IES MASTER

Institute for Engineers (IES/GATE/PSUs)

ESE 2019

Prelims Exam

Paper - II

ELECTRICAL ENGINEERING

Detailed Solution

(SET-C)

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SET - C

1. The defining equations for V_1 and V_2 analyzing a two-port network in terms of its impedance parameters are respectively

(a) $Z_{12}I_1 + Z_{12}I_2$ and $Z_{21}I_1 + Z_{21}I_2$

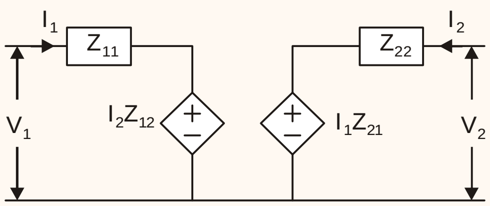
(b) $Z_{11}I_1 + Z_{12}I_2$ and $Z_{21}I_1 + Z_{22}I_2$

(c) $Z_{21}I_1 + Z_{21}I_2$ and $Z_{12}I_1 + Z_{12}I_2$

(d) $Z_{12}I_1 + Z_{12}I_2$ and $Z_{22}I_1 + Z_{22}I_2$

Ans. **(b)**

Sol. V_1 and V_2 in impedance parameter (z-parameter) are given by



$$V_1 = Z_{11}I_1 + Z_{12}I_2$$
$$V_2 = Z_{21}I_2 + Z_{22}I_2$$

So, answer (b).

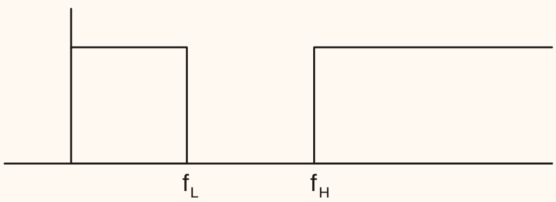
2. A filter that allows high and low frequencies to pass but attenuates any signal with a frequency between two corner frequencies is a

(a) Notch filter (b) Band pass filter

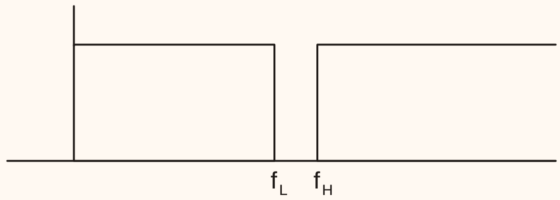
(c) Band stop filter (d) Multiband filter

Ans. **(c)**

Sol. **Band stop filter**



Note: Narrow band stop filter is called Notch filter



3. When a number of two-port networks are cascaded then

(a) z-parameters are added up

(b) y-parameters are added up

(c) h-parameters are multiplied

(d) ABCD-parameters are multiplied

Ans. **(d)**

Sol. When a number of 2-port network are cascaded then ABCD parameters are multiplied.

→ Z-parameters gets added up in series connection.

→ Y-parameters gets added up in parallel connection.

→ h-parameters gets added up in series parallel connection.

4. A 3-phase star-connected 1000 volt alternator supplies power to a 500 kW delta-connected induction motor. If the motor power factor is 0.8 lagging and its efficiency 0.9, then the current in each alternator and motor phase respectively are nearly

(a) 321 A and 231.5A

(b) 401 A and 231.5A

(c) 321 A and 185.4A

(d) 401 A and 185.4A

Ans. **(b)**

Sol. Given :

V_L = 1000 V (line voltage)

Motor output power :

= 500 kW

$\cos\phi$ = 0.8 (lagging)

η = 0.9

So, motor input power :

$$= \frac{500}{0.9}\text{kW}$$

$$P_{in} = 555.55 \text{ kW}$$

Line current,

$$I_L = \frac{P_{in}}{\sqrt{3}V_L \cos\phi}$$

$$\boxed{I_L = \frac{555.55\times10^3}{\sqrt{3}\times1000\times0.8} = 401 \text{ Amp}}$$

As motor is delta connected, current in each phase of motor is

$$I_P = \frac{I_L}{\sqrt{3}} = \frac{401}{\sqrt{3}}$$

$$\boxed{I_P = 231.5\,\text{A}}$$

5. Consider the following statements:

1. Mutual inductance describes the voltage induced at the ends of a coil due to the magnetic field generated by a second coil.
2. The dot convention allows a sign to be assigned to the voltage induced due to mutual inductance term.
3. The coupling coefficient is given by

$$k = \frac{M}{\sqrt{L_1 + L_2}}$$

Which of the above statements are correct?

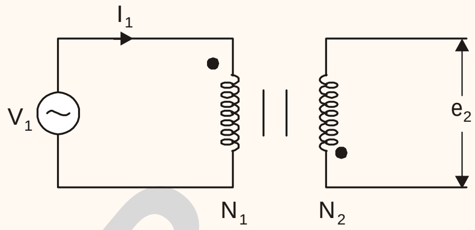
(a) 1, 2 and 3 (b) 1 and 3 only

(c) 1 and 2 only (d) 2 and 3 only

Ans. **(c)**

Sol.

1.



$$e_2 = -M_{21}\frac{dI_1}{dt}$$

So, statement (I) is true.

2. **Dot convention:** If current enters the dotted terminal of one coil then mutual voltage in the second coil is (+)ve at dotted terminal.

3. Co-efficient of coupling is given by

$$K = \frac{M}{\sqrt{L_1L_2}}$$

So, only (1) and (2) correct.

6. Consider the following statements:

1. The rules for series and parallel combinations of capacitors are opposite to those for resistors.
2. The rules for series and parallel combinations of inductors are same as those for resistors.
3. An inductor is a short circuit to dc currents.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

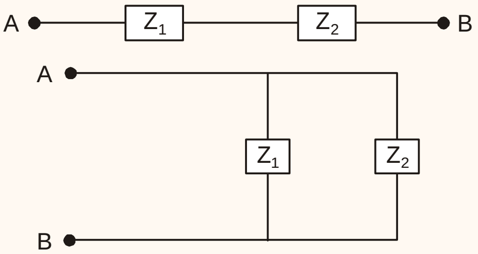
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol. **1.** Z_{AB} (series) = $Z_1 + Z_2$

$R_{AB} = R_1 + R_2$

$$\frac{1}{\omega C_{AB}} = \frac{1}{\omega C_1} + \frac{1}{\omega C_2}$$



Z_{AB} (parallel) $\Rightarrow$

$$\frac{1}{Z_{AB}} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$\frac{1}{R_{AB}} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{For resistance}$$

$$\frac{\omega C_{AB}}{1} = \frac{\omega C_1}{1} + \frac{\omega C_2}{1} \quad \text{For capacitance}$$

2. Series combination of Inductor

$Z_{AB} = Z_1 + Z_2$

$\omega L_{AB} = \omega L_1 + \omega L_2$

Parallel combination of Inductor

$$\frac{1}{Z_{AB}} = \frac{1}{Z_1} + \frac{1}{Z_2} \Rightarrow \frac{1}{\omega L_{AB}} = \frac{1}{\omega L_1} + \frac{1}{\omega L_2}$$

3. Impedance for Inductor $Z_L = \omega L$

For dc currents $\omega = 0$ so, $Z_L = 0\ \Omega$

so behaves as short circuit at steady state.

So, all statements (1), (2) and (3) are true.

7. The standard resistor is a coil of wire of some alloy having the properties of

(a) Low electrical resistivity and high temperature coefficient of resistance

(b) High electrical resistivity and high temperature coefficient of resistance

(c) Low electrical resistivity and low temperature coefficient of resistance

(d) High electrical resistivity and low temperature coefficient of resistance

Ans. (d)

Sol. Properties of a Standard Resistor:

1. Low temperature coefficient
2. High electrical resistivity
3. Long term stability
4. Good high frequency properties, i.e., parasitic effects are negligible.

8. Which one of the following materials is used for the swamping resistance of moving coil instruments?

(a) Carbon (b) Manganin

(c) Silver (d) Brass

Ans. (b)

Sol. 'Manganin' is used as a swamping resistance in moving coil instrument to compensate the change in temperature as this material has negligible temperature coefficient.

9. In a PMMC instrument, the swamping resistor is used to

(a) Increase the damping of the instrument

(b) Reduce the current within safe limits

(c) Compensate for temperature variations

(d) Increase the full-scale sensitivity

Ans. (c)

Sol.
- In a PMMC instrument, the swamping resistor is used to compensate for temperature variations.
- Swamping resistance is made of maganin which has a negligible temperature coefficient.
- Swamping resistance is 20 to 30 times the coil resistance.

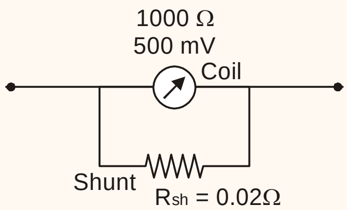
10. A moving coil ammeter has a fixed shunt of $0.02\,\Omega$. With a coil resistance of $R = 1000\,\Omega$ and a potential difference of 500 mV across it, full scale deflection is obtained. The current through the moving coil to give full scale deflection will be

(a) 25A (b) 0.5×10^{-2}A

(c) 0.25×10^{-3}A (d) 0.5×10^{-3}A

Ans. **(d)**

Sol.



Current through the coil

$$= \frac{500\times10^{-3}}{1000}$$

$= 0.5$ mA

$= 0.5 \times 10^{-3}$ A

Current through shunt

$$= \frac{500\times10^{-3}}{0.02}$$

$= 25$ A

Hence, current through the moving coil to give full scale deflection

$= 0.5 \times 10^{-3}$ A

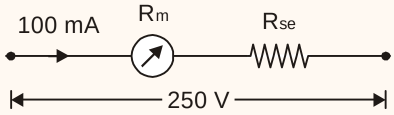
11. A moving iron instrument has full scale current of 100 mA. It is converted into a 250V voltmeter by using a series resistance made of a material having negligible resistance temperature coefficient. The meter has a resistance of 320Ω at 20°C. After carrying a steady current of 100 mA for a long time, the resistance of the coil increases to 369Ω due to self heating. When a voltage of 250V is applied continuously, the error due to self-heating will be nearly.

(a) –1.1% (b) –1.9%

(c) –2.5% (d) –3.3%

Ans. **(b)**

Sol.



Given :

$$R_{m_1} = 320\Omega \text{ at } 20°C$$

$$R_{m_2} = 369\Omega$$

At 20°C,

$$V = I(R_{m_1} + R_{se})$$

$$\Rightarrow \quad 250 = 100 \times 10^{-3} (320 + R_{se})$$

$$\Rightarrow \quad R_{se} = \left(\frac{250}{0.1}\right) - 320 = 2180\Omega$$

After meter is carrying 100 mA for a long time,

$$V' = I(R_{m_2} + R_{se})$$

$$= 100 \times 10^{-3} (369 + 2180)$$

$$= 0.1 \times 2549$$

$$= 254.9 \text{ Volt}$$

$$\therefore \quad \text{Error} = V - V'$$

$$= 250 - 254.9 = -4.9 \text{ V}$$

$$\% \text{ Error} = \frac{V - V'}{V} = \frac{-4.9}{250}\times100$$

$$= -1.96\%$$

12. There will be serious errors if power factor of non-sinusoidal waveform is measured by electrodynamometer power factor meter. This is true for

(a) Single-phase meters alone

(b) 3-phase meters only

(c) Both Single-phase meters and 3-phase meters

(d) 3-phase meters with balanced loads

Ans. **(a)**

Sol. The electrodynamometer type 3ϕ power factor meter, the meter gives indications which are independent of waveform and frequency of supply because the currents in the two moving coils are equally affected by any change of frequency.

However, in single phase power factor meter, the instrument is used at the frequency for which it is designed. Otherwise, it gives serious error as the reactance of the choke coil will change at different frequency.

13. The ramp type digital voltmeter can measure accurately with

(a) A positive going ramp voltage only

(b) A negative or positive going linear ramp voltage

(c) A negative going ramp voltage only

(d) An asymptotic ramp voltage only

Ans. **(b)**

Sol. The principle of ramp-type Digital Voltmeter is to measure the time that a linear ramp voltage takes to change from level of input voltage to zero voltage or, zero voltage to input voltage, i.e., the ramp can be a negative or positive going linear ramp voltage. An electronic counter count and displayed (as a number of digits on electronic indicating) this time interval.

14. The self-capacitance of a coil measured by the resonating capacitor. The measurement gives the value of tuning capacitor as C_1 = 460 pF at a frequency, f_1 = 2 MHz. The second measurement at f_2 = 4 MHz yields a new value of tuning capacitor, C_2 = 100 pF. The distributed capacitance C_d will be

(a) 10 pF (b) 20 pF

(c) 30 pF (d) 40 pF

Ans. **(b)**

Sol. Resonance at frequency f_1 and capacitance c_1,

$$f_1 = \frac{1}{2\pi\sqrt{L(C_1+C_d)}}$$

and resonance at frequency f_2 and capacitance c_2,

$$f_2 = \frac{1}{2\pi\sqrt{L(C_2+C_d)}}$$

i.e., $$\frac{f_2}{f_1} = \sqrt{\frac{C_1+C_d}{C_2+C_d}}$$

$$\Rightarrow \quad 4 = \frac{C_1+C_d}{C_2+C_d}$$

$$\Rightarrow \quad 4C_2 + 4C_d = C_1 + C_d$$

$$\Rightarrow \quad C_d = \frac{C_1-4C_2}{3}$$

$$= \frac{460-(4\times 100)}{3}$$

$$= \frac{460-400}{3}$$

$$= 20 \text{ pF}$$

i.e., distributed capacitance,

$$\boxed{C_d = 20 \text{ pF}}$$

15. Vertical delay line in CRO

(a) Gives proper time for thermionic emission of electrons

(b) Delays the signal voltage by 200 ns

(c) Allows the horizontal sweep to start prior to vertical deflection

(d) Delays the generation of sweep voltage

Ans. **(c)**

Sol. In the vertical signal path, before the delay line, there is typically a trigger pick off which supplies an undelayed copy of the vertical signal to the trigger and sweep circuitry. Trigger and sweep circuitry need about 60 ns to react. Without a delay line, the trigger event would already have come and gone before the scope can trigger and sweep.

Vertical delay line allows the horizontal sweep to start prior to vertical deflection.

16. A 0-150 V voltmeter has a guaranteed accuracy of 1% full scale reading. The voltage measured by this instrument is 83 V. The limiting error will be nearly

(a) 1.2% (b) 1.8%

(c) 2.4% (d) 3.2%

Ans. (b)

Sol. Guaranteed accuracy

$$= 150 \times \frac{1}{100} = 1.5 \text{ V}$$

So, while measuring 83 V on (0–150)V voltmeter, it may read (83 ± 1.5)V. Hence,

$$\text{limiting error} = \frac{1.5}{83} \times 100$$

$$= 1.8\%$$

17. The variations in the measured quantity due to sensitivity of transducer to any plane other than the required plane is

(a) Cross sensitivity

(b) Sensitivity

(c) Interference

(d) Distributed sensitivity

Ans. (a)

Sol. The variation in the measured quantity due to sensitivyt of transducer to any plane other than the required plane is called cross-sensitivity. Sometimes situation may occur where the equipment is very sensitive to the plane perpendicular to the required plane and we have to abandon that equipment due to erroneous result.

