j\frac{3\pi}{2}nt}$ ....(2)

Compare (1) & (2)

$$C_n = \frac{1}{1+j\pi n}, \qquad |C_n| = \frac{1}{\sqrt{1+(\pi n)^2}}$$

$$|C_3| = \frac{1}{\sqrt{1+9\pi^2}}\ , \ |C_{-3}| = \frac{1}{\sqrt{1+9\pi^2}}$$

So, the amplitude of third harmonic component is

$$= |C_3| + |C_{-3}|$$
$$= \frac{2}{\sqrt{1+9\pi^2}}$$

41. Ans: (c)

Sol: $$H(\omega) = \frac{1+j2\omega+(j\omega)^2}{\{1+(j\omega)^2\}\{4+(j\omega)^2\}}$$

$$= \frac{1+j2\omega+(j\omega)^2}{4+5(j\omega)^2+(j\omega)^4} = \frac{Y(\omega)}{X(\omega)}$$

$4Y(\omega) + 5(j\omega)^2\, Y(\omega) + (j\omega)^4\, Y(\omega)$

$= X(\omega) + j2\omega\, X(\omega) + (j\omega)^2\, X(\omega)$

Apply IFT

$$4y(t) + \frac{5d^2y(t)}{dt^2} + \frac{d^4y(t)}{dt^4} = x(t) + 2\frac{dx(t)}{dt} + \frac{d^2x(t)}{dt^2}$$

42. Ans: (a)

Sol: Constant y(0) is added. So, it is a non-linear system. Present output depends on past and future inputs. So, dynamic system.

For a bounded input, Unbounded output results. So, unstable system.

43. Ans: (b)

Sol: The signal extending from 0 to 3. So, it is multiplied with [u(n) – u(n – 4)].

The signal is $x(n) = 4(1/2)^n\,[u(n) - u(n-4)]$

Given $x(n) = A\alpha^n[u(n) - u(n-N)]$

$A = 4, \alpha = ½, N = 4$

$A + \alpha + N = 8.5$

44. Ans: (b)

Sol: (1) Assume $x(t) = x_1(t)\,x_2(t)$

$x(-t) = x_1(-t)\,x_2(-t)$

Assume $x_1(t)$ is even $\Rightarrow x_1(-t) = x_1(t)$

Assume $x_2(t)$ is odd $\Rightarrow x_2(-t) = -x_2(t)$

So, $x(-t) = -x_1(t)\,x_2(t) = -x(t)$.

So, x(t) is odd.

So, statement(1) is false.

(2) $\omega_0 = 4$

$$T_0 = \frac{2\pi}{\omega_0} = \frac{2\pi}{4} = \frac{\pi}{2}$$

So, statement(2) is false.

(3) It is a periodic signal. So, power signal

So, statement(3) is true.

(4) $y_1(t) = x(3t - t_0)$

$y(t - t_0) = x(3(t - t_0)) = x(3t - 3t_0)$

$y_1(t) \neq y(t - t_0)$

So, time variant system.

So, statement(4) is false.

45. Ans: (b)

Sol: $\omega_1 = \frac{2}{3},\ \omega_2 = \frac{1}{2},\ \ \omega_3 = \frac{1}{3}$

$$\omega_0 = \text{GCD}\left(\frac{2}{3},\frac{1}{2},\frac{1}{3}\right) = \frac{1}{6}\,\text{rad/sec}$$

46. Ans: (b)

Sol: From product property $x(n)\,\delta(n - n_0) = x(n_0)\,\delta(n - n_0)$

$z(n) = x(n)\,y(n) = 2^n\delta(n-3)$

$= 2^3\delta(n-3) = 8\delta(n-3)$

$$\sum_{n=-\infty}^{\infty} z(n) = \sum_{n=-\infty}^{\infty} 8\delta(n-3) = 8$$

47. Ans: (c)

Sol: For the input $\delta(n)$,

$h(n) = \delta(n + 2) - \delta(n - 2)$

$\therefore$ For the input x(n), y(n) is the output.

