IES MASTER
Institute for Engineers (IES/GATE/PSUs)

ESE 2018

Prelims Exam
Paper - II

ELECTRICAL ENGINEERING

DETAILED SOLUTION (SET-C)

Office Address
DELHI: F-126, Katwaria Sarai, New Delhi - 110 016
Ph: 011-41013406, Mobile: 8130909220, 9711853908

NOIDA: B-23 A, 5th Floor, Gaurav Deep Heights, Near Fortis Hospital
Sector 62, Noida- 201305 **Ph:** 0120 415 1100

Web: www.iesmaster.org | E-mail: info@iesmaster.org

Explanation of Electrical Engg. Prelims Paper-II (ESE - 2018)

SET - C

1. Which of the following is considered a time domain technique in control systems?

(a) Nyquist criterion

(b) Bode plot

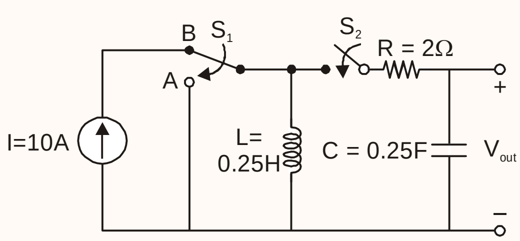
(c) Root locus plot

(d) Routh-Hurwitz criterion

Ans. (c)

Sol. Root locus plot is a time domain analysis whereas Nyquist criterion and bode plot are frequency domain analysis. Stability of system is found by Routh Hurwiz criterion.

2.



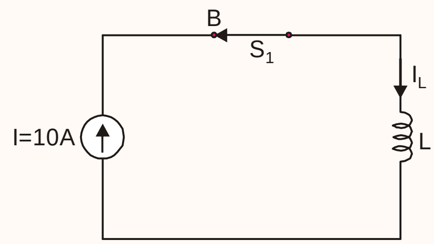
For the circuit as shown, consider that switch S_1 has been in position B for a very long time and switch S_2 has been open all the time. At time t = 0, the switch S_1 moves to position A and switch S_2 closes instantaneously. What is the value of V_{out} at $t = 0^+$, assuming initial charge on C = 0?

(a) 2.5 V (b) 2.0 V

(c) 1.5 V (d) 0 V

Ans. (d)

Sol. The circuit diagram at t = 0 can be drawn as given below.



Given, S_1 is connected to B and S_2 is open.

The current through the inductor can't change instantaneously.

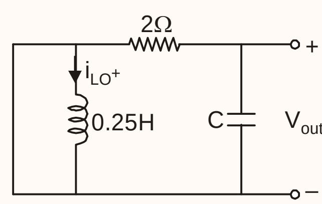
$\therefore$ at $t = 0^+$ (i.e. just after time t = 0)

$$I_{LO^+} = 10A$$

The voltage across the capacitor will also not change instantaneously.

$\therefore$ at $t = 0^+$, $V_{CO^+} = 0V$ (because $V_{co^-} = 0V$)

The circuit diagram for time $t = 0^+$ can be drawn as



$\therefore$ V_{out} at $t = 0^+ = 0V$

Correct option (d).

3. What is phasor sum of currents $I_1 = (10a - a^2)$ and $I_2 = -j10$ for two complex operators which are individually defined by $a^3 = 1$ and $j^2 = 1$?

(a) $17.32\angle 90°$ (b) $7.32\angle 90°$

(c) $17.32\angle 0°$ (d) $7.32\angle 0°$

SCROLL DOWN

Ans. **(b)**

Sol. We know that,

$$1 + a + a^2 = 0$$

$$\therefore \quad a^2 = -(1 + a) \quad \ldots \text{(i)}$$

Given, $I_1 = 10(a - a^2)$

Using equation (i)

$$I_1 = 10(a + (1 + a))$$
$$= 10(2a + 1)$$

$$\therefore \quad I = I_1 + I_2$$

$$= 10(2 \times 1\angle 120^\circ + 1) - j10$$

$$= 7.32 \angle 90^\circ$$

4. A series RLC circuit with $R = 2\Omega$, $L = \frac{1}{2}$H, $C = \frac{1}{4}$F is excited by a 100 V dc source. The circuit is initially in quiescent state. The expression for the current response i(t) due to a dc source will be of the form (K, K_1, K_2 are constants)