18. A resistance strain gauge with a gauge factor of 2 is fastened to a steel member subjected to a stress of 1050 kg/cm^2. The modulus of elasticity of steel is 2.1× 10^6 kg/cm^2. The change in resistance ΔR of the strain gauge element due to the applied stress will be

(a) 0.1% (b) 0.2%

(c) 0.3% (d) 0.4%

Ans. (a)

Sol. Given : Gauge factor,

$$G_f = 2$$

$$\text{Stress} = 1050 \text{ kg/cm}^2$$

Modulus of elasticity,

$$Y = 2.1 \times 10^6 \text{ kg/cm}^2$$

Since, Modulus of elasticity,

$$Y = \frac{\text{Stress}}{\text{Strain}}$$

$$\therefore \quad \text{Strain} = \frac{\text{Stress}}{Y} = \frac{1050}{2.1 \times 10^6}$$

Now, gauge factor,

$$G_f = \frac{\left(\Delta R/R\right)}{\left(\Delta \ell/\ell\right)} = \frac{\left(\Delta R/R\right)}{\text{strain}}$$

$$\Rightarrow \quad \frac{\Delta R}{R} = G_f \times \text{Strain}$$

$$= 2 \times \frac{1050}{2.1 \times 10^6}$$

$$= 0.001$$

Percentage change in resistance

$$= 0.001 \times 100$$

$$= 0.1\%$$

19. In which one of the following classes of computers, is the relationship between architecture and organization very close?

(a) Microcomputers

(b) Mini computers

(c) Mainframe computers

(d) Super computers

Ans. (a)

Sol. In microcomputers, the relationship between architecture and organization are very close. Any changes in the technology not only influence organization but also it leads to enhance the architecture. The RISC machine is good example of this.

20. The decimal equivalent of binary number 1001.101 is

(a) 9.750 (b) 9.625

(c) 10.750 (d) 10.625

Ans. (b)

Sol. Decimal equivalent of

$1001.101 = 2^3 \times 1 + 2^2 \times 0 + 2^1 \times 0 + 2^0 \times 1 + 2^{-1} \times 1 + 2^{-2} \times 0 + 2^{-3} \times 1$

$$= 9 + \frac{1}{2} + \frac{1}{8}$$

$= 9.625$

21. Convert decimal 41.6875 into equivalent binary:

(a) 100101.1011 (b) 100101.1101

(c) 101001.1011 (d) 101001.1101

Ans. (c)

Sol. $41.6875 = 32 + 8 + 1 + 0.5 + 0.125 + 0.0625$

$= 2^5 \times 1 + 2^3 \times 1 + 2^0 \times 1 + 2^{-1} \times 1 + 2^{-3} \times 1 + 2^{-4} \times 1$

$(41.6875)_{10} = (101001.1011)_2$

22. The Central Processing Unit (CPU) consists of

(a) ALU and Control unit only

(b) ALU, Control unit and Registers only

(c) ALU, Control unit and System bus only

(d) ALU, Control unit, Registers and Internal bus

Ans. (d)

Sol. The CPU consists of following component :

(i) ALU : Arithmetic and Logical Unit

(ii) Control Unit

(iii) Registers

(iv) Internal bus

23. When enough total memory space exists to satisfy a request, but it is not contiguous, then this problem is known as

(a) Internal Fragmentation

(b) External Fragmentation

(c) Overlays

(d) Partitioning

Ans. (b)

Sol. External fragmentation problem exists when enough total memory exists to satisfy a request but it is not continguous.

24. The total average read or write time T_{total} is

(a) $T_s + \frac{1}{2r} + \frac{b}{N}$ (b) $T_s + \frac{1}{2r} + \frac{b}{rN}$

(c) $\frac{T_s}{rN} + \frac{b}{N}$ (d) $T_s + 2r + \frac{b}{rN}$

where,

T_s = average seek time

b = number of bytes to be transferred

N = number of bytes on a track

r = rotation speed, in revolutions per second

Ans. (b)

Sol. Total average read or write time

= Seek Time + Total Delay + Time require to read b bytes

Given : Seek Time = T_S

Rotation speed = r revolution/second

$\because$ r revolution in 1 second

$\therefore$ 1 revolution in $\frac{1}{r}$ second

Total delay = $\frac{1}{2r}$

Number of bytes on a track = N

N bytes can be transferred in $\frac{1}{r}$ second

1 byte can be transferred in $\frac{1}{Nr}$ second

b bytes can be transferred in $\frac{b}{Nr}$ second.

Total average read or write time

$$= T_S + \frac{1}{2r} + \frac{b}{Nr}$$

25. If a cache has 64-byte cache lines, how long does it take to fetch a cache line if the main memory takes 20 cycles to respond to each memory request and returns 2 bytes of data in response to each request?

(a) 980 cycles (b) 640 cycles

(c) 320 cycles (d) 160 cycles

Ans. (b)

Sol. A cache has 64 byte cache line.

Main memory response time = 20 cycles

Data size as response = 2 bytes

$$\frac{64 \text{ bytes}}{2 \text{ bytes}} \times 20 \text{ cycles} = 640 \text{ cycles}$$

26. Which of the following statements are correct about SRAM?

1. It provides faster access as compared to DRAM
2. It is cheaper than DRAM
3. It is more expensive than DRAM
4. It has higher bit density than DRAM.

(a) 1 and 4 only (b) 1 and 3 only

(c) 1, 3 and 4 only (d) 2 and 4 only

Ans. (b)

Sol.
- SRAM is faster than DRAM
- SRAM is more expensive than DRAM
- DRAM has higher bit density than SRAM

Hence 1 & 3 only.

27. Features of solid state drives (SSDs) are

1. High-performance in input/output operations per second
2. More power consumption than comparable size HDDs
3. Lower access times and latency rates
4. More susceptible to physical shock and vibration

(a) 2 and 3 only (b) 2 and 4 only

(c) 1 and 3 only (d) 1 and 4 only

Ans. (c)

Sol. SSD can locate, retrieve or write data instantly. There is no any movable read write head like hard disk (HDD). SSD uses software instructions to go directly to the location where data is stored. So access time is reduced.

Since, there is no any moving parts in SSD. So there are less power consumption while working and while idle.

28. The decimal value of signed binary number 11101000 expressed in 1's complement is

(a) – 223 (b) –184

(c) –104 (d) –23

Ans. (d)

Sol. Given binary number is in 1's complement form

1 | 1 1 0 1 0 0 0

sign bit

(–) Taking 1's complement again

1 | 0 0 1 0 1 1 1 = –23

sign (–ve)

29. The memory management function of virtual memory includes

1. Space allocation
2. Program relocation
3. Program execution
4. Code sharing

(a) 1, 2 and 3 only (b) 1, 2 and 4 only
(c) 1, 3 and 4 only (d) 2, 3 and 4 only

Ans. **(c)**

Sol. Program relocation is the process of assigning load address for portion-dependent code and data of a program and adjust the code and data to reflect the assigned address.

So, memory management function of virtual memory does not includes program relocation. It includes space allocation, program execution and code sharing.

30. Which of the following instructions of 8085 are the examples of implied addressing?

1. CMA
2. IN byte
3. RET

(a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

Ans. **(d)**

Sol. Implied addressing mode has implicit operand. Thus, CMA (Complement accumulator, and RET (return) are implied addressing mode instruction.

31. Consider the discrete-time sequence

$$x(n) = \cos\left(\frac{n\pi}{8}\right)$$

When sampled at frequency f_s = 10 kHz, then f_0, the frequency of the sampled continuous time signal which produced this sequence will at least be

(a) 625 Hz (b) 575 Hz
(c) 525 Hz (d) 475 Hz

Ans. **(a)**

Sol. Given :

$$x(n) = \cos\left(\frac{n\pi}{8}\right) \quad ...(1)$$

Let the signal $x(t) = \cos(w_0 t)$

$$x(t) = \cos(2\pi f_0 t)$$

After sampling,

$$x(nT_S) = \cos(2\pi f_0 nT_S)$$

$$x(n) = \cos\left(2\pi n\frac{f_o}{f_S}\right)$$

On comparing with eq. (1)

$$\frac{2\pi f_o}{f_S} = \frac{\pi}{8}$$

$$f_o = \frac{f_S}{16} = \frac{10\times10^3}{16}$$

$$= 625 \text{ Hz}$$

32. How many bits are required in an A/D converter with a B+1 quantizer to get a signal-to-quantization noise ratio of at least 90 dB for a Gaussian signal with range of $\pm 3\sigma_x$?

(a) B + 1 = 12 bits (b) B + 1 = 14 bits
(c) B + 1 = 15 bits (d) B + 1 = 16 bits

Ans. **(d)**

Sol. For (B+1) quantizer SNR

$$\text{SNR} = 6.02\,B + 10.8 - 20\log_{10}\left(\frac{\chi_m}{\sigma_x}\right) \quad ..(1)$$

it is given that $\chi_{m=\pm3\sigma_x}$ full scale value of $\chi_{m=3\sigma_x}$ and (SNR) = 90dB

From (1)

$$90 = 6.02B + 10.8 - 20\log_{10}\left(\frac{3\sigma_x}{\sigma_x}\right)$$

$$90 = 6.02B + 10.8 – 20\ \log_{10}3$$
$$90 = 6.02B+10.8–9.54$$
$$6.02B = 88.74$$
$$B = 14.74 \approx 15$$

Therefore,

$$B+1 = 15+1$$
$$= 16.$$

33. Let x(n) be a left-sided sequence that is equal to zero for n > 0. If X(z) =

$\dfrac{3z^{-1} + 2z^{-2}}{3 - z^{-1} + z^{-2}}$, then x(0) will be

(a) 0 (b) 2

(c) 3 (d) 4

Ans. **(b)**

Sol. $x(z) = \dfrac{3z^{-1}+2z^{-2}}{3-z^{-1}+z^{-2}} = \dfrac{3z+2}{3z^2-z+1}$

The x(n) is left sided. Hence by long division

$$\begin{array}{r|l} 1 - z + 3z^2 & 2 + 3z \;(\; 2 + 5z + \ldots.. \\ & \underset{-}{2} \underset{+}{-} \underset{-}{2z} + 6z^2 \\ & \quad 5z - 6z^2 \\ & \quad \underset{-}{5z} \underset{+}{-} \underset{-}{5z^2} + 15z^3 \\ & \quad - - - \end{array}$$

Hence, x(n) = {– – –, 5, 2}

x(0) = 2

34. The noise variance σ_ε^2 at the output of

$H(z) = \dfrac{0.5z}{z - 0.6}$ with respect to input will be nearly

(a) 40% (b) 50%

(c) 60% (d) 70%

Ans. **(b)**

Sol. In frequency modulation (FM), the carrier frequency (sinusoidal signal) would be varied in proportion to the message (information) signal.

35. If the complex multiply operation takes $1\mu s$, the time taken to compute 1024-point DFT directly will be nearly

(a) 3.45s (b) 2.30s

(c) 1.05s (d) 0.60s

Ans. **(c)**

Sol. Total number of complex multiplication in direct DFT is = N^2

Time taken to compute 1024 point DFT directly

$= N^2.t_M$

$= (1024)^2 \times 1 \times 10^{-6}$ sec

$= 1.0485 \simeq 1.05$ sec

36. Consider the following data to design a low-pass filter

Cut-off frequency $\omega_c = \dfrac{\pi}{2}$,

Stop band ripple δ_c = 0.002,

Transition bandwidth no larger than 0.1π

Kaiser window parameters β and N respectively are

(a) 2.99 and 45 (b) 4.99 and 45

(c) 2.99 and 65 (d) 4.99 and 65

Ans. **(d)**

Sol. $A = -20\log_{10}(\delta_c)$

$= -20\ \log_{10}\ (0.002)$

$= 53.98$

$\beta = 0.1102(A - 8.7);\ A > 50$

$= 4.99$

$$N = \frac{A-8}{2.285(2\pi b)} + 1$$

$\because$ Transition bandwidth, $2\pi b = 0.1\pi$

N = 65

37. A transfer function $G(s) = \frac{1 - sT}{1 + sT}$ has a phase angle of $(-2\tan^{-1}\omega T)$ which varies from 0° to –180° as ω is increased from 0 to ∞. It is the transfer function for

(a) All pass system

(b) Low pass system

(c) High pass system

(d) Band pass system

Ans. **(a)**

Sol. $$G(s) = \frac{1-sT}{1+sT}$$

$$|G(s)| = \frac{\sqrt{1+\omega^2T^2}}{\sqrt{1+\omega^2T^2}} = 1$$

$$|G(j\omega)| = 1$$

For all frequencies, output is present.

$\therefore$ It passes all frequencies.

$\therefore$ It is All Pass System.

38. The open-loop and closed-loop transfer functions of a system are respectively given by

$$G(s) = \frac{K}{j\omega\tau + 1}; \text{ (open loop)},$$

$$G(s) = \frac{\frac{K}{(1+K)}}{j\omega\tau_c + 1}; \text{ (closed loop)},$$

The ratio of the bandwidth of closed loop to open loop system is

(a) K (b) (1+K)

(c) $(1+K)^2$ (d) $\frac{K^2}{(1+K)}$

Ans. **(b)**

Sol. $$A_C = \frac{A_o}{(1+A\beta)}$$

$$(1+A\beta) = \frac{A_o}{A_C} = 1+K$$

For closed loop

$$B_C = (1+A\beta)B_o$$

$$\frac{B_C}{B_O} = 1 + AB = 1 + K$$

39. The system sensitivity of open loop and closed loop system are respectively

(a) 1 and $\frac{1}{1+GH}$

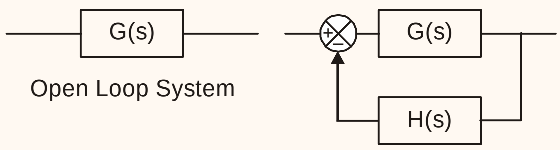
(b) $\frac{1}{1+GH}$ and 1

(c) $\frac{1}{GH}$ and 1

(d) 1 and $\frac{1}{GH}$

Ans. **(a)**

Sol.



$$C(s) = \frac{G(s)}{1+G(s)\cdot H(s)}$$

Sensitivity of open loop system is

$$S_G^G = \frac{\frac{\partial G}{G}}{\frac{\partial G}{G}} = 1$$

Sensitivity of closed loop system is

$$S_G^C = \frac{\frac{\partial C}{C}}{\frac{\partial G}{G}} = \frac{\partial C}{\partial G} \times \frac{G}{C}$$

$$= \frac{\partial}{\partial G}\left[\frac{G}{1+GH}\right] \times \frac{G}{\frac{G}{1+GH}}$$

$$= \frac{\partial}{\partial G}\left[\frac{G}{1+GH}\right] \times (1+GH)$$

$$= \frac{1+GH-GH}{(1+GH)^2} \times (1+GH)$$

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

$$= \frac{1}{1+GH}$$

40. The steady state error of a type-1 system to a unit step input is

(a) $\frac{1}{(1+K_p)}$ (b) 0

(c) ∞ (d) $\frac{1}{K_v}$

Ans. (b)

Sol. e_{ss} (steady state error) for unit

$$\text{step input} = \frac{1}{1+\underset{S\to 0}{Lt}\, G(s)}$$

If G(s) is type-1 system

$$\underset{S\to 0}{Lt}\, G(s) = \infty$$

$$\therefore \quad e_{ss} = \frac{1}{1+\infty} = \frac{1}{\infty} = 0.$$

41. The direction of the net encirclements of the origin of Real-Imaginary plane in a Nyquist plot for the system to be stable is

(a) Clockwise of the origin

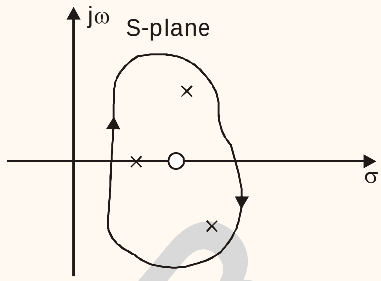
(b) Counter-clockwise of the origin

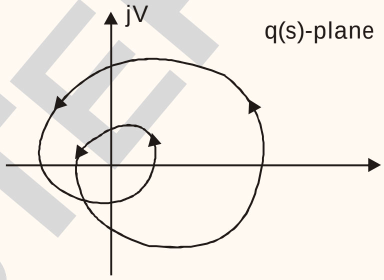
(c) Left hand side s-plane

(d) Right hand side s-plane

Ans. (b)

Sol.





$$q(s) = 1+G(s)H(s)=0$$

$$= \frac{|S-\alpha_1||S-\alpha_2|......}{|S-\beta_1|\,|S-\beta_2|.....}$$

For each zero f q(s) enclosed by the s-plane contour, the corresponding q(s)-plane contour encircles the origin once in the clockwise direction.