$y(n) = x(n) * h(n)$

$\therefore\ y(n) = x(n + 2) - x(n - 2)$

48. Ans: (c)

Sol: $f_{max} = 50\text{Hz} \Rightarrow \text{N.R} = 2(50) = 100\text{Hz}$

2 times the N.R = 200Hz = 200 Samples/sec

The number of samples obtained in 3 sec

= (200) (3)

= 600 samples

49. Ans: (b)

Sol: Given $y(n) = x(n) - 0.5\,x(n-1)$

Apply Z-transform

$Y(z) = X(z) - 0.5\, z^{-1}\, X(z)$

$$\frac{Y(z)}{X(z)} = H(z) = 1 - 0.5z^{-1}$$

$$H_{INV}(z) = \frac{1}{H(z)} = \frac{1}{1-0.5z^{-1}} = \frac{Y(z)}{X(z)}$$

$Y(z) - 0.5z^{-1}\, Y(z) = X(z)$

Apply IZT

$y(n) - 0.5y(n-1) = x(n)$

50. Ans: (c)

Sol: Given $x(t) = \cos(t)\, u(t - \pi/4)$

$$x(t) = \cos\left(t - \frac{\pi}{4} + \frac{\pi}{4}\right)u\left(t - \frac{\pi}{4}\right)$$

$$x(t) = \cos\left(t - \frac{\pi}{4}\right)u\left(t - \frac{\pi}{4}\right)\frac{1}{\sqrt{2}} - \sin\left(t - \frac{\pi}{4}\right)u\left(t - \frac{\pi}{4}\right)\frac{1}{\sqrt{2}}$$

$$\cos(t)u(t) \leftrightarrow \frac{s}{s^2+1}$$

$$\cos\left(t - \frac{\pi}{4}\right)u\left(t - \frac{\pi}{4}\right) \leftrightarrow \frac{e^{-s\frac{\pi}{4}}.s}{s^2+1}$$

$$\sin(t)\, u(t) \leftrightarrow \frac{1}{s^2+1}$$

$$\sin\left(t - \frac{\pi}{4}\right)u\left(t - \frac{\pi}{4}\right) \leftrightarrow \frac{e^{-s\frac{\pi}{4}}}{s^2+1}$$

$$X(s) = \frac{e^{-s\frac{\pi}{4}}.s}{\sqrt{2}(s^2+1)} - \frac{e^{-s\frac{\pi}{4}}}{\sqrt{2}(s^2+1)} = \frac{e^{-s\frac{\pi}{4}}(s-1)}{\sqrt{2}(s^2+1)}$$

51. Ans: (a)

Sol: $$X(s) = \frac{2s+4}{s^2+4s+3}$$

$$X(s) = \frac{2s+4}{(s+1)(s+3)}$$

$$X(s) = \frac{A}{s+1} + \frac{B}{s+3}$$

$$X(s) = \frac{1}{s+1} + \frac{1}{s+3},\ -3 < \text{Re}\{s\} < -1$$

Apply ILT

$$-e^{-t}u(-t) \leftrightarrow \frac{1}{s+1},\ \text{Re}\{s\} < -1$$

$$e^{-3t}u(t) \leftrightarrow \frac{1}{s+3},\ \text{Re}\{s\} > -3$$

So, $x(t) = -e^{-t}\, u(-t) + e^{-3t}\, u(t)$

52. Ans: (b)

Sol: Step response $s(t) = e^{-t}\, u(t)$

$\therefore$ Output due to r(t) is $y(t) = \dot{s}(t) * r(t)$

$y(t) = s(t) * \dot{r}(t)$

$$= e^{-t}\, u(t) * u(t)\ \left[x(t) * \dot{y}(t) = \dot{x}(t) * y(t)\right]$$

Apply Laplace transform

$$Y(s) = \frac{1}{s+1}\frac{1}{s}$$

$$Y(s) = \frac{1}{s} - \frac{1}{s+1}$$

Apply inverse Laplace transform

$y(t) = (1 - e^{-t})\, u(t)$

53. Ans: (c)

Sol: Two point average filter is

$$y(n)=\frac{1}{2}[x(n)+x(n-1)]$$

Apply Z-transform

$$Y(z)=\frac{X(z)+z^{-1}X(z)}{2}$$

$$H(z)=\frac{Y(z)}{X(z)}=\frac{1}{2}+\frac{1}{2}z^{-1}$$

Apply IZT

$$h(n)=\left\{\frac{1}{2},\frac{1}{2}\right\}=\frac{1}{2}\{1,1\}$$

54. Ans: (b)

Sol: Given $h(t) = (1 - e^{-2t})\, u(t)$

$h(t) = 0,\ t < 0$. So, causal system.