(a) $Ke^{-4t}\sin\left(4t + \frac{\pi}{3}\right)$

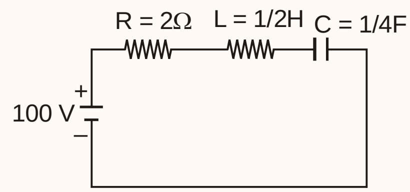
(b) $Ke^{-2t}\sin\sqrt{8}t$

(c) $(K_1 + K_2 t)e^{-2t}$

(d) $K_1 e^{-2t} + K_2 e^{-4t}$

Ans. **(a)**

Sol. The given circuit is drawn as given below



The given circuit is a second order circuit.

The characteristics equation of a second order circuit is given by,

$$S^2 + \frac{R}{L}s + \frac{1}{LC} = 0 \quad \ldots \text{(i)}$$

Putting the values of elements in equation (i),

$$S^2 + 4S + 8 = 0$$

Comparing this equation to standard equation of second order circuit

$$S^2 + 2\xi\omega_n s + \omega_n^2 = 0$$

$$\omega_n = \sqrt{8}$$

$$2\xi\omega_n = 4 \quad \Rightarrow \quad \xi = \frac{2}{\sqrt{8}}$$

This given system is an underdamped system and for step response

$$i(t) = 1 - \frac{e^{-\xi\omega_n t}}{\sqrt{1-\xi^2}}\sin(\omega_n t + \theta)$$

where, $\theta = \cos^{-1}(\xi)$

Only option (a) satisfies the given expression.

5. The impulse response of an LTI system is given by 5u(t). If the input to the system is given by e^{-t} then the output of the system is

(a) $5(1 - e^{-t})u(t)$ (b) $(1 - 5e^{-t})\ u(t)$
(c) $5 - e^{-t}\ u(t)$ (d) $5u\ (t) - e^{-t}$

Ans. **(a)**

Sol. Impulse response is given as

$$h(t) = 5u(t)$$

$$\frac{C(s)}{R(s)} = H(s) = \frac{5}{s}$$

now, input $r(t) = e^{-t}$

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

$$\therefore \quad C(s) = H(s)\ .\ R(s)$$

$$= \frac{5}{s(s+1)} = \frac{5}{s} - \frac{5}{s+1}$$

taking inverse laplace transform,

$$C(t) = 5u(t) - 5e^{-t}U(t)$$

$$\boxed{C(t) = 5(1 - e^{-t})u(t)}$$

6. A series RLC circuit has a resistance of 50Ω, inductance of 0.4H and a capacitor of 10μF. The circuit is connected across a 100V supply. The resonance frequency and the current through the resistance are

(a) 500 rad/s and 2A
(b) 1000 rad/s and 2A
(c) 500 rad/s and 0.5A
(d) 1000 rad/s and 0.5A

Ans. **(a)**

Sol. The resonance frequency for a second order RLC circuit is given by,

$$f = \frac{1}{\sqrt{LC}} \qquad ...(i)$$

given, L = 0.4 H

C = 10×10^{-6} F

putting the values in equation (i),

$$f = \frac{1}{\sqrt{0.4\times10\times10^{-6}}}$$

= 500 rad/sec.