Whereas the enclosure of a pole of q(s) by the s-plane contour. The corresponding q(s) plane contour encircles the origin once in the counter clockwise direction.

Thus,, if P poles and Z zeros of q(s) enclosed by the s-plane contour, then the corresponding q(s) plane contour must encircle the origin (P-Z) times in the counter clockwise direction. This is called "principle of argument".

42. A unity negative feedback control system has an open-loop transfer function as

$$G(s) = \frac{K(s+1)(s+2)}{(s+0.1)(s-1)}$$

The range of values of K for which the closed loop system is stable will be

(a) $0 < K < 0.3$ (b) $K > 0.3$
(c) $K > 3$ (d) $K < 0.3$

Ans. (b)

Sol. Characteristic equation is

$$1 + G(s).H(s) = 0$$
$$(S + 0.1)(S - 1) + K(S + 1)(S + 2) = 0$$
$$S^2 + 0.1S - S - 0.1 + K(S^2 + 3S + 2) = 0$$
$$S^2 - 0.9S - 0.1 + K(S^2 + 3S + 2) = 0$$
$$(1 + K)S^2 + (3K - 0.9)S + (2K - 0.1) = 0$$

$$\begin{array}{c|cc} S^2 & 1+K & 2K-0.1 \\ S^1 & 3K-0.9 & \\ S^0 & 2K-0.1 & \end{array}$$

$$\therefore\ \begin{array}{c|c|c} 1+K>0 & 3K-0.9>0 & 2K-0.1>0 \\ K>-1 & 3K>0.9 & 2K>0.1 \\ & K>0.3 & K>0.05 \end{array}$$

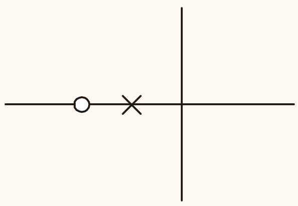
$\therefore$ $K > 0.3$

43. The lag system of a ‘lag lead compensator’ has one pole and one zero. Then pole and zero are

(a) Real and pole is to the left of zero
(b) Real and pole is to the right of zero
(c) Imaginary and pole is above zero
(d) Imaginary and pole is below zero

Ans. (b)

Sol. In lag system pole should be dominant than zero.



$\therefore$ Pole is real and pole is right side of zero.

44. A system with characteristic equation

$F(s) = s^4 + 6s^3 + 23s^2 + 40s + 50$

will have closed loop poles such that

(a) All poles lie in the left half of the s-plane and no pole lies on imaginary axis
(b) Two poles lie symmetrically on the imaginary axis of the s-plane
(c) All four poles lie on the imaginary axis of the s-plane
(d) All four poles lie in the right half of the s-plane

Ans. (a)

Sol. $F(s) = s^4 + 6s^3 + 23s^2 + 40s + 50 = 0$

$$\begin{array}{c|ccc} s^4 & 1 & 23 & 50 \\ s^3 & 6 & 40 & \\ s^2 & \dfrac{6\times23-40}{6}=16.33 & 50 & \\ s^1 & \dfrac{16.33\times40-6\times50}{16.33}=21.62 & & \\ s^0 & 50 & & \end{array}$$

All the elements in first column of RH-criterion have same sign (positive sign). Therefore, all poles lie in the left half of the s-plane.

45. A unity feedback (negative) system has open loop transfer function $G(s) = \dfrac{K}{s(s+2)}$

The closed loop system has a steady state unit ramp error of 0.1. The value of gain K should be

(a) 20 (b) 30
(c) 40 (d) 50

Ans. (a)

Sol. e_{ss} (steady state error) for unit ramp input is

$$= \frac{1}{\underset{s\to0}{Lt}\, s\cdot G(s)}$$

$$e_{ss} = \frac{1}{\underset{s\to 0}{Lt}\, s\cdot\frac{K}{s(s+2)}}$$

$$0.1 = \frac{1}{K/2}$$

$$0.1 = \frac{2}{K}$$

$$\therefore \quad \frac{1}{10} = \frac{2}{K}$$

$$\therefore \quad \boxed{K = 20}$$

46. Transfer function of discrete time system derived from state model is given by

(a) $C(zI-A)^{-1} B + D$

(b) $C(zI - A)^{-1} D + B$

(c) $B(zI - A)^{-1} D + C$

(d) $D(zI - A)^{-1} B + C$

Ans. **(a)**

Sol. Discrete state variable model equations are

$$x(k + 1) = Ax(k) + Bu(k) \quad ...(1)$$

$$y(k) = Cx(k) + Du(k) \quad ...(2)$$

Taking z-transform for eqn. (1) & (2), we get

$$zX(z) - zX_0 = AX(z) + BU(z)$$

$$Y(z) = CX(z) + DU(z)$$

where x_0 is the initial state of the system.

$$(zI - A)X(z) = zX_0 + BU(z)$$

$$X(z) = (zI - A)^{-1}zX_0 + (zI-A)^{-1}BU(z)$$

To find out the transfer function, initial conditions are assumed to be zero

i.e., $X_0 = 0$

Thus, $$Y(z) = \left[C[zI-A]^{-1}B+D\right]U(z)$$

$$\therefore \quad G(z) = \frac{Y(z)}{U(z)} = C(zI-A)^{-1}B+D$$

47. The closed-loop response of a system subjected to a unit step input is

$$c(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t}$$

The expression for the closed loop transfer function is

(a) $\frac{100}{(s+60)(s+10)}$ (b) $\frac{600}{(s+60)(s+10)}$

(c) $\frac{60}{(s+60)(s+10)}$ (d) $\frac{10}{(s+60)(s+10)}$

Ans. **(b)**

Sol. Step input is u(t)

$$u(s) = L[u(t)] = \frac{1}{s}$$

$$\therefore \text{ Transfer function } Y(s) = \frac{C(s)}{U(s)}$$

Given, $$C(t) = \frac{1}{s}+\frac{1}{5}e^{-60t}-\frac{6}{5}e^{-10t}$$

$$C(s) = \frac{1}{s}+\frac{1}{5(s+60)}-\frac{6}{5(s+10)}$$

$$= \frac{5(s+10)(s+60)+s(s+10)-6s(s+60)}{5s(s+10)(s+60)}$$

$$= \frac{5\left[s^2+70s+600\right]+s^2+10s-6s^2-360s}{5s(s+10)(s+60)}$$

$$C(s) = \frac{600}{s(s+10)(s+60)}$$

$$\therefore \text{ Transfer function } = \frac{C(s)}{1/s}$$

$$= \frac{600}{(s+10)(s+60)}$$

48. If it is possible to transfer the system state $x(t_0)$ to any desired state x(t) in specified finite time by a control vector u(t), then the system is said to be

(a) Completely observable

(b) Completely state controllable

(c) Random state system

(d) Steady state controlled system

Ans. (b)

Sol. **Controllability** deals with possibility of forcing the system to a particular state by the application of a control input.

Complete Controllability : If there exist an input sequence, x_k, $k = 0,1,2,...N$. For initial stage x(0) and final state x(N), which can transfer x(0) to x(N) for some finite N.

49. Consider the following statements regarding parallel connection of 3-phase transformers:

1. The secondaries of all transformers must have the same phase sequence.
2. The phase displacement between primary and secondary line voltages must be the same for all transformers which are to be operated in parallel.
3. The primaries of all transformers must have the same magnitude of line voltage.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 1 and 3 only

(c) 1 and 2 only (d) 2 and 3 only

Ans. (a)

50. A 500 kVA transformer has an efficiency of 95% at full load and also at 60% of full load, both at upf. The efficiency η of the transformer at $\frac{3}{4}$ th full load will be nearly

(a) 98% (b) 95%

(c) 92% (d) 87%

Ans. (b)

Sol. Transformer 50 KVA,

Efficiency $\eta = 95\%$ at full load upf.

Efficiency x%, $\eta = \dfrac{x \times P_{out}}{x \times P_{out} + P_i + x^2 P_{cu}} \times 100\%$

At full load

$$\eta_{fl} = \frac{(1 \times 1 \times 1)}{(1 \times 1 \times 4) + P_i + (1)^2 P_{cu}} \times 100\%$$

$$95 = \frac{1}{1 + P_i + P_{cu}} \times 100$$

$$\Rightarrow \quad P_i + P_{cu} = 0.05263 \quad ....(i)$$

where P_i = ironloss P_{cu} = Full load copper loss

At x = 60% and upf

$$95\% = \frac{0.6 \times 1}{0.6 \times 1 + P_i + (0.6)^2 P_{cu}} \times 100$$

$$\Rightarrow \quad P_i + 0.36 P_{cu} = 0.3158 \quad ...(ii)$$

For eqn. (i) and (ii)

P_{cu} = 0.0329 Pu

P_i = 0.0197 Pu

At $3/4$ th full load x = 0.75, upf

$$\eta = \frac{0.75 \times 1}{0.75 \times 1 + 0.0197 + (0.75)^2 \times 0.0329} \times 100\%$$

= 95.15%

51. What is the condition of retrogressive winding in dc machines?

(a) $Y_b > Y_f$ (b) $Y_b < Y_f$

(c) $Y_b = Y_f$ (d) $Y_b = 0.5Y_f$

Ans. (b)

Sol. The coil side displacement of the front end connection is called the front pitch. The coil side displacement of back end connection is called back pitch. The direction in which the winding progresses depends upon which is more Yb or Yf.

For retrogressive winding Yb < Yf

For progressive winding Yb > Yf

52. What is the useful flux per pole on no load of a 250V, 6-pole shunt motor having a wave connected armature winding with 110 turns, armature resistance of 0.2Ω and armature current 13.3 A at no load speed of 908rpm?

(a) 12.4 mWb (b) 22.6 mWb
(c) 24.6 mWb (d) 49.5 mWb

Ans. (c)

Sol. Given : V_t = 250V, poles P = 6

No. of turns N = 110

$\therefore$ Conductors Z = 110 × 2 = 220

Ra = 0.2Ω, I_a = 13.3A, Speed n = 908 rpm.

Motor constant $Ka = \dfrac{ZP}{2\pi A}$

A = No. of parallel paths

(A = 2 for wave wound m/c)

$$\Rightarrow Ka = \frac{220\times6}{2\pi\times2} = \frac{330}{\pi}$$

$$Ka = \frac{330}{\pi}$$

Back emf, $Ea = V_t - I_aR_a = 250 - 13.3\times0.2$

$$Ea = 247.34V$$

$$\because \quad Ea = Ka\phi\omega_m = Ka\phi\frac{2\pi n}{60}$$

$$247.34 = \frac{300}{\pi}\times\phi\times\frac{2\pi}{60}\times908$$

$$\Rightarrow \quad \phi = 24.8 \text{ mWb}$$

53. The cross magnetizing effect of the armature reaction can be reduced by

(a) Making pole shoes flat faced

(b) Making the main field ampere-turns larger compared to the armature ampere turns

(c) Increasing the flux density under one half of the pole

(d) Keeping the direction of rotation of generator in the same direction as motor

Ans. (b)

54. A 500kW, 500V, 10-pole, dc generator has a lap wound armature with 800 conductors. If the pole face covers 75% of pole pitch, the number of pole-face conductors in each pole of a compensating winding will be

(a) 12 (b) 10
(c) 8 (d) 6

Ans. (d)

55. Cogging in an induction motor is caused

(a) If the number of stator slots are unequal to number of rotor slots

(b) If the number of stator slots are an integral multiple of rotor slots

(c) If the motor is running at fraction of its rated speed

(d) Due to 5th harmonic

Ans. (b)

Sol. Cogging also called magnetic locking, it occurs when the number of stator slots are an integral multiple of rotor slots. Strong alignment force are produced between stator and rotor. If alignment forces are more than starting torque then motor fails to start.

56. A 500 hp, 6-pole, 3-phase, 440V, 50Hz induction motor has a speed of 950 rpm on full-load. The full load slip and the number of cycles the rotor voltage makes per minute will be respectively

(a) 10% and 150 (b) 10% and 125
(c) 5% and 150 (d) 5% and 125

Ans. (c)

Sol. Poles P = 6, f = 50 Hz rotor speed Nr = 950 rpm at full load

$$\text{Synch. speed Ne} = \frac{120f}{P}$$

$$= \frac{120\times50}{6} = 1500\,\text{rpm}$$

Full load slip = $\frac{N_S - N_r}{N_s} = \frac{1000-950}{1000} = 0.05$

%s = 5%

Rotor frequency,

f_r = sf = 0.05 × 50 = 2.5 Hz.

Rotor Voltage. speed. $\frac{120f}{P} = \frac{120 \times 2.5}{P} = \frac{300}{P}$

$\because$ P should be integer hence,

P = 2 then speed of voltage = $\frac{300}{2} = 150\,\text{rpm}$

P = 4 speed of voltage = $\frac{300}{4} = 45\,\text{rpm}$

Hence option (c) correct.

57. Effective armature resistance R_a(eff) of a synchronous machine is

(a) $\frac{\text{Short circuit load loss(per phase)}}{(\text{Short circuit armature current})^2}$

(b) $\frac{\text{Short circuit load loss(per phase)}}{\text{Short circuit load current}}$

(c) $\frac{\text{Total short circuit load loss}}{\text{Short circuit armature current}}$

(d) $\frac{\text{Total short circuit load loss}}{\text{Short circuit load current}}$

Ans. **(a)**

Sol. Short circuit load loss = 3 (short circuit armature current)^2 × R_a(eff)

$\Rightarrow R_a(\text{eff})$ =

$$\frac{\text{short circuit load loss(perphase)}}{(\text{Short circuit amature current})^2}$$

58. A 3-phase synchronous motor has 12-poles and operates from 440V, 50Hz supply. If it takes a line current of 100A A at 0.8 power factor leading, its speed and torque are nearly

(a) 500 rpm and 1165 N-m

(b) 1000 rpm and 2330 N-m

(c) 500 rpm and 2330 N-m

(d) 1000 rpm and 1165 N-m

Ans. **(a)**

Sol. Synchronous motor P = 12, f = 50 Hz, V = 440V, Ia = 100A

Synch speed, Ns = $\frac{120f}{P} = \frac{120 \times 50}{12} = 500\,\text{rpm}$

Power input to motor P = $\sqrt{3}\, VI_a \cos\phi$

$= \sqrt{3} \times 440 \times 100 \times 0.8$

P = 60968.2W

$\because$ P = $T \cdot \omega$

T = Torque

$\Rightarrow$ T = $\frac{P}{\omega_s} = \frac{60968.2}{\frac{2\pi}{60} \times 500}$

T = 1164.5 Nm

59. Which of the following are the advantages of using a stepper motor?

(a) Compatibility with transformers and sensors needed for position sensing

(b) Compatibility with digital systems and sensors are not required for position and speed sensing

(c) Resonance effect often exhibited at low speeds and decreasing torque with increasing speed

(d) Easy to operate at high speeds and compatible with analog systems

Ans. **(b)**

Sol. Due to discrete control available. It is compatible with digital systems.