$$\int_{-\infty}^{\infty}|h(t)|dt=\int_{-\infty}^{\infty}\left[u(t)-e^{-2t}u(t)\right]dt$$

$$=\int_{0}^{\infty}1\,dt-\int_{0}^{\infty}e^{-2t}\,dt$$

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

Unstable system

55. Ans: (d)

Sol: By using matrix method

y(n) = x(n) * h(n) =

	4	1	3
2	8	2	6
5	20	5	15
0	0	0	0
4	16	4	12

$$y(n) = x(n) * h(n) = \{8, 22, 11, \underset{\uparrow}{31}, 4, 12\}$$

$$y(0) = 31$$

56. Ans: (b)

Sol: x(n) = {1, 0, 0, 1} and h(n) = {4, ,3 2, 1}

$$x(n)\ Ⓝ\ h(n)=\begin{bmatrix}1&1&0&0\\0&1&1&0\\0&0&1&1\\1&0&0&1\end{bmatrix}\begin{bmatrix}4\\3\\2\\1\end{bmatrix}=\{7,5,3,5\}$$

57. Ans: (d)

Sol: Zero's of linear-phase FIR filter are

$Z_1 = 3+4j$

$Z_2 = Z_1^* \Rightarrow 3-4j$

$$Z_3=\frac{1}{Z_1}\Rightarrow\frac{3}{25}-\frac{4}{25}j$$

$$Z_4=Z_3^*\Rightarrow\frac{3}{25}+\frac{4}{25}j$$

$\left(\frac{1}{3}-\frac{1}{4}j\right)$ is not a zero of linear phase FIR filter.

58. Ans: (b)

Sol: Type-1 chebyshev filters are all pole filters and exhibits equiripple characteristics in the pass band and monotonic characteristics in stop band

Therefore only statement 2 is correct

59. Ans: (c)

Sol: Given, $h(n) = \{5,0,10,0,\underset{\uparrow}{7},-11,3,0,0,0,0,4\}$

By the definition of D.T.F.T

$$H(e^{j\omega}) = F\{h(n)\} = \sum_{n=-\infty}^{\infty} h(n).e^{-j\omega n}$$

Put $\omega = 0$,

$$H(e^{j0}) = \sum_{n=-\infty}^{\infty} h(n) = \sum_{n=-4}^{7} h(n)$$

$= 5 + 10 + 7 + (-11) + 3 + 4$

$= 18$

$H(e^{j0}) = 18$

60. Ans: (a)

Sol: $\because h(n) = \{1,2,3\}$ & $y(n) = \{1,1,2,-1,3\}$

$H(z) = 1+2z^{-1}+3z^{-2}$

$Y(z) = 1+z^{-1}+2z^{-2}-z^{-3}+3z^{-4}$

$\because Y(z) = X(z) . H(z)$

$$\Rightarrow X(z) = \frac{Y(z)}{H(z)}$$

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

$X(z) = 1 - z^{-1} + z^{-2}$

$\Rightarrow x(n) = \{\underset{\uparrow}{1},-1,1\}$

61. Ans: (a)

Sol: $$H(z) = \frac{1-a^{-1}z^{-1}}{1-az^{-1}}$$

$$= \frac{1-\frac{1}{az}}{1-\frac{a}{z}} = \frac{az-1}{az} \times \frac{z}{z-a}$$

$$H(z) = \frac{az-1}{a(z-a)} = \frac{z-\frac{1}{a}}{z-a}$$

Pole of H(z) = ‘a’

Given system is causal. So, For a causal system, to be stable, all the poles must lies inside the unit circle. So $|a| < 1$.