The current through resistance at resonance,

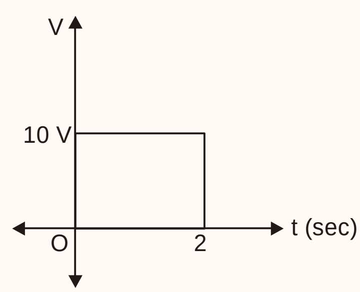
$$I_R = \frac{V_s}{R} = \frac{100}{50} = 2A$$

7. A pulse of +10V in magnitude and 2s in duration is applied to the terminals of a lossless inductor of 1.0H. The current through the inductor would

(a) be a pulse of +20A for the duration of 2 s
(b) be a pulse of –20A for the duration of 2 s
(c) increase linearly from zero to 20A in 2 s, and in the positive direction, and, from thereon, it remains constant at +20A
(d) increase linearly from zero to –20A in 2s, and in the negative direction, and, from thereon, it remains constant at –20A

Ans. **(c)**

Sol. The pulse given to the inductor is of +10V for 2 seconds,



The current through the inductor is given by.

$$i = \frac{1}{L}\int v\,dt$$

given, L = 1.0H

$$\therefore \quad i = \frac{1}{10}\int_0^2 10\,dt = 20A$$

The current through the inductor can't change instantaneously and will increase linearly as due to the absence of any resistance.

The current remains constant at +20A after the removal of pulse as there is no resistance of energy dissipation and the energy remains conserved and stored in the inductor.

8. Consider the following statements regarding power measurement of three-phase circuits by two-wattmeter method

1. Total power can be measured if the three-phase load is balanced and can be represented by an equivalent Y connection only
2. Total power can be measured for the three-phase load irrespective of, whether the load is balanced or not and connected in Y or Δ
3. Power factor can be calculated only if the three phase load is balanced

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. **(c)**

Sol. Power measurement of three-phase circuit by two wattmeter method:

1. Total power can be measured for the three phase load irrespective of whether the load is balanced or not

Total power = $V_1i_1 + V_2i_2 + V_3i_3$

= $W_1 + W_2$

= Sum of the two wattmeter readings

2. But in two wattmeter method, power factor can be calculated only when load is balanced

Readings of wattmeters,

$$W_1 = \sqrt{3}\,VI\cos(30^\circ - \phi)$$

$$W_2 = \sqrt{3}\,VI\cos(30^\circ + \phi)$$

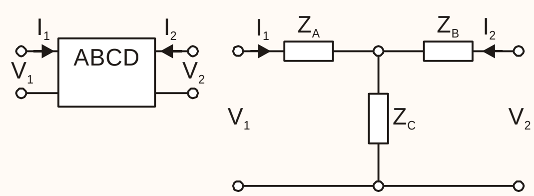
Total active power, P = $W_1 + W_2$

Total reactive power, $Q = \sqrt{3}\left(W_1 - W_2\right)$

So, power factor of load,

$$\cos\phi = \cos\left[\tan^{-1}\frac{\sqrt{3}\left(W_1 - W_2\right)}{\left(W_1 + W_2\right)}\right]$$

9.



In terms of ABCD-parameters of a 2-port network, the parameters Z_A, Z_B and Z_C of the equivalent-T-network are, respectively

(a) $\frac{A-1}{C}, \frac{D-1}{C}$ and $\frac{1}{C}$

(b) $\frac{A}{C}, \frac{D-1}{C}$ and $\frac{1}{C}$

(c) $\frac{A-1}{C}, \frac{D}{C}$ and $\frac{1}{C}$

(d) $\frac{A}{C}, \frac{D}{C}$ and BC

Ans. (a)

Sol. The first two-port network is given in transmission or ABCD parameters

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

The equations can be written as

$V_1 = AV_2 - BI_2$ ...(i)

$I_1 = CV_2 - DI_2$ ...(ii)

The equation (i) and (ii) can be modified and rewritten as

$$V_1 = \frac{AI_1}{C} + \frac{(AD-BC)}{C} I_2$$

$$V_2 = \frac{I_1}{C} + \frac{D}{C} I_2$$

Therefore, the z-parameter of the network can be written as,

$$[Z] = \begin{bmatrix} \frac{A}{C} & \frac{AD-BC}{C} \\ \frac{1}{C} & \frac{D}{C} \end{bmatrix} \quad ...(iii)$$