IES MASTER

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ESE-2019 Conventional Test Schedule, Electrical Engineering

Date	Topic
17th Mar 2019	**N.T.** : ECF-1, MC-1, MC-2, ADE-2
	R.T. :
24th Mar 2019	**N.T.** : ECF-2, MI-1, CS-1, CS-2
	R.T. : ECF-1, MC-1, MC-2, ADE-2
31st Mar 2019	**N.T.** : ECF-3, MI-2, MC-3, MC-4
	R.T. : ECF-2, MI-1, CS-1, CS-2
07th Apr 2019	**N.T.** : BEX-1, ADE-1, ADE-3
	R.T. : ECF-3, MI-2, MC-3, MC-4
14th Apr 2019	**N.T.** : EM-1, MATH-1, PS-1, SSP-1
	R.T. : BEX-1, ADE-1, ADE-3
21st Apr 2019	**N.T.** : CF-1, MATH-2, PS-2, PE-1
	R.T. : EM-1, MATH-1, PS-1, SSP-1
28th Apr 2019	**N.T.** : BEX-2, MI-3, CS-3, SSP-2
	R.T. : CF-1, MATH-2, PS-2, PE-1
05th May 2019	**N.T.** : EM-2, PS-3
	R.T. : BEX-2, MI-1, MI-3,. CS-3, SSP-2, ADE-3, MC-1, MC-2
12th May 2019	**N.T.** : CF-2, PE-2
	R.T. : EM-2, ECF-1, ECF-3, MI-2, PS-2, PS-3, ADE-2, CS-2
19th May 2019	**N.T.** : CF-3, MATH-3
	R.T. : CF-2, ECF-2, MI-1, BEX-1, EM-1, CS-1, MI-3, CS-3, ADE-3, PE-2, SSP-1
26th May 2019	**N.T.** :
	R.T. : MATH-1, MATH-3, EM-1, EM-2, ECF-1, BEX-2, CF-3, ADE-2, CS-2, PS-1, PS-3 PE-1, SSP-2
02nd Jun 2019	Full Length-1 (Test Paper-1 + Test Paper-2)
09th Jun 2019	Full Length-2 (Test Paper-1 + Test Paper-2)
16th Jun 2019	Full Length-3 (Test Paper-1 + Test Paper-2)

Test Type	Timing	Day
Conventional Test	10:00 A.M. to 1:00 P.M.	Sunday
Conventional Full Length Test Paper-1	10:00 A.M. to 1:00 P.M.	Sunday
Conventional Full Length Test Paper-2	02:00 P.M. to 5:00 P.M.	Sunday

Note : The timing of the test may change on certain dates. Prior information will be given in this regard.

*N.T. : New Topic. *R.T. : Revision Topic

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Subject Code Details

Subject	Code	Topics
Engineering Mathematics (MATH)	MATH-1	♦ Linear Algebra ♦ Complex Variables ♦ Transform Theory
	MATH-2	♦ Calculus ♦ Differential Equations
	MATH-3	♦ Probability and Statistics ♦ Numerical Methods
Electrical Materials (EM)	EM-1	♦ Crystal Structures & Solid State ♦ Band Theory ♦ Dielectrics ♦ Magnetic materials
	EM-2	♦ Conductive materials ♦ Photo conductivity ♦ Nano materials ♦ Superconductors
Electric Circuits & Fields (ECF)	ECF-1	♦ Circuit Elements ♦ 3-phase Circuits ♦ Network Graphs ♦ Transient and steady state Response
	ECF-2	♦ Magnetically Coupled Circuits ♦ Network Theorems ♦ Two-port networks ♦ Resonance ♦ Basic Filters
	ECF-3	♦ Electrostatics and Magneto statics ♦ Time varying fields & Maxwell's Equations
Electrical & Electronic Measurements	MI-1	♦ Errors, Units, Dimensions & standards ♦ Galvanometers ♦ Types of Instruments ♦ Measurement of Power
	MI-2	♦ Measurement of Energy ♦ Measurement of resistance ♦ Potentiometers ♦ AC bridges ♦ CRO ♦ Q-meter
	MI-3	♦ Electronic Instrumentation ♦ Data Acquisition System ♦ Transducers
Computer Fundamentals (CF)	CF-1	♦ Architecture, CPU, I/O, Memory, Peripheral devices ♦ Boolean algebra ♦ Number system arithmetic functions
	CF-2	♦ Basic of OS, Virtual memory ♦ File system ♦ Networking
	CF-3	♦ Data Representation and Programming, Programming languages
Basic Electronics Engineering (BEX)	BEX-1	♦ Basics of diodes, BJT, FET, MOSFET
	BEX-2	♦ Transistor amplifiers – equivalent circuits & frequency response ♦ Oscillators, Feedback amplifiers
Analog Digital Electronics (ADE)	ADE-1	♦ OPAMP ♦ Multivibrator, Sample and Hold circuits ♦ Filters
	ADE-2	♦ Digital Electronics ♦ Microprocessors
	ADE-3	♦ Communications
Systems and Signal Processing (SSP)	SSP-1	♦ Continuous & discrete-time signals ♦ Shifting and scaling ♦ Linear, time-invariant and causal system ♦ Laplace & Z-transform
	SSP-2	♦ Fourier series ♦ Discrete Fourier Transform ♦ FFT ♦ FIR and IIR Filters ♦ Bilinear Transformation
Control System (CS)	CS-1	♦ Basics ♦ Block diagram Algebra ♦ Signal flow ♦ Mathematical Modeling
	CS-2	♦ Time Response Analysis ♦ Stability ♦ Root Locus
	CS-3	♦ Controllers & Compensators ♦ State Variable Analysis ♦ Frequency Response & its stability
Electrical Machines (MC)	MC-1	♦ Transformers ♦ Basic concepts of Rotating Machines
	MC-2	♦ Polyphase Induction Machines ♦ Single Phase motors
	MC-3	♦ DC Machines
	MC-4	♦ Synchronous Machines
Power System (PS)	PS-1	♦ Electric Power Sources-Thermal, Hydro Nuclear, Wind & Solar ♦ Performance of lines & cables ♦ HVDC & Corona ♦ Smart Grid; Environment Implications
	PS-2	♦ Symmetrical Components & Fault Analysis ♦ Power System stability & dynamics ♦ Load flow; Matrix Representation
	PS-3	♦ Economic Load Dispatch & Power Economics ♦ Load Frequency control ♦ Voltage Control & Compensation ♦ FACTS ♦ Power System Protection ♦ Solid state Relays
Power Electronics and Drivers (PE)	PE-1	♦ Power Semiconductor Devices ♦ High Frequency Inductors & transformers ♦ Diode Rectifiers ♦ Phase Controlled Rectifiers
	PE-2	♦ Choppers; DC-DC switched mode converters ♦ Inverters; DC-AC switched mode converters ♦ AC Voltage Controllers ♦ Cycloconverters ♦ Electric Drives ♦ Resonant Converters

60. The disadvantage of hunting in synchronous machines is

(a) Fault occurs in the supply system

(b) Causes sudden change in inertia

(c) Causes large mechanical stresses and fatigue in the rotor shaft

(d) Causes harmonics

Ans. (c)

Sol. ..

61. Consider the following statements for a large national interconnected grid:

1. Better load frequency control
2. Same total installed capacity can meet lower demands
3. Better hydro/thermal/nuclear/renewable co-ordination and energy conservation

Which of the above statements are correct?

(a) 1 and 3 only (b) 1 and 2 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. (a)

Sol.

Interconnecting different coherent areas, requires a better load frequency control. It also facilitates better coordination of conventional and non-conventional power plants leading to energy conservation. Hence, statement-1 and 3 are correct. Whereas, statement-2 is incorrect.

62. A single-phase transformer is rated 110/440 V, 2.5 kVA. Leakage reactance measured from the low-tension side is 0.06Ω. The per unit leakage reactance will be

(a) 0.0062/unit (b) 0.0124/unit

(c) 0.0496/unit (d) 0.1983/unit

Ans. (b)

Sol. Given data,

Single-phase transformer, 2.5 KVA, 110/440V

Leakage impedance (LV) $\Rightarrow Z_L = 0.06\,\Omega$

$\because$ Base impedance at LV side

$$Z_b\big|_{LV} = \frac{(KV)_b^2}{(MVA)_b}$$

$$= \frac{(110)^2}{2.5\times10^3} = 4.84\Omega$$

Now, per unit leakage reactance,

$$Z_{pu} = \frac{Z_L}{Z_b\big|_{LV}} = \frac{0.06}{4.84}$$

$$= 0.01239$$

$$\approx 0.0124$$

63. A concentric cable has a conductor diameter of 1cm and an insulation thickness of 1.5cm. When the cable is subjected to a test pressure of 33kV, the maximum field strength will be nearly

(a) 41,000V (b) 43,200V

(c) 45,400V (d) 47,600V

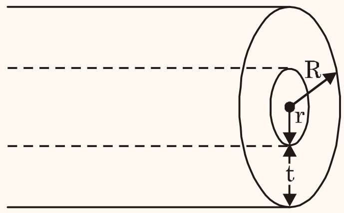
Ans. (d)

Sol. Given data,

Conductor diameter (2r = d) = 1cm

Insulation thickness (t) = 1.5cm

Test voltage (V) = 33 KV



Hence, $D = 2R = 2r+2t = d+2t$

$= 4cm$

Maximum field strength is given as,

$$E_{max} = \frac{V}{r\ln\frac{R}{r}} = \frac{V}{r\ln\frac{D}{d}}$$

$$= \frac{33000}{0.5\ln\frac{4}{1}} \simeq 47,608.93V / cm$$

64. Radio influence voltage (RIV) generated on a transmission line conductor surface is not affected by

(a) System voltage

(b) Corona discharges on the conductors

(c) Rain

(d) Nearby radio receivers

Ans. **(d)**

Sol. Radio-Influence voltage (RIV) is high frequency voltage, generated by any source of ionization current that appears at the terminals of electrical power appratus or on power circuits.

RIV is affected by

– Operating system voltage

– Corona discharge

– Atmospheric conditions (rain, dust)

– Surface irregularity

Though it does not depend upon nearby radio receivers.

65. Consider the following properties regarding insulation for cables:

1. A low specific resistance

2. High temperature withstand

3. High dielectric strength

Which of the above properties of insulation are correrct while using cables?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(c)**

Sol. The insulation of cables should have

– a high specific resistance

– high temperature withstand capability

– high dielectric strength to handle high voltage stress.

66. Which one of the following faults occurs more frequently in a power system?

(a) Grounded star-delta

(b) Double line faults

(c) LLG faults

(d) Single line-to-ground (LG) faults

Ans. **(d)**

Sol. The relative frequency of occurrence of various type of faults.

Types of fault	Frequency
LLL	5%
LLG	10%
LL	15%
LG	70%

67. The maximum permissible time of de-energization of the faulty circuit is dependent on

(a) Voltage on the system

(b) The number of conductros involved

(c) Load carried by the faulty circuit

(d) Fault current and its duration

Ans. **(d)**

Sol. The maximum permissible time of de-energization of the faulty circuit depends upon the fault current magnitude and its time persistency.

68. Which one of the following is used for communication with the aim of achieving high figure of merit in HVDC circuit breakers?

(a) Oil interrupter

(b) Air interrupter

(c) Vacuum interrupter

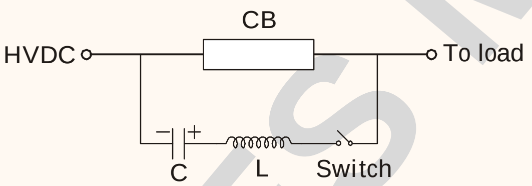
(d) SF_6 interrupter

Ans. **(c)**

Sol. Due to the absence of natural current zero while breaking an HVDC current. An HVDC circuit breaker must overcome three problems:

1. Creation of artificial current zero.
2. Prevention of arc restrike.
3. Dissipation of stored energy.

The HVDC circuit breaker is nothing but a vacuum circuit breaker. The LC circuit along with a switch is connected in parallel with this circuit breaker. The capacitor C is precharged capacitor with polarities shown in the figure.



When the circuit breaker starts opening, the switch in the LC circuit gets closed. Due to the charged capacitor, the discharging current starts flowing in opposite direction to that of the load current carried by the circuit breaker. Due to this, arcing current starts oscillating producing artificial currrent zeros.

69. Which of the following buses are used to form bus admittance matrix for load flow analysis?

1. Load bus
2. Generator bus
3. Slack bus

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol. Bus admittance matrix is constructed by using all the buses i.e.

Load buses (PQ)
Generator buses (PV)
Slack bus
For an n-bus system, the size of Y_{BUS} is (n×n) (hence, including all PQ, PV and slack buses).

70. In a 3-phase, 60Hz, 500MVA, 15kV, 32-pole hydroelectric generating unit, the values of ω_{syn} and ω_{msyn} will be nearly

(a) 754 rad/s and 47.6 rad/s

(b) 377 rad/s and 46.7 rad/s

(c) 377 rad/s and 23.6 rad/s

(d) 754 rad/s and 23.6 rad/s

Ans. **(c)**

Sol. Given data,

3-phase, 60 Hz, 500 MVA, 15KV, 32-pole, hydroelectric generating unit.

$$\omega_{syn} = 2\pi f = 2\times 3.14\times 60$$

$$= 376.8 \simeq 377 \text{ rad/s}$$

$$\because \quad \theta_e = \frac{P}{2}\theta_m$$

[where, P is the number of poles]

$$\Rightarrow \quad \frac{d\theta_e}{dt} = \frac{P}{2}\frac{d\theta_m}{dt}$$

$$\omega_{syn} = \frac{P}{2}\omega_{msyn}$$

$$\Rightarrow \quad \omega_{syn} = \frac{2}{P}\omega_{syn} = \frac{2}{32}\times 377$$

$$= 23.6 \text{ rad/s}$$

71. The methods adopted for improving the steady state stability of power system are

1. Quick response excitation system
2. Higher excitation voltages
3. Maximum power transfer by use of series capacitor or reactor

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (c)

Sol. Quick response excitation system improves transient stability.

Steady state stability refer to the ability of the system to come back to the stable operating condition after the occurrence of slow and gradual changes in the system.

The steady state stability limit is given as

$$\text{SSSL} = \frac{|V_1||V_1|}{X_{eff}}$$

Higher the SSSL, higher the margin for steady state stability. Hence X_{eff} should be low and $|V_1| \simeq |V_2|$ should be high.

Hence, statement-2 is correct, as higher excitation voltages $\rightarrow$ high SSSL. Statement-3 is incorrect, as series capacitor leads to reduction in effective reactance but series reactor increase the effective reactance.

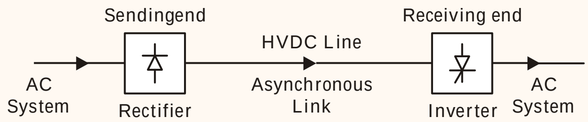
Whereas, for SSSL$\uparrow$, $X_{eff}\downarrow$.

72. The HVDC system uses

(a) Rectifier station at sending end and inverter station at receiving end
(b) Inverter station at sending as well as at the receiving end
(c) Rectifier station at sending end as well as at the receiving end
(d) Inverter station at sending end and rectifier station at receiving end

Ans. (a)

Sol.



At the sending end, AC power is rectified to DC with the help of rectifiers. Whereas, at the receiving end DC is again converted to AC with the help of inverters as most of the practical loads are driven by AC power.