62. Ans: (a)

Sol: For an LTI system, output,

y(t) = input x(t) $*$ impulse response h(t)

$$y(t) = \int_{-\infty}^{\infty} x(\tau)\, h(t-\tau)\, d\tau$$

So, statement (1) is true.

A causal LTI system, need not be always stable. Ex: $h(t) = e^{2t}u(t-3)$

So, statement (2) is false.

For a stable LTI system, $\int_{-\infty}^{+\infty} h(\lambda)\, d\lambda$ is finite.

So, statement (3) is true.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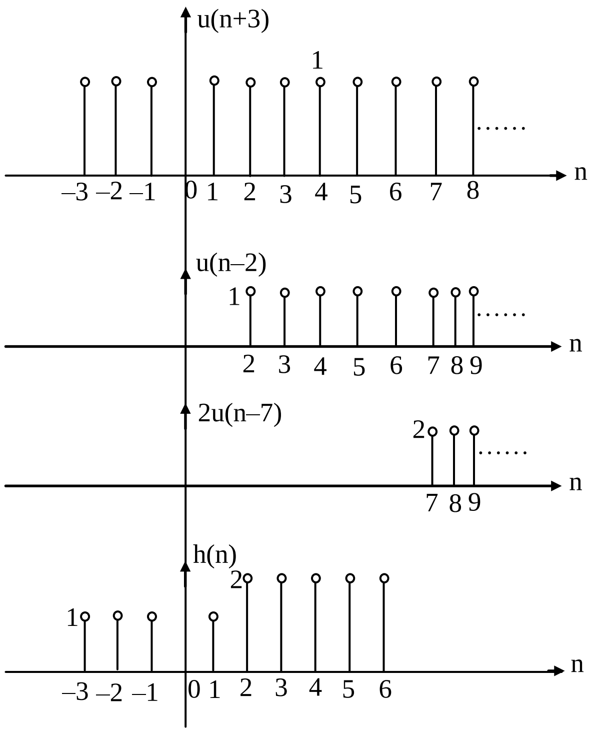
63. Ans: (d)

Sol:



$h(n) \neq 0$ for $n < 0$ .So, non causal system.

$\sum_{n=-\infty}^{\infty} |h(n)| < \infty$ .So, stable system

64. Ans: (d)

Sol: 1. $x(t) \rightarrow a_k$

$$b_k = \frac{1}{T}\int_T x(t-t_0)e^{-jk\omega_0 t}dt$$

$\tau = t - t_0$

$d\tau = dt$

$$b_k = \frac{1}{T}\int_T x(\tau)e^{-jk\omega_0(\tau+t_0)}d\tau$$

$$= e^{-jk\omega_0 t_0}\frac{1}{T}\int_T x(\tau)e^{-jk\omega_0 \tau}d\tau$$

$b_k = e^{-jk\omega_0 t_0} . a_k$

$|b_k| = |a_k|$ [Statement (1) is correct]

2. $x(-t) = \sum_{k=-\infty}^{\infty} a_k e^{-jk\omega_0 t}$

$k = -m$

$y(t) \rightarrow b_k$

then $y(t) = x(-t) = \sum_{k=-\infty}^{\infty} a_{-m}\, e^{jm\omega_0 t}$

$b_k = a_{-k}$ [Statement (2) is correct]

3. If $x(t)$ is even $(x(-t) = x(t))$

Then fourier series coefficients also even.

$a_{-k} = a_k$ [Statement (3) is correct]

4. If $x(t)$ is odd $(x(-t) = -x(t))$

Then fourier series coefficients also odd.

$a_{-k} = -a_k$ [Statement (1) is correct]

65. Ans: (b)

Sol: The correct statements are

1. Analog system poles in the left half s-plane map on to digital system poles inside the circle $|Z| = 1$ in z-plane.

3. Analog system poles on the imaginary axis of S-plane map on to digital system poles on the unit circle $|Z| = 1$ in z-plane.