The z-parameter for the t-circuit given can be written as

$$[Z] = \begin{bmatrix} Z_A + Z_C & Z_C \\ Z_C & Z_B + Z_C \end{bmatrix} \quad ...(iv)$$

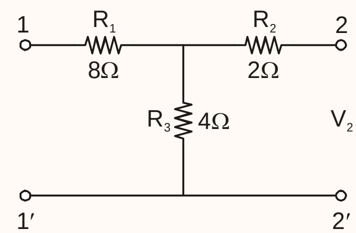
Comparing (iii) and (iv) we get,

$$Z_A = \frac{A-1}{C}$$

$$Z_B = \frac{D-1}{C}$$

$$Z_C = \frac{1}{C}$$

10.



The Z parameters Z_{11}, Z_{12}, Z_{21} and Z_{22} for the circuit as shown in figure, respectively, are

(a) $12\Omega, 4\Omega, 4\Omega$ and 6Ω

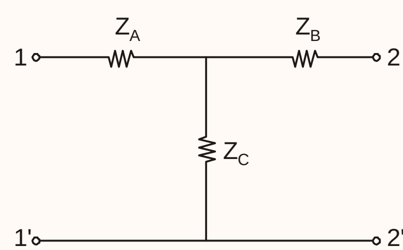
(b) $8\Omega, 6\Omega, 4\Omega$ and 4Ω

(c) $12\Omega, 6\Omega, 6\Omega$ and 4Ω

(d) $8\Omega, 4\Omega, 6\Omega$ and 6Ω

Ans. (a)

Sol. The Z-parameter of t-circuit is given by,



$$[Z] = \begin{bmatrix} Z_A + Z_C & Z_C \\ Z_C & Z_B + Z_C \end{bmatrix}$$

Given, $Z_A = 8\Omega$

$Z_B = 2\Omega$

$$Z_C = 4\Omega$$

$$\therefore \quad Z_{11} = Z_A + Z_C = 12\Omega$$

$$Z_{12} = Z_C = 4\Omega$$

$$Z_{21} = Z_C = 4\Omega$$

$$Z_{22} = Z_B + Z_C = 6\Omega$$

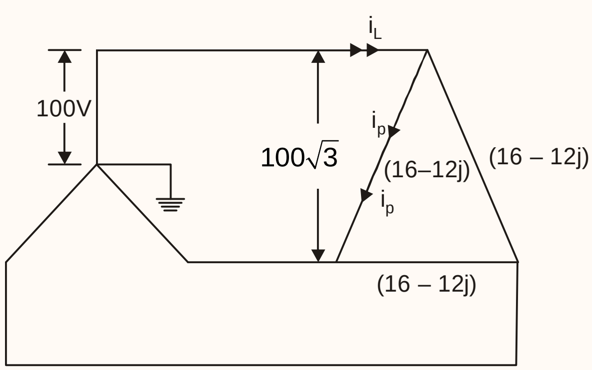
11. A balanced 3-phase RYB sequence star-connected supply source with phase voltage 100 V is connected to a delta-connected balanced load $16 - j12\Omega$ per phase. The phase and line currents are, respectively

(a) $5\sqrt{3}$A and 30A (b) $10\sqrt{3}$A and 30A

(c) $5\sqrt{3}$A and 15A (d) $10\sqrt{3}$A and 15A

Ans. **(c)**

Sol.



$$i_p = \frac{100\sqrt{3}}{(16-12j)} = 8.66\angle 36.86^\circ = 5\sqrt{3}\text{A}$$

$$i_L = \sqrt{3}i_p = 5\sqrt{3} \times \sqrt{3} = 15\text{A}$$

12. The maximum potential-gradient that can be imposed in air at atmospheric pressure without breakdown is 30 kV/cm. The corresponding energy density is nearly