73. Which one of the following in not required for power diode?

(a) High speed operation
(b) Fast communication
(c) Small recovery time
(d) Low on state voltage drop

Ans. (b)

Sol. The power diode should have

(i) High speed operation for that, small recovery time is required.

(ii) Low on state voltage drop to reduce conduction losses.

74. The reverse recovery time of a diode is t_{rr} = 3μs and the rate of fall of the diode current is $\frac{di}{dt}$ = 30 A/μs. The storage charge Q_{RR} and the peak inverse current I_{RR} will be respectively

(a) 135μC and 90A

(b) 270μC and 90A

(c) 270μC and 60A

(d) 135μC and 60A

Ans. (a)

Sol. $I_{RR} = \left(\frac{dI}{dt}\right) \times t_{rr} = 30\left(\frac{A}{\mu s}\right) \times 3\,(\mu s)$

$$\boxed{I_{RR} = 90\text{ A}}$$

$$Q = \frac{1}{2} \times t_{rr} \times I_{RR}$$

$$= \frac{1}{2} \times 3 \times 10^{-6} \times 90$$

$= 135 \times 10^{-6}$ C

$= 135\ \mu$C

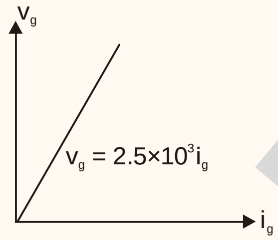
75. The i_g–v_g characteristics of a thyristor is a straight line passing through origin with a gradient of 2.5×10^3. If $P_g = 0.015$ watt, the value of gate voltage will be nearly

(a) 5.0V (b) 6.1V

(c) 7.5V (d) 8.5V

Ans. **(b)**

Sol. The power dissipated in diode is



$$P_g = v_g i_g$$

given, $v_g = 2.5 \times 10^3\ i_g$

$$\therefore \quad 0.015 = \left(2.5\times10^3 i_g\right)\left(i_g\right)$$

$$\therefore \quad \left(i_g\right)^2 = \frac{0.015}{2.5\times10^3} = 6\times10^{-6}$$

$$i_g = \sqrt{6\times10^{-6}} = 0.00244$$

$$\therefore \quad v_g = 2.5 \times 10^3\ i_g$$

$$= 2.5 \times 10^3 \times 0.00244$$

$$v_g = 6.12\text{V}$$

76. A single-phase 220V, 1kW heater is connected to half wave controlled rectifier and is fed from a 220V, 50Hz ac supply. When the firing angle α = 90°, the power absorbed by the heater will be nearly

(a) 1000W (b) 750W

(c) 500W (d) 250W

Ans. **(d)**

Sol. The output RMS voltage of half wave rectifier is given by

$$(V_{rms})_0 = \frac{V_m}{\sqrt{2}\,\pi}\left\{(\pi-\alpha)+\sin\left(\frac{\alpha}{2}\right)\right\}^{1/2}$$

$$= \frac{220\sqrt{2}}{\sqrt{2}\,\pi}\left\{\frac{\pi}{2}+\frac{1}{\sqrt{2}}\right\}^{1/2}$$

$$= \frac{220}{\pi}\{1.57+0.707\}^{1/2}$$

$$= \frac{220}{\pi}\times(2.27)^{1/2}$$

$$= \frac{220}{\pi}\times1.5$$

$$(V_{rms})_0 = \frac{220}{2} = 110\text{ V}$$

Power absorbed by resistance,

$$P \propto (V_{rms})^2$$

$$\frac{P_{rated}}{P_2} = \frac{(V_{rms})^2_{rated}}{(V_{rms})^2_0}$$

$$P_2 = 1000\times\frac{(110)^2}{(220)^2}$$

$$P_2 = \frac{1000}{4} = 250\text{ W}$$

77. When we compare the half bridge converter and full bridge converter

1. The maximum collector current of a full bridge is only double that of the half bridge

2. Full bridge uses 4-power switches instead of 2, as in the double bridge.
3. Output power of a full bridge is twice that of a half bridge with the same input voltage and current.

When of the above statements are correct?

(a) 1, 2 and 3 (b) 1 and 2 only
(c) 1 and 3 only (d) 2 and 3 only

Ans. **(b)**

78. A single-phase fully controlled bridge converter is connected with RLE load where R = 5Ω, L = 4mH and E = 50V. This converter circuit is supplied from 220V, 50Hz ac supply. When the firing angle is 60°, the average value of the load current will be nearly

(a) 12.2 A (b) 9.8 A
(c) 6.4 A (d) 4.2 A

Ans. **(b)**

Sol. There will be continuous current due to inductor value being very high.

$$\therefore \quad V_0 = \frac{2V_m}{\pi}\cos\alpha$$

$$= \frac{220\sqrt{2}}{3.14}\times\cos 60°$$

$$V_0 = 99.07 \text{ V}$$

$\therefore$ Average Current :

$$I_o = \frac{V_o - E}{R}$$

$$= \frac{99.07-50}{5}$$

$$= \frac{49.07}{5} = 9.8 \text{ A}$$

79. Consider the following statements regarding ac drives:

1. For the same kW rating, ac motors are 20% to 40% light weight as compared to dc motors.
2. The ac motors are more expensive as compared to same kW rating dc motors.
3. The ac motors have low maintenance as compared to dc motors.

Which of the above statements are correct?

(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Ans. **(c)**

Sol. ..

80. A 3-phase induction motor drives a blower where load torque is directly proportional to speed squared. If the motor operates at 1450 rpm, the maximum current in terms of rated current will be nearly

(a) 2.2 (b) 3.4
(c) 4.6 (d) 6.8

Ans. **(a)**

Sol. For N = 1450rpm,

$$s = \frac{1500-1450}{1500} \Rightarrow S = 0.033$$

The slip at which T_2 is maximum for blower type load $\left(T_L \propto \omega^2\right)$ is s = $\frac{1}{3}$

$$\frac{I_{2\max}}{I_{2(\text{rated})}} = \frac{\frac{\sqrt{1}}{3}\times\frac{2}{3}}{\sqrt{0.033\times(1-0.033)}}$$

$$\Rightarrow \quad (I_2)_{\max} = 2.2 I_{2\text{rated}}$$

81. Consider the following statements.

1. SMPS generates both the electromagnetic and radio frequency interference due to high switching frequency.
2. SMPS has high ripple in output voltage and its regulation is poor.
3. The output voltage of SMPS is less sensitive with respect to input voltage variation.

Which of the above statements are correct?

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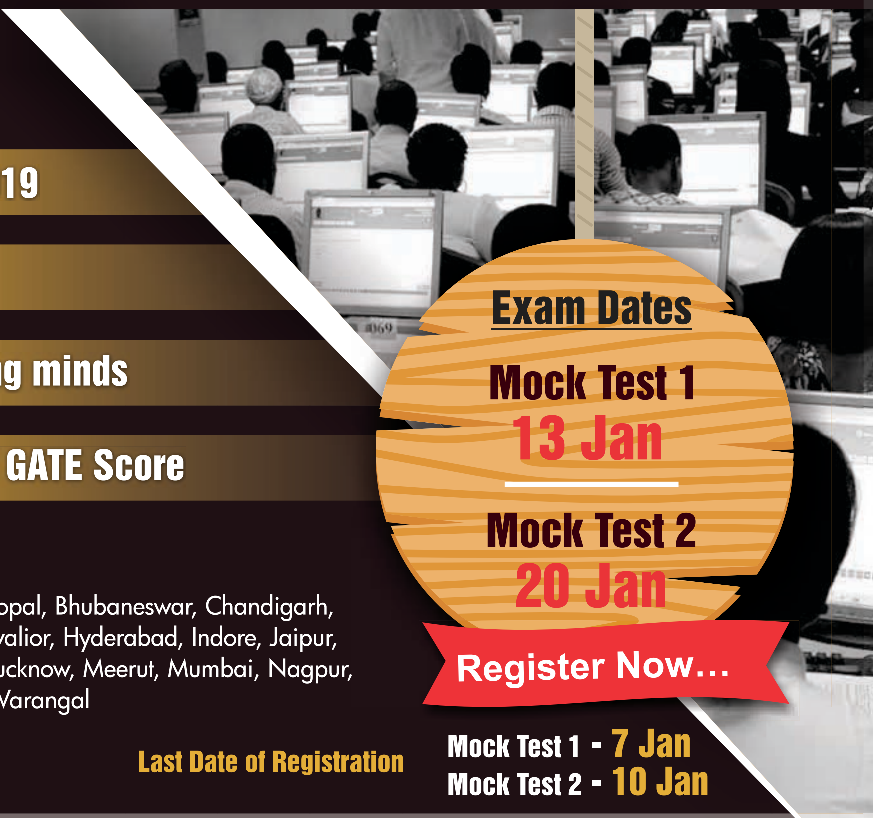

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(a) 1 and 3 only (b) 2 and 3 only
(c) 1 and 2 only (d) 1, 2 and 3

Ans. **(d)**

Sol.
- SMPS has high ripple in output voltage and its regulation is poor.
- SMPS produces electromagnetic as well as radio frequency interference, since current is switched ON and OFF sharply.
- The output voltage of SMPS is less sensitive w.r.t. input voltage variation as compared to linear supply.

82. Consider the following features with respect to the flyback converters:

1. It is used mostly in application below 100W.
2. It is widely used for high-output voltage.
3. It has low cost and is simple

Which of the above statetments are correct?

(a) 1, 2 and 3 (b) 1 and 2 only
(c) 1 and 3 only (d) 2 and 3 only

Ans. **(a)**

Sol.
- The Flyback type SMPS circuit offers simple topology and low cost, although its efficiency is inferior to other SMPS circuits.
- That's why it is used in low power circuits, from few watts to less than 100 W.
- Flyback converters are well suited for high output voltages.

83. Consider the following statements regarding the function of dc-dc converter in a dc motor:

1. It acts as regenerative brake
2. It controls the speed of motor
3. It controls the armature voltage of a dc motor.

Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(d)**

Sol. The dc-dc converter can change the speed of a dc motor, by changing the armature voltage of a dc motor.

$$I_a = \left(\frac{V - E_b}{R_a + R_{se}}\right) \quad \{\text{for motor operation}\}$$

If, V is made less than E_b, I_a can be reverse to make dc motor work as generator hence regenerative braking can be obtained by changing V with help of dc–dc converter.

84. The power supplies which are used extensively in industrial applications are required to meet

1. Isolation between the source and the load
2. High conversion efficiency
3. Low power density for reduction of size and weight
4. Controlled direction of power flow

Which of the above specifications are correct?

(a) 1, 2 and 3 only (b) 1, 3 and 4 only
(c) 1, 2 and 4 only (d) 2, 3 and 4 only

Ans. **(c)**

Sol. The power supplies which are used in industrial application, must have :

(a) Isolation between source and load so that load disturbance does not make supply unstable.
(b) High conversion efficiency.
(c) High power density so that size and weight of supply is reduced.
(d) Controlled direction of power flow.

85. **Statement (I) :** Soft iron does not retain magnetism permanently.

Statement (II) : Soft iron has no retentivity.

Ans. **(c)**

Sol.
- Soft iron does not retain magnetism permanently as it has very low retentivity (H_c). Hence, soft magnetic materials are easy to magnetize and easy to demagnetize.
- Hard magnetic materials are hard to magnetize and hard to demagnetize because it has high retentivity (H_c).

So, Statement-I is true but Statement-II is false.

86. **Statement (I) :** Reaction turbines are generally used for sites with high head and low flow.

Statement (II) : Kaplan and Francis turbines are reaction turbines.

Ans. **(d)**

Sol. Statement I is false as impulse turbines are used for high head sites and reaction turbines are used for low head sites.

Statement II is true as both Kaplan and Francis turbines are reaction turbines.

Francis turbines are mixed flow turbine since water enters radially but leaves turbine axially.

Kaplan turbines are axial flow turbine since water enters axially and leaves the turbine axially.

87. **Statement (I) :** One can formulate problems more efficiently in a high-level language and need not have a precise knowledge of the architecture of the computer.

Statement (II) : High level languages permit programmes to describe tasks in a form which is problem oriented than computer oriented.

Ans. **(a)**

Sol. A high-level programming language is a programming language with strong abstraction from the details of the architecture of the computer.

88. **Statement (I) :** Sign magnitude representation is generally used in implementing the integer portion of the ALU.

Statement (II) : In sign magnitude representation there are two representation of 0.

Ans. **(d)**

Sol. Sign-magnitude representation is rarely used in implementing the integer portion of the ALU. The most common scheme is two's complement representation.

In signed magnitude representation, there are two ways two represent zero.

00000000 = 0

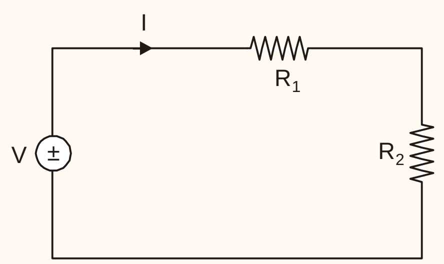
10000000 = –0

89. **Statement (I) :** When a non-linear resistor, in series with a linear resistor, both being non-inductive, is connected to a voltage source, the current in the circuit cannot be determined by using Ohm's law.

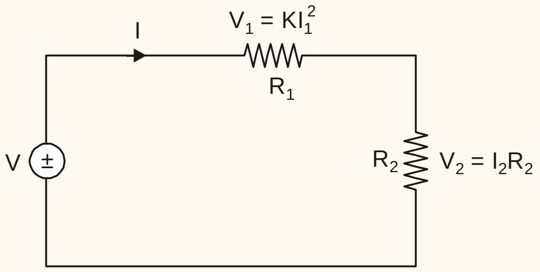
Statement (II) : If the current-voltage characteristic of the non-linear resistor is known, the current-voltage characteristic of the series circuit can be obtained by graphical solution.

Ans. **(b)**

Sol.



Ohm's law is applicable for linear resistor only so we cannot determine the current using Ohm's law.



We can obtain I–V characteristic of series circuit by combining both the graphs or by using KVL.

So, both statements are individually true but statement (II) is not correct explanation of (I).

90. **Statement (I) :** Soft magnetic materials, both metallic and ceramic are used for making transformers core, whereas, hard magnetic materials both metallic and ceramic are used for making permanent magnets.

Statement (II) : Magnetic materials, both metallic and ceramic are classified as soft or hard according to the magnetic hysteresis loop being narrow or broad.

Ans. **(a)**

Sol.
- Soft magnetic materials, both metallic and ceramic are used for making transformers core, to minimize the hysteresis loss as soft magnetic materials have narrow hysteresis loop.
- Hard magnetic materials both metallic and ceramic are used for making permanent magnets as these have broad hysteresis loop.

So, Statement-I and Statement-II both are correct and Statement-II is the correct explanation of Statement-I.

91. The important fact about the collector current is

(a) It is greater than emitter current.

(b) It equals the base current divided by the current gain.

(c) It is small.

(d) It approximately equals the emitter current.