66. Ans: (b)

Sol: (1) LT $[\delta(t)] = s^2$ LT $[r(t)]$

So, statement (1) is false

(2) $\delta(t) = \frac{d}{dt}u(t)$

So, statement (2) is false

(3) LT[δ(t)] = s LT[u(t)]

So, statement (3) is true

(4) $\delta(t) = \frac{d}{dt}(u(t))$

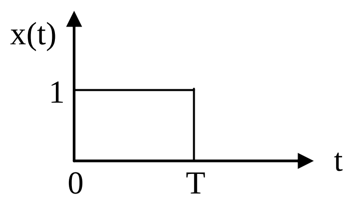
So, statement (4) is true

67. Ans: (c)

Sol: $X(s) = \frac{1}{s} - \frac{1}{s}e^{-sT}$

Apply inverse laplace transform

$= u(t) - u(t-T)$



68. Ans: (b)

Sol: For $x(t) = e^t\, u(t)$, exponentially growing function.

Only Laplace transform exists.

$e^t u(t) \rightarrow \frac{1}{s-1}, \ \sigma > 1$

Fourier transform doesn't exist. $\because$ x(t) is not absolutely integrable.

i.e., $\int_{-\infty}^{\infty} |x(t)| dt < \infty$ is not satisfied

69. Ans: (c)

Sol: $T_{max} = \frac{180}{2\pi N_s}\frac{E_{20}^2}{2x_{20}}$

$S_{Tmax} = \frac{R_2}{X_{20}}$;

$N_{Tmax} = N_s(1 - \frac{R_2}{X_{20}})$

By adding additional resistance in the rotor circuit $R_2 / S_{T\max}$ remains constant, hence rotor current and rotor input power at maximum torque conditions. Therefore maximum torque remains constant. But slip and speed at which maximum torque occurs depends on rotor resistance and they change.

Statement (I) is correct and Statement (II) is wrong.

70. Ans: (a)

Sol: Distribution transformers (in India) usually have the ratings of 3-phase, 11 kV/400-440 V; 50 Hz. They are installed near residential colonies, small-scale industries etc.

A particular feature of these loads is that they vary periodically, with a period of one day. During the course of a day there will be periods when the load is maximum and periods when there is no load (or very light load).

However, the transformer must remain energized all through the day (no one knows)when some connected load might be switched on). Even when on no load, such transformer would therefore be drawing energy for its core losses, thus wasting energy. This energy waste can be reduced if these transformers are designed to have low core losses. This is achieved by operating them at low flux density.

Both ' **Statement-I**' and ' **Statement-II** ' are true '**Statement-II**' is the correct explanation for the ' **Statement-I**'.

71. Ans: (b)

Sol: If normal excitation is used in this test, the resulting induced emf may circulate more than the rated current in the phases. Hence a reduced excitation is used.

It is also true that the phase currents lag their respective induced voltages by 90° (neglecting phase resistances) and hence the armature mmf directly opposes the field mmf. But this is not the reason for using reduced excitation. This reduced excitation is used to prevent the possible damage to the machine under short circuit test.

72. Ans: (d)

Sol: Here, Statement (I) is not correct because due to the armature reaction effect, depending upon load the resultant magnetic field axis shift backwards in case of motor and shift's forwards in case of generator. Here Statement (II) is individually correct.

73. Ans: (b)

Sol: Rotational losses consist of friction and windage losses and eddy current and hysterisis(core losses). Since the two machines are mechanically coupled, friction and windage losses are the same for both machines. But the generator has more excitation and so has more core losses. This is compensated by the larger armature current, larger field distortion, and hence the larger stray losses of motor. Thus, both Statement (I) and Statement (II) are true but Statement (II) is not the correct reason for Statement (I).

74. Ans: (a)

Sol: The total energy of an energy signal falls between the limits 0 and ∞.

So, Statement (I) is true.

The average power of an energy signal is zero.

So, Statement (II) is true.

Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)

75. Ans: (d)

Sol: For a real valued periodic function $f(t) = f^*(t)$

And from exponential Fourier series

$C_n = C_{-n}^*$

Statement (I) is False but statement (II) is True because the discrete magnitude spectrum of real function f(t) is even and phase spectrum is odd.