Ans. **(d)**

Sol. $I_C = \dfrac{\beta}{\beta+1} I_E$

As β is very high

$I_C \simeq I_E$

92. What is Shockley's equation of a semiconductor diode in the forward bias regions?

(a) $I_D = I_S\left(e^{V_D^2/nV_T} - 1\right)$

(b) $I_D = I_S\left(e^{V_D/nV_T} - 1\right)$

(c) $I_D = I_S\left(e^{nV_D/V_T} - 1\right)$

(d) $I_D = I_S\left(e^{V_T/nV_D} - 1\right)$

where :

I_S is reverse saturation current

V_D is applied forward-bias voltage across the diode

V_T is thermal voltage

n is an ideality factor

Ans. **(b)**

Sol. Shockley's equation

$I_D = I_s(e^{V_D/\eta V_T} - 1)$

93. The thermal voltage V_T of a semiconductor diode at 27°C temperature is nearly

(a) 17 mV (b) 20 mV
(c) 23 mV (d) 26 mV

Ans. **(d)**

Sol. Thermal voltage $(V_T) = \frac{kT}{q}$

k is Boltzman's constant

for T = 27°C,

$$V_T = \frac{1.38\times10^{-23}\times300}{1.6\times10^{-19}}$$

= 25.87 mV

$\simeq 26\,\text{mV}$

94. The disadvantage of a typical MOSFET as compared to BJT is

(a) Increased power-handling levels
(b) Reduced power-handling levels
(c) Increased voltage-handling levels
(d) Reduced voltage-handling levels

Ans. **(b)**

Sol. MOSFET has lower power handling capacity compared to BJT.

95. Which one of the following conditions will be satisfied for an impedance matched system?

(a) The decibel power gain is equal to twice the decibel voltage gain
(b) The decibel power gain is equal to the decibel voltage gain
(c) The decibel power gain is half the decibel voltage gain
(d) The decibel power gain is equal to thrice the decibel voltage gain

Ans. **(c)**

Sol. For impedance matched systems

Decibel voltage gain = 2 × Decibel power gain

96. For most FET configurations and for common-gate configurations, the input impedances are respectively

(a) High and high (b) High and low
(c) Low and low (d) Low and high

Ans. **(b)**

Sol. For most configuration

$R_{in} \to \infty$ (very high)

For common gate

$$R_{in} = \frac{1}{g_m}\text{(low)}$$

97. The dB gain of cascaded systems is simply

(a) The square of the dB gains of each stage
(b) The sum of the dB gains of each stage
(c) The multiplication of the dB gains of each stage
(d) The division of the dB gains of each stage

Ans. **(b)**

Sol. Cascaded gain

$A = A_1A_2$

$20 \log A = 20 \log (A_1A_2)$

$= 20\log A_1 + 20 \log A_2$

98. The Miller effect input capacitance C_{M_i} is

(a) $(1-A_V^2)C_f$ (b) $(1 - A_V)C_f$
(c) $(1 - C_f)A_V$ (d) $(1-C_f^2)A_V$

where, C_f = feedback capacitance

$$A_V = \frac{V_o}{V_i}$$

Ans. **(b)**

Sol. Input capacitance (Miller effect)

$C_M = C_f(1 - Av)$

99. For an op-amp having a slew rate of 2 V/µs, if the input signal varies by 0.5 V in 10 µs, the maximum closed-loop voltage gain will be

(a) 50 (b) 40
(c) 22 (d) 20

Ans. **(b)**

Sol. Slow rate = 2V/µs

For proper working of amplifier

$$(A_v)\frac{(0.5)}{10} = 2$$

$$A_v = \frac{20}{0.5}$$

$$A_v = 40$$

100. A negative feedback amplifier where an input current controls an output voltage is called

(a) Current amplifier
(b) Transconductance amplifier
(c) Transresistance amplifier
(d) Voltage amplifier

Ans. **(c)**

Sol. Controlling voltage using input current

$$\frac{V}{I} \rightarrow \text{Transresistance amplifier}$$

101. In emergency lighting system, the component used for maintaining the charge on the battery is

(a) LED (b) Shockley diode
(c) Thermistor (d) SCR

Ans. **(d)**

Sol. **Silicon Controlled Rectifier (SCR) :** An SCR circuit is used for maintaining the charge on the battery in the emergency lightening system.

Shockley Diode (named after physicist William Shockley) is a four layer semi-conductor diode, which was one of the first semiconductor devices invented. It was a "pnpn" diode. It is equivalent to a thyristor with a disconnected gate.

Application – A relaxation oscillator circuit.

Thermistor : An electrical resistor whose resistance is greatly reduced by heating.

LED (Light Emitting Diode) : It is a semi-conductor light source that emits light when current flows through it when a current flows through the diode, electrons are able to recombine with electron holes within the device.

102. For RC phase shift oscillator using FET, the gain of the amplifier stage must be practically somewhat greater than

(a) 27 (b) 28
(c) 29 (d) 30

Ans. **(c)**

Sol. In RC phase shift oscillator, amplifier stage gain $\frac{R_2}{R_1} > 29$ (practically) to sustain oscillation.

103. The time delay in a look-ahead carry adder is independent of

(a) Number of operands only
(b) Propagation delay only
(c) Number of bits in the operand only
(d) Bits in the operand, number of operands and propagation delay

Ans. **(c)**

Sol. Carry look-ahead adder has just two levels of gate delay from any input to any output. Thus, time delay is independent of number of bits in operand. But it depends on the number of operands, propagation delay.

Hence optin is (c).

104. The time delay Δt introduced by a SISO shift register in digital signals is given by

(a) $N^2 \times \frac{1}{f_c}$ (b) $N^2 \times f_c$

(c) $\frac{f_c}{N}$ (d) $N \times \frac{1}{f_c}$

where,

N is the number of stages

f_c is the clock frequency

Ans. **(d)**

Sol. For a SISO (consider 4 bit)

Any input will be available

at OUT after 4 clock cycles ie $4 \times \frac{1}{f_c}$ time

For N stages, $\Delta t = N \times \frac{1}{f_c}$

105. An analog output voltage for the input 1001 to a 4 bit D/A converter for all possible inputs assuming the proportionality factor K = 1 will be

(a) 9 (b) 6

(c) 3 (d) 1

Ans. **(a)**

Sol. With i/p as 1001 t_c 4 bit D/A converter and K = 1, we get o/p as $[2^3 \times 1 + 2^2 \times 0 + 2^1 \times 0 + 2^0 \times 1] \times K = 9$

106. In microprocessor interface, the concept of detecting some error condition such as 'no match found' is called

(a) Syntax error (b) Semantic error

(c) Logical error (d) Error trapping

Ans. **(c)**

Sol. "No Match found" is a logical error which occurs during execution.

107. The maximum number of input or output devices that can be connected to 8085 microprocessor are

(a) 8 (b) 16

(c) 40 (d) 256

Ans. **(d)**

Sol. 8085 μp has 8 bit IO addresses. Hence, 2^8 (= 256) IO devices can be connected.

108. The contents of the accumulator and register C are 2EH and 6CH respectively. The instruction ADD C is used. The values of AC and P flags are

(a) 0 and 0 (b) 1 and 1

(c) 0 and 1 (d) 1 and 0

Ans. **(b)**

Sol. Given, [C] = 6CH = 0 1 1 0 1 1 0 0

[A] = 2EH = 0 0 1 0 1 1 1 0

[A] = [C] + [A] = 1 0 0 1 1 0 1 0

1 = AC

Thus AC = 1

P = 1 [even no. of 1s]

109. When an information signal is multiplied by an auxiliary sinusoidal signal to translate its frequency, the modulation is called

(a) Phase modulation

(b) Frequency modulation

(c) Amplitude modulation

(d) Quadrature amplitude modulation

Ans. **(c)**

Sol. Information (message) signal is multiplied with Auxiliary (Carrier) signal in Amplitude Modulation to translate baseband frequency to higher frequencies.

110. The transmission power efficiency for a tone modulated signal with modulated index of 0.5 will be nearly

(a) 6.7% (b) 11.1%

(c) 16.7% (d) 21.1%

Ans. **(b)**

Sol. Transmission power efficiency

$$\eta = \frac{\mu^2}{2+\mu^2}$$

For $\mu = 0.5$

$$\eta = \frac{(0.5)^2}{2+(0.5)^2} = \frac{\frac{1}{4}}{2+\frac{1}{4}}$$

$$\eta = \frac{1}{9} = 11.1\%$$

111. For practical purposes, the signal to noise ratio for acceptable quality transmission of analog signals and digital signals respectively are

(a) 10 – 30 dB and 05 – 08 dB

(b) 40 – 60 dB and 10 – 12 dB

(c) 60 – 80 dB and 20 – 24 dB

(d) 70 – 90 dB and 30 – 36 dB

Ans. **(c)**

Sol. For digital data transmission minimum SNR required should be greater than 20dB.

and for voice transmission should be $\geq$ 25dB.

112. The discrete samples of an analog signal are to be uniformly quantized for PCM system. If the maximum value of the analog sample is to be represented within 0.1% accuracy, then minimum number of binary digits required will be nearly

(a) 7 (b) 9

(c) 11 (d) 13

Ans. **(b)**

Sol. Give accuracy = 0.1% of maximum value.

hence,

$$\frac{\Delta}{2} = \frac{0.1}{100} \times A_{max}$$

$$\frac{A_{max}}{2 \times 2^n} = \frac{0.1}{100} \times A_{max}$$

$$\left[\because \text{ Step size} = \frac{A_{max}}{2^n}\right]$$

$$2^n = \frac{1000}{2}$$

$$2^n = 500$$

$$\boxed{n = 9}$$

Hence, number of binary digits are 9.

113. A signal m(t) = 2 cos 6000 πt + 4 cos 8000 πt + 6 cos 10000 πt is to be truthfully represented by its samples. The minimum sampling rate using band pass consideration will be

(a) 5,000 Hz (b) 10,000 Hz

(c) 15,000 Hz (d) 20,000 Hz

Ans. **(b)**

Sol. Given :

m(t) = 2 cos 6000 πt + 4 cos 8000 πt + 6 cos 10000 πt

Hence, f_1 = 3 kHz

f_2 = 4 kHz

f_3 = 5 kHz

$f_S = 2 \times \max(f_1, f_2, f_3)$

$= 2 \times 5$ kHz

f_S = 10 kHz

114. If 'N' signals are multiplexed using PAM band limited to f_M, the channel bandwidth need ***not*** be larger than

(a) $N \cdot \frac{f_M}{2}$ (b) $N \cdot f_M$

(c) $2N \cdot f_M$ (d) $N^2 \cdot f_M$

Ans. **(c)**

Sol. For message signal band limited to fm, sampling frequency f_s is equal to 2 fm.

For PAM of N signals, bandwidth

$$BW = N \times f_S$$
$$= N \times 2fm \text{ or } 2Nfm$$

115. A linear discrete-time system is characterized by its reponse $h_k(n) = (n - k)u(n-k)$ to a delayed unit sample $\delta(n-k)$. The system will be

(a) Shift invariant (b) Shift variant

(c) Scale invariant (d) Scale variant

Ans. **(a)**

Sol. If input is shifted by n_o

$$\delta(n - n_o - k)$$

$$\delta(n - (n_o + k))$$

Response will be

$$h_{n_o+k}(n) = (n - (n_o + k))u(n - (n_o + k))$$

This is same to response shifted by n_o

$h_k(n - n_o) = (n - n_o - k)u(n - n_o - k)$

$= (n - (n_o + k))u(n - (n_o + k))$

Hence shift invariant.

116. Consider the analog signal

$$x_a(t) = 3\cos 100\pi t$$

The minimum sampling rate F_s required to avoid aliasing will be

(a) 100 Hz (b) 200 Hz

(c) 300 Hz (d) 400 Hz

Ans. **(a)**

Sol. Given :

$$x_a(t) = 3\cos 100\pi t$$
$$w = 100\pi$$
$$2\pi f_m = 100\pi$$
$$f_m = 50 \text{ Hz}$$

Minimum sampling frequency $f_s = 2 f_m$ to avoid aliasing.

$$f_S = 2 \times 50$$
$$f_S = 100 \text{ Hz}$$

117. The response of the system $y(n) = x(n)$ to the following input signal

$$x(n) = \begin{cases} |n|, & -3 \le n \le 3 \\ 0, & \text{otherwise} \end{cases}$$

(a) Is delayed from input

(b) Is exactly same as the input

(c) Leads the input

(d) Varies with signal

Ans. **(b)**

Sol. The response of the system

$$y(n) = x(n)$$

and $$x(n) = \begin{cases} |n|; & -3 \le n \le 3 \\ 0; & \text{otherwise} \end{cases}$$

The response of system is exactly same as input.

118. The complex exponential Fourier representation for the signal

$$x(t) = \cos\omega_0 t \text{ is}$$

(a) $\sum_{k=-\infty}^{\infty} c_k e^{-jk\omega_0 t}$ (b) $\sum_{k=-\infty}^{\infty} c_k e^{-j\omega_0 t}$

(c) $\sum_{k=-\infty}^{\infty} c_k e^{2jk\omega_0 t}$ (d) $\sum_{k=-\infty}^{\infty} c_k e^{jk\omega_0 t}$

Ans. **(d)**

Sol. $x(t) = \cos\omega_0(t)$

The frequency of signal is ω_0 hence fourier series

$$x(t) = \sum_{k=-\infty}^{\infty} C_k \cdot e^{jk\omega_0 t}$$

119. The continuous LTI system is described by

$$\frac{dy(t)}{dt} + 2y(t) = x(t).$$

Using the Fourier transform, for

$x(t) = e^{-t}u(t)$, the output $y(t)$ will be

(a) $(e^{-t} - e^{2t})\ u(t)$

(b) $(e^{t} + e^{-2t})\ u(t)$

(c) $(e^{-t} - e^{-2t})\ u(t)$

(d) $(e^{t} + e^{2t})\ u(t)$

Ans. **(c)**

Sol. $$\frac{dy(t)}{dt} + 2y(t) = x(t)$$

Taking Fourier transform

$$jwY(\omega) + 2Y(\omega) = X(\omega) \qquad ...(1)$$

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

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

From (1)

$$Y(\omega)[j\omega+2] = \frac{1}{j\omega+1}$$

$$Y(\omega) = \frac{1}{(j\omega+1)(j\omega+2)} = \frac{1}{j\omega+1} - \frac{1}{j\omega+2}$$

$y(n) = (e^{-t} - e^{-2t})u(t)$

120. The discrete Fourier series representation for the following sequence :

$x(n) = \cos\frac{\pi}{4}n$ is

(a) $\frac{1}{2}e^{j\Omega_0 n} + \frac{1}{2}e^{-j\Omega_0 n}$ and $\Omega_0 = \frac{\pi}{8}$

(b) $\frac{1}{2}e^{-j\Omega_0 n} + \frac{1}{2}e^{-2j\Omega_0 n}$ and $\Omega_0 = \frac{\pi}{4}$

(c) $\frac{1}{2}e^{-j\Omega_0 n} + \frac{1}{2}e^{-j\Omega_0 n}$ and $\Omega_0 = \frac{\pi}{6}$

(d) $\frac{1}{2}e^{j\Omega_0 n} + \frac{1}{2}e^{j7\Omega_0 n}$ and $\Omega_0 = \frac{\pi}{4}$

Ans. **(a)**

Sol. $$x(n) = \cos\left(\frac{\pi}{4}n\right)$$

Discrete Fourier series

$$x(n) = \sum_{k=-\infty}^{\infty} C_k e^{j\Omega_0 nk}$$

From given signal, $\Omega_0 = \frac{\pi}{8}$

and $C_1 = \frac{1}{2}$ and $C_{-1} = \frac{1}{2}$

$$x(n) = \frac{1}{2}e^{j\Omega_0 n} + \frac{1}{2}e^{-j\Omega_0 n}$$

where $\Omega_0 = \frac{\pi}{8}$.

121. What are the values of k for which the system of equations

$(3k - 8)\ x + 3y + 3z = 0$

$3x + (3k - 8)\ y + 3z = 0$

$3x + 3y + (3k - 8)\ z = 0$

has a non-trivial solution?

(a) $k = \frac{2}{3}, \frac{11}{3}, \frac{10}{3}$

(b) $k = \frac{2}{3}, \frac{10}{3}, \frac{11}{3}$

(c) $k = \frac{11}{3}, \frac{11}{3}, \frac{11}{3}$

(d) $k = \frac{2}{3}, \frac{11}{3}, \frac{11}{3}$

Ans. (d)

Sol. $A = \begin{bmatrix} (3k-8) & 3 & 3 \\ 3 & (3k-8) & 3 \\ 3 & 3 & (3k-8) \end{bmatrix}$

For non trivial solution $|A| = 0$

$C_1 \to C_1 + C_2 + C_3$

$$\begin{vmatrix} (3k-2) & 3 & 3 \\ (3k-2) & (3k-8) & 3 \\ (3k-2) & 3 & (3k-8) \end{vmatrix} = 0$$

$$\Rightarrow (3k-2)\begin{vmatrix} 1 & 3 & 3 \\ 1 & (3k-8) & 3 \\ 1 & 3 & (3k-8) \end{vmatrix} = 0$$

$(3k-2)((3k-11))(3k-11) = 0$

$\Rightarrow K = \frac{2}{3}, \frac{11}{3}, \frac{11}{3}$

122. If

$A = \begin{bmatrix} 2+i & 3 & -1+3i \\ -5 & i & 4-2i \end{bmatrix}$

then AA* will be

(where, A* is the conjugate transpose of A)

(a) Unitary matrix

(b) Orthogonal matrix

(c) Hermitian matrix

(d) Skew Hermitian matrix

Ans. (c)

Sol. $AA^* = \begin{bmatrix} 2+i & 3 & -1+3i \\ -5 & i & 4-2i \end{bmatrix}\begin{bmatrix} 2+i & -5 \\ 3 & i \\ -1+3i & 4-2i \end{bmatrix}$

$= \begin{bmatrix} 15 & -20+2i \\ -20-2i & 46 \end{bmatrix} = B$

Which is Hermitian Matrix

$[\because B^* = B]$

123. If $y = 2x^3 - 3x^2 + 3x - 10$, the value of $\Delta^3 y$ will be

(where, Δ is forward differences operator)

(a) 10 (b) 11

(c) 12 (d) 13

Ans. (c)

Sol. $y = f(x) = 2x^3 - 3x^2 + 3x - 10$

$f(x+1) = 2(x+1)^3 - 3(x+1)^2 + 3(x+1) - 10$

So, $\Delta y = f(x+1) - f(x)$

$= 6x^2 + 6x + 2 - 6x - 3 + 3 - 10$

$\Delta y = 6x^2 - 8$

Similarly,

$\Delta^2 y = [6(x+1)^2 - 8] - [6x^2 - 8]$

$= 12x + 6$

Now, $\Delta^3 y = (12(x+1)+6) - (12x+6)$

$= 12$

124. The solution of the differential equation

$x^2 \frac{d^2y}{dx^2} - x\frac{dy}{dx} + y = \log x$ is

(a) $y = (c_1 + c_2 x) \log x + 2 \log x + 3$

(b) $y = (c_1 + c_2 x^2) \log x + \log x + 2$

(c) $y = (c_1 + c_2 x) \log x + \log x + 2$

(d) $y = (c_1 + c_2 \log x)x + \log x + 2$

Ans. (d)

Sol. $x^2 y'' - xy' + y = \log x$

Let $D = \frac{d}{dx}$ then $(x^2D^2 - xD + 1)y = \log x$ ...(1)

Using Cauchy's transformations

$$(D_1(D_1-1)-D_1+1)y = Z$$

$$(D_1^2-2D_1+1)y = Z \qquad ....(2)$$

Where, $D_1 = \dfrac{d}{dz}$ and $x = e^Z$

AE of (2) is $m^2-2m+1=0 \Rightarrow m=1,1$

So, $\qquad CF = (C_1+C_2Z)e^Z$

$$= (C_1+C_2\log x).x$$

$$PI = \frac{1}{(D_1^2-2D_1+1)}(Z)$$

$$= (1-D_1)^{-2}(z)$$

$$= (1+2D_1+3D_1^2+....)(Z)$$

$$= Z+2$$

$$= \log x+2$$

So, sol. of (1) is $y = CF + PI$

$$y = (C_1+C_2\log x)x+\log x+2$$

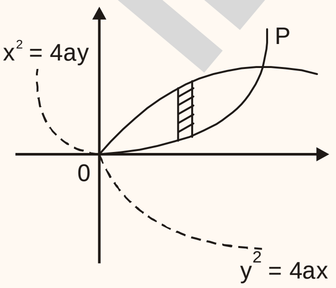
125. The area between the parabolas $y^2 = 4ax$ and $x^2 = 4ay$ is

(a) $\dfrac{2}{3}a^2$ (b) $\dfrac{14}{3}a^2$

(c) $\dfrac{16}{3}a^2$ (d) $\dfrac{17}{3}a^2$

Ans. **(c)**

Sol.



$$\text{Area} = \iint(1)\,dy\,dx$$

$$= \int_0^{4a}\int_{x^2/4a}^{\sqrt{4ax}}(1)\,dy\,dyx$$

$$= \int_0^{4a}\left(\sqrt{4ax}-\frac{x^2}{4a}\right)dx$$

$$= \frac{16}{3}a^2$$

126. The volume of the solid surrounded by the surface

$$\left(\frac{x}{a}\right)^{2/3}+\left(\frac{y}{b}\right)^{2/3}+\left(\frac{z}{c}\right)^{2/3}=1$$

is

(a) $\dfrac{4\pi abc}{35}$ (b) $\dfrac{abc}{35}$

(c) $\dfrac{2\pi abc}{35}$ (d) $\dfrac{\pi abc}{35}$

Ans. **(a)**

Sol. Let $\left(\dfrac{x}{a}\right)^{2/3} = u \Rightarrow x = au^{3/2}$

$$\therefore \qquad dx = \frac{3a}{2}u^{1/2}du$$

$$\left(\frac{y}{b}\right)^{2/3} = \nu \Rightarrow y = b\nu^{3/2}$$

$$\therefore \qquad dy = \frac{3b}{2}\nu^{1/2}d\nu$$

$$\left(\frac{z}{c}\right)^{2/3} = w \Rightarrow z = cw^{3/2}$$

$$\therefore \qquad dz = \frac{3c}{2}w^{1/2}dw$$

For the positive octant,

$$x \ge 0 \Rightarrow au^{3/2} \ge 0 \Rightarrow u \ge 0$$

$$y \ge 0 \Rightarrow b\nu^{3/2} \ge 0 \Rightarrow \nu \ge 0$$

$z \geq 0 \Rightarrow cw^{3/2} \geq 0 \Rightarrow w \geq 0$

Then, we have $u + v + w = 1$, $u \geq 0$, $v \geq 0$, $w \geq 0$

Required volume $= 8\iiint dxdydz$

$$= 8\iiint \frac{3a}{2}u^{1/2} \cdot \frac{3b}{2}v^{1/2} \cdot \frac{3c}{2}w^{1/2} du\ dv\ dw$$

$$= 27abc\iiint u^{\frac{3}{2}-1} v^{\frac{3}{2}-1} w^{\frac{3}{2}-1} du\ dv\ dw$$

$$= 27abc\frac{\Gamma\left(\frac{3}{2}\right)\Gamma\left(\frac{3}{2}\right)\Gamma\left(\frac{3}{2}\right)}{\Gamma\left(\frac{11}{2}\right)} = \frac{4\pi abc}{35}$$

127. The solution of the partial differential equation

$$x^2\frac{\partial z}{\partial x} + y^2\frac{\partial z}{\partial y} = (x + y)\ z \text{ is}$$

(a) $f\left(\frac{1}{x}-\frac{1}{y}, \frac{xy}{z}\right) = 0$

(b) $f\left(\frac{1}{xy}, \frac{xy}{z}\right) = 0$

(c) $f\left(\frac{1}{x}-\frac{1}{y}, xyz\right) = 0$

(d) $f\left(\frac{1}{x}+\frac{1}{y}+\frac{1}{z}, \frac{xy}{z}\right) = 0$

Ans. (a)

Sol. $x^2\frac{\partial z}{\partial x} + y^2\frac{\partial z}{\partial y} = xz + yz$

Lagrange's subsidiary equations are

$$\frac{dx}{x^2} = \frac{dy}{y^2} = \frac{dz}{xz+yz} \quad ...(i)$$

Taking 1st two, $\int\frac{dx}{x^2} = \int\frac{dy}{y^2} + C_1$

$$-\frac{1}{x} = -\frac{1}{y}+C \Rightarrow u = \frac{1}{x}-\frac{1}{y} = C_1$$

Now using multipliers $\left(-\frac{z}{x}\right), \left(\frac{-z}{y}\right)$ & (1)

Each fraction in eq.(i)

$$= \frac{-\left(\frac{z}{x}\right)dx - \left(\frac{z}{y}\right)dy + (1)dz}{0}$$

$$\Rightarrow \frac{dx}{x}+\frac{dy}{y} = \frac{dz}{z}$$

$\Rightarrow \log x + \log y = \log z + \log C_2$

$$\Rightarrow v = \frac{xy}{z} = C_2$$

So general solution of give PDE is

$$\phi\{u,v\} = 0 \Rightarrow \phi\left\{\frac{1}{x}-\frac{1}{y}, \frac{xy}{z}\right\} = 0$$

128. The complex number $\left(\frac{2+i}{3-i}\right)^2$ is

(a) $\frac{1}{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$

(b) $\frac{1}{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{2}\right)$

(c) $\frac{1}{2}(\cos\pi + i\sin\pi)$

(d) $\frac{1}{2}\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

Ans. (b)

Sol. $\left(\frac{2+i}{3-i}\right)^2 = \left(\frac{(2+i)(3+i)}{3^2-i^2}\right)^2$

$$= \left(\frac{5+5i}{10}\right)^2$$

$$= \left(\frac{1}{2}+\frac{i}{2}\right)^2$$

$$= \left(\frac{1}{\sqrt{2}}e^{\frac{\pi}{4}i}\right)^2 = \frac{1}{2}e^{\frac{\pi}{2}i}$$

$$= \frac{1}{2}\left(\cos\frac{\pi}{2}+i\sin\frac{\pi}{2}\right)$$

129. If n is a positive integer then,

$\left(\sqrt{3}+i\right)^n+\left(\sqrt{3}-i\right)^n$ is

(a) $2^n \sin\frac{n\pi}{6}$ (b) $2^n \cos\frac{n\pi}{6}$

(c) $2^{n+1} \cos\frac{n\pi}{6}$ (d) $2^{n+1} \sin\frac{n\pi}{6}$

Ans. (c)

Sol.

$$\left(\sqrt{3}+i\right)^n+\left(\sqrt{3}-i\right)^n = 2^n\left[\frac{\sqrt{3}}{2}+\frac{i}{2}\right]^n + 2^n\left[\frac{\sqrt{3}}{2}-\frac{i}{2}\right]^n$$

$$= 2^n\left[e^{\frac{\pi}{6}i}\right]^n + 2^n\left[e^{-\frac{\pi}{6}i}\right]^n$$

$$= 2^n\left[e^{\frac{n\pi}{6}i}+e^{\frac{-n\pi}{6}i}\right]$$

$$= 2^n\left[2\cos\frac{n\pi}{6}\right]$$

$$= 2^{n+1}\cos\left(\frac{n\pi}{6}\right)$$

130. The nature of singularity of function

$f(z) = \dfrac{1}{\cos z-\sin z}$ at $z=\dfrac{\pi}{4}$ is

(a) Removable singularity

(b) Isolated singularity

(c) Simple pole

(d) Essential singularity

Ans. (b)

Sol. $f(z) = \dfrac{1}{\cos z-\sin z}$

Singularities of f(z) ae

$$\cos z - \sin z = 0$$

$$\tan z = 1$$

$$Z = \ldots\ldots \frac{-3\pi}{4}, \frac{\pi}{4}, \frac{5\pi}{4}, \frac{9\pi}{4}, \ldots.$$

$\because$ $Z = \dfrac{\pi}{4}$

is the only singularity in it's neighborhood, so it is isolated singularity.

131. If x is a discrete random variable that follows Binomial distribution, then which one of the following response relations is correct?

(a) $P(r+1) = \dfrac{n-r}{r+1}P(r)$

(b) $P(r+1) = \dfrac{p}{q}P(r)$

(c) $P(r+1) = \dfrac{n+r}{r+1}\dfrac{p}{q}P(r)$

(d) $P(r+1) = \dfrac{n-r}{r+1}\dfrac{p}{q}P(r)$

Ans. (d)

Sol. $P(r) = {}^nC_r p^r q^{n-r}$

$$P(r+1) = {}^nC_{r+1}p^{r+1}q^{n-r-1}$$

$$\frac{P(r+1)}{P(r)} = \frac{{}^nC_{r+1}}{{}^nC_r}\frac{p^{r+1}q^{n-r-1}}{p^rq^{n-r}}$$

$$= \frac{\dfrac{\lfloor n}{\lfloor r+1\lfloor n-r-1}}{\dfrac{\lfloor n}{\lfloor r\lfloor n-r}}\times\frac{p}{q}$$

$$= \frac{(n-r)}{(r+1)}\frac{p}{q}$$

$$\frac{P(r+1)}{P(r)} = \frac{(n-r)}{(r+1)}\cdot\frac{p}{q}$$

$$P(r+1) = \frac{n-r}{r+1}\cdot\frac{p}{q}p(r)$$

132. If the probability that an individual suffers a bad reaction from a certain infection is 0.001, what is the probability that out of 2000 individuals, more than 2 individuals will suffer a bad reaction?

(a) $\frac{1}{2}-\frac{5}{e^2}$ (b) $1.2-\frac{5}{e^2}$

(c) $1-\frac{5}{e^2}$ (d) $\frac{5}{e^2}$

Ans. (c)

Sol. P(individual suffers a bad reaction) = 0.001

$$= \frac{1}{1000}$$

i.e. out of 1000 persons, average number of persons, suffer from bad reaction = 1

So for 2000 persons, Average = 2 i.e. $\lambda = 2$

Let $X = \begin{Bmatrix} \text{No. of persons suffer from} \\ \text{bad reaction in 2000 persons} \end{Bmatrix}$

So, req. probability is

$$p(x \geq 3) = 1 - P(x \leq 2)$$

$$= 1 - P(X=0) - P(X=1) - P(X=2)$$

$$= 1 - \frac{e^{-\lambda}\cdot\lambda^{\circ}}{\lfloor 0} - \frac{e^{-\lambda}\cdot\lambda^{1}}{\lfloor 1} - \frac{e^{-\lambda}\lambda^{2}}{\lfloor 2}$$

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

$$= 1 - \frac{5}{e^2}$$

133. Materials in which the atomic order extends uninterrupted over the entirety of the specimen; under some circumstances, they may have flat faces and regular geometric shapes, are called

(a) Anisotropy (b) Crystallography

(c) Single crystals (d) Crystal system

Ans. (c)

Sol. Single crystals are materials in which the atomic order extends uninterrupted over the entirety of the specimen; under some circumstances, they may have flat faces and regular geometric shapes. The vast majority of crystalline solids, however, are polycrystalline, being composed of many small crystals or, grains having different crystallographic orientations.

134. Which material possesses the following properties?

- Shining white colour with lustre
- Soft, malleable and can be drawn into wires
- Poor in conductivity and tensile strength
- Used in making alloys with lead and copper
- Used for fuses and cable sheathing

(a) Silver (b) Tin

(c) Nickel (d) Aluminium

Ans. (b)

Sol.
- Tin-lead alloy is used for fuse wire.
- Silver and aluminium have very high electrical conductivity.

135. The saturaton magnetization for Fe_3O_4, given that each cubic unit cell contains 8 Fe^{2+} and 16 Fe^{3+} ions, where Bohr magneton is 9.274×10^{-24} A.m^2 and that the unit cell edge length is 0.839 nm, will be

(a) 1.25×10^5 A/m (b) 5×10^5 A/m

(c) 10×10^5 A/m (d) 20×10^5 A/m

Ans. (b)

Sol. Edge length of unit cell = 0.839×10^{-9} m

Volume of unit cell = $(0.839 \times 10^{-9})^3$ m^3

Magnetic moment per Fe^{2+} ion

= 4 Bohr magnetons

Number of Fe^{2+} ions per unit cell = 8

Hence, saturation magnetisation,

$$M_S = N_{Fe^{2+}} \times 4 \times \mu_B$$

$$= \frac{8}{(0.839\times10^{-9})^3}\times4\times(9.27\times10^{-24})$$

$= 5 \times 10^5$ A/m

136. Consider the following applications of the materials :

- Bismuth strontium calcium copper oxide used as a high temperature superconductor
- Boron carbide used in helicopter and tank armour
- Uranium oxide used as fuel in nuclear reactors
- Bricks used for construction

The materials used in these applications can be classified as

(a) Ceramic (b) Constantan

(c) Manganin (d) Tantalum

Ans. **(a)**

137. The saturation flux density for Nickel having density of 8.90 g/cm^3, stomic number 58.71 and net magnetic moment per atom of 0.6 Bohr magnetons is nearly

(a) 0.82 tesla (b) 0.76 tesla

(c) 0.64 tesla (d) 0.52 tesla

Ans. **(c)**

Sol. Saturation Magnetization (M_S) :

$M_S = 0.60 \times \mu_B \times N_{Ni}$

$$= 0.60(9.27\times10^{-24})\times\left(\frac{\rho_{Ni}N_A}{A_{Ni}}\right)$$

$$= 0.60\times9.27\times10^{-24}\times\frac{8.90\times10^6\times6.023\times10^{23}}{58.71}$$

$= 0.60 \times 9.27 \times 10^{-24} \times 9.12 \times 10^{28}$

$= 5.1 \times 10^5$ A/m

So, saturation flux density,

$B_S = \mu_0 M_s$

$$= (4\pi\times10^{-7})\times(5.1\times10^5)$$

$= 0.64$ T

138. The temperature at which iron ceases to be ferromagnetic and becomes paramagnetic is

(a) Curie-Weiss point

(b) Thermo-magnetic point

(c) Ferro-paramagnetic point

(d) Curie point

Ans. **(d)**

Sol. The temperature at which iron ceases to be ferromagnetic and becomes paramagnetic is curie-temperature.

Paramagnetism: Curie law, $\chi_m = \frac{C}{T}$

Ferromagnetism: Curie-Weiss law,

$$\chi_m = \frac{C}{T-\theta} \quad (T > \theta)$$

where θ is Curie temperature.

Antiferromagnetism:

Curie-Weiss law,

$$\chi_m = \frac{C}{T+\theta_N}; \quad \text{at } T > T_N$$

where T_N = Neel temperature.

139. Fick's laws refer to

(a) Finding whether a semiconductor is n or p type

(b) Diffusion

(c) Crystal imperfections

(d) Electric breakdown

Ans. **(b)**

Sol.
- Fick's law refers to diffusion.
- It is used to find diffusion coefficient.
- The law is,

$$J = -D \cdot \frac{d\phi}{dx}$$

where, J = Diffusion flux

D = Diffusion coefficient

ϕ = Concentration of substance per unit volume

x = Position

140. A magnetic field applied perpendicular to the direction of motion of a charged particle exerts a force on the particle perpendicular to both the magnetic field and the direction of motion of the particle. This phenomenon results in

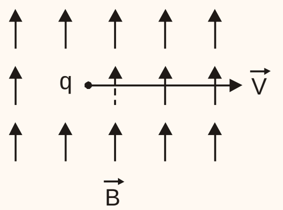
(a) Flux effect (b) Hall effect

(c) Magnetic field effect

(d) Field effect

Ans. **(b)**

Sol.



Force = $q(\vec{V} \times \vec{B})$ (Lorentz Force)

Due to this perpendicular force, moving charges accumulates on one surface of specimen, producing hall voltage. This phenomenon is known as Hall Effect.

141. An electric kettle is marked 500 W, 230 V and is found to take 15 minutes to bring 1 kg of water at 15ºC to 100ºC. IF the specific heat of water is 4200 J/kg/ºC, the heat efficiency of the kettle will be

(a) 87.3% (b) 83.6%

(c) 79.3% (d) 75.6%

Ans. **(c)**

Sol. Heat absorbed by water = $ms\Delta T$

= 1 × 4200 × 85 Joules

Energy delivered by electric Kettle

= Power × Time

= 500 × 15 × 60 J

Hence, heat efficiency,

$$= \frac{\text{Heat absorbed by water}}{\text{Energy delivered by Kettle}}$$

$$= \frac{4200 \times 85}{500 \times 15 \times 60}$$

$$= \frac{3570}{4500}$$

= 0.7933 i.e. 79.33%

i.e. option (c).

142. With reference to nano materials, the prefix nano stands for

(a) Nano centimetre (b) Nanometre

(c) Nano micrometre (d) Nano millimetre

Ans. **(b)**

Sol. In nano materials, the prefix nano extends for nanometer. The size of nanomaterial is less than approximately 100 nanometers.

143. Consider the following applications :

- High temperature heat engines
- Nuclear fusion reactors
- Chemical processing industry
- Aeronautical and space industry

Which one of the following materials will be used for these applications?

(a) Zirconia (b) Alumina
(c) Ceramic (d) Silicon carbide

Ans. **(d)**

Sol. Silicon carbide is used for

1. High temperature heat engines
2. Nuclear fusion reactors
3. Chemical processing industry
4. Aeronautical and space industry.

144. The machine used for the preparation of nano particles of alumina is

(a) Attrition mill
(b) Grinding machine
(c) Vending machine
(d) Welding machine

Ans. **(a)**

Sol. **Attrition Mill** is a device for mechanically reducing solid particle size by intense agitation of a slurry of material being milled and coarse milling media.

Grinding Machine is a type of machine which uses abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the workpiece through shear deformation.

Vending Machine : A vending machine is an automated machine that provides items such as snacks, beverages etc.

Welding Machine : It helps join materials usually metals or thermoplastics, by using heat to melt parts together and allowing them to cool causing fusion.

145. If the voltage across an element in a circuit is linearly proportional to the current through it, then it is a

(a) Capacitor (b) Transformer
(c) Resistor (d) Inductor

Ans. **(c)**

Sol. (a) $V_C = \frac{1}{C}\int idt$

(b) $V_1I_1 = V_2I_2$

(c) $V_R = IR$

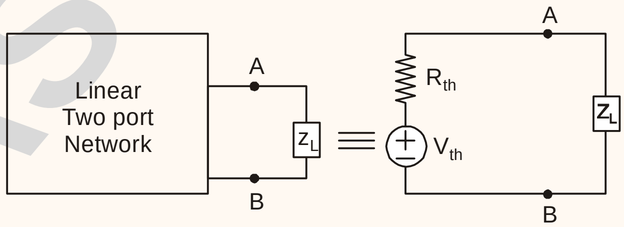
(d) $V_L = L\frac{di}{dt}$

146. Thevenin's equivalent circuit consists of

(a) Current source and series impedance
(b) Voltage source and series impedance
(c) Voltage source aned shunt impedance
(d) Current source and shunt impedance

Ans. **(b)**

Sol.



V_{th} = Open circuit Thevenins voltage across A-B

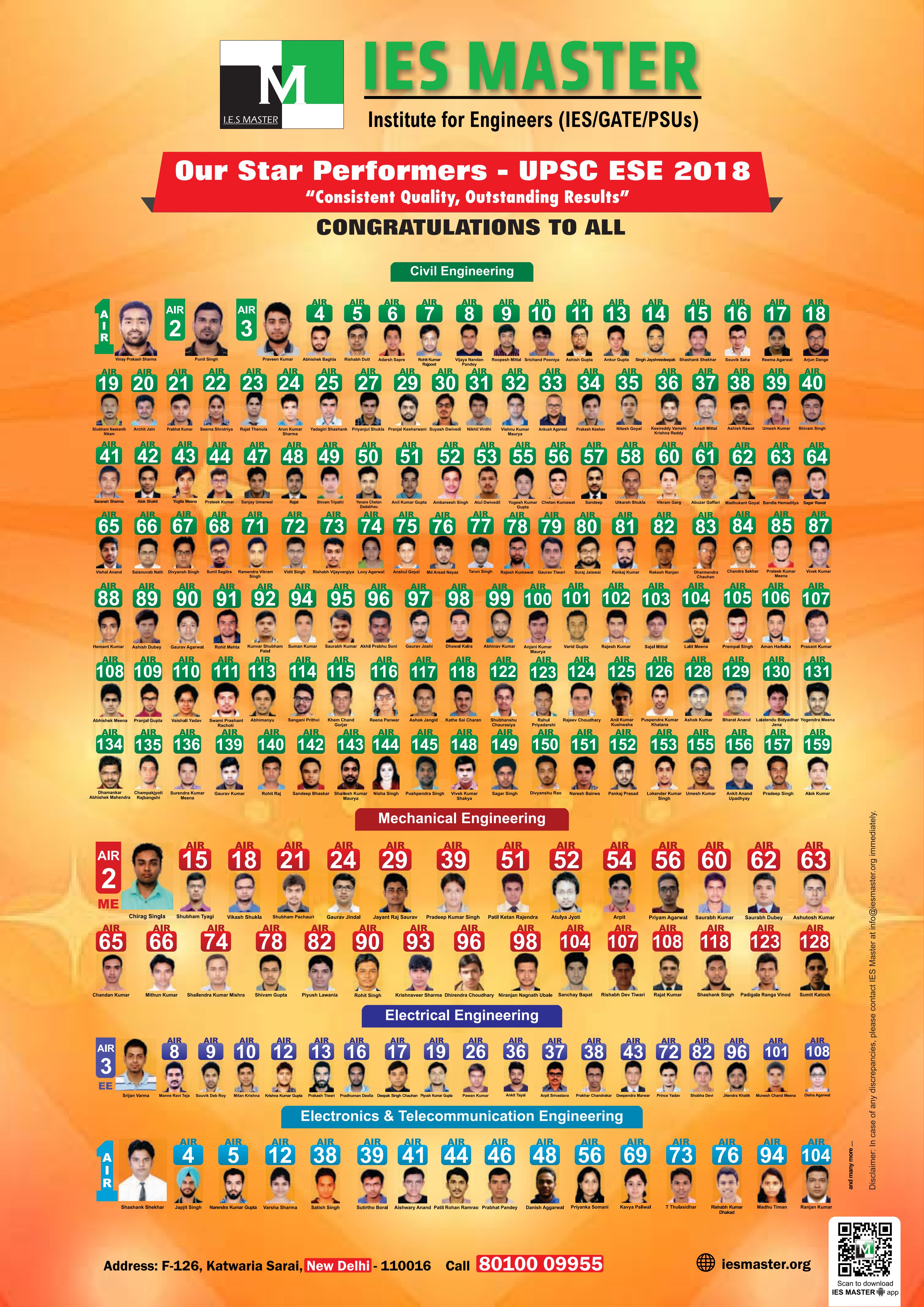
R_{th} = Terminal impedance by deactivating all independent sources

147. When the voltage sources are replaced with short circuits and current sources are replaced with open circuits, leaving dependent sources in the circuit, the theorem applied is

(a) Superposition (b) Thevenin
(c) Norton (d) Millman

Ans. **(b)**

Sol. According to Thevenin's theorem, a two port complex network can be represented as.



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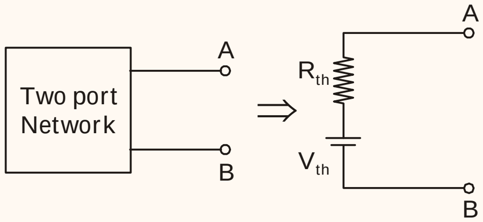


where, V_{th} is the Thevenin's voltage across terminals A-B and

R_{th} is the Thevenin's resistance as seen through terminals A-B when voltage sources are replaced with short circuit and current sources are replaced with open circuit.

148. The maximum power is delivered from a source to a load when the source resistance is

(a) Greater than the load resistance

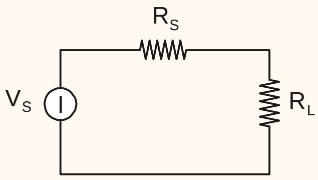
(b) Equal to zero

(c) Less than the load resistance

(d) Equal to the load resistance

Ans. **(b)**

Sol.



If R_S is variable and we have option to vary R_S then maximum power will be delivered when R_S = 0.

$$P_L = I_R^2 R_L = \left(\frac{V_S}{R_L}\right)^2 R_L = \frac{V_S^2}{R_L}$$

if $R_S \neq 0$

$$P_L = I_R^2 R_L = \left(\frac{V_S}{R_L + R_S}\right)^2 R_L = \frac{V_S^2 R_L}{(R_L + R_S)^2}$$

which is less than above case.

So, answer (b).

If R_L is variable and R_S is fixed then maximum power will be transferred when $R_L = R_S$ i.e. load is equal to source impedance.

149. A network delivers maximum power to the load resistance when it is

(a) Greater than Norton's equivalent resistance of the network

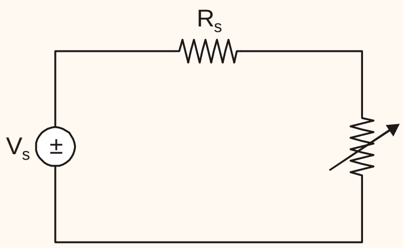
(b) Equal to Thevenin's equivalent resistance of the network

(c) Less than cource resistance

(d) Less than Norton's equivalent resistance of the network

Ans. **(b)**

Sol.



Here load is variable so

$$P_L = \left(\frac{V_S}{R_S + R_L}\right)^2 R_L$$

$$\frac{dP_L}{dR_L} = \frac{V_S^2[(R_S + R_L)^2 - R_L 2(R_S + R_L)]}{(R_S + R_L)^4} = 0$$

$R_S + R_L - 2R_L = 0$

$\boxed{R_L = R_S}$ for maximum power.

150. The impedance of a parallel circuit is (10 – j 300 Ω at 1 MHz. The values of circuit elements will be

(a) 10Ω and 6.4 mH

(b) 100Ω and 4.7 nF

(c) 10Ω and 4.7 mH

(d) 100Ω and 6.4 nF

Ans. **(b)**

Sol. Let's assume R and jX_L are in parallel.

In parallel :

$$Y = \frac{1}{R}+\frac{1}{jX_L} = G - jB_L$$

$$Y = \frac{1}{2} = \frac{1}{R}+\frac{1}{jX_L}$$

$$\frac{1}{10-j30} = \frac{1}{R}+\frac{1}{jX_L}$$

$$\frac{10+j30}{100+900} = \frac{1}{R}+\frac{1}{jX_L}$$

Comparing $\boxed{R=100}$ and $X_L = -\frac{1000}{30}$

So, its capacitor

$$\frac{1}{wC} = \frac{1000}{30}$$

$$\Rightarrow \quad C = \frac{3}{100\times 2\pi\times 10^6} = 4.7 \text{ nF}$$