(a) 30 J/m^3 (b) 35 J/m^3

(c) 40 J/m^3 (d) 45 J/m^3

Ans. **(c)**

Sol. Given potential gradient for air

E = 30 KV/cm = 3 × 10^6 V/m

Energy density is given by $\frac{1}{2}\varepsilon_o E^2$

$$\therefore \quad \frac{1}{2}\varepsilon_o E^2 = \frac{1}{2} \times 8.854 \times 10^{-12} \times (3 \times 10^6)^2$$

or Energy density = 39.84 J/m^3

The nearest option is 40 J/m^3

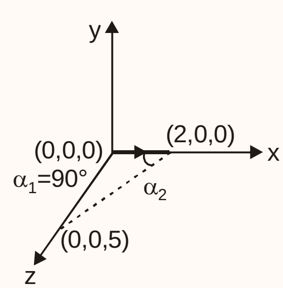
13. A steady flow of 10A is maintained in a thin wire placed along the X-axis from (0,0,0) to (2,0,0) to find the value of the magnetic field intensity H at (0,0,5). When end effects are ignored, H is

(a) $-59.1\,\hat{a}_y \text{mA/m}$ (b) $59.1\,\hat{a}_y \text{mA/m}$

(c) $-118.2\,\hat{a}_y \text{mA/m}$ (d) $118.2\,\hat{a}_y \text{mA/m}$

Ans. **(a)**

Sol. Based on given information :



Magnetic field intensity for a finite current element is given by

$$H = \frac{I}{4\pi\rho}[\cos\alpha_2 - \cos\alpha_1]$$

$$\cos\alpha_1 = \cos 90° = 0$$

$$\cos\alpha_2 = \frac{2}{\sqrt{2^2+5^2}} = 0.3714$$

ρ is perpendicular distance from current element, hence, ρ = 5 m

Now, for I = 10 A

$$H = \frac{10}{4\pi\times 5}(0.3714-0) = 0.0591\,A$$

or 59.1 mA

The direction of H can be given by right hand thumb rule where thumb points the current direction and finger points the direction of H. Thus direction of H is $-\hat{a}_y$

$$\therefore H = -59.1\hat{a}_y \text{ mA/m}$$

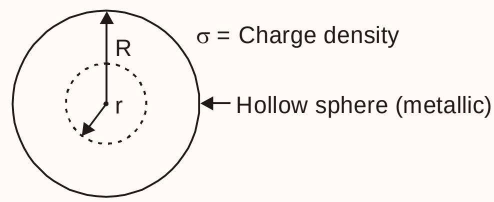
14. A hollow metallic sphere of radius R is charged to a surface density of σ. The strength of the electric field inside the sphere at a radius r(<R) is

(a) $\frac{\sigma}{\pi r^2}$ (b) $\frac{\sigma}{2\pi r^2}$

(c) $\frac{\sigma}{4\pi r^2}$ (d) zero

Ans. (d)

Sol.



By Gauss law,

$$\varepsilon\oint \vec{E}\cdot d\vec{s} = Q_{enclosed}$$

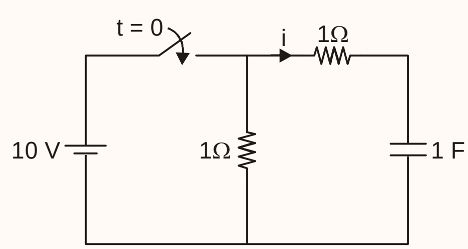
For a Gaussian surface at radius 'r' inside the sphere, the enclosed charge is zero

Thus,

$$\varepsilon\oint_s \vec{E}\,.\,d\vec{s} = \varepsilon_0 E(4\pi r^2) = 0$$

or $\boxed{E=0}$

15.



In the circuit as shown in figure, the switch is closed at t = 0. The current through the capacitor will decrease exponentially with a time constant of magnitude

(a) 0.5 s (b) 1 s

(c) 2 s (d) 4 s

Ans. (b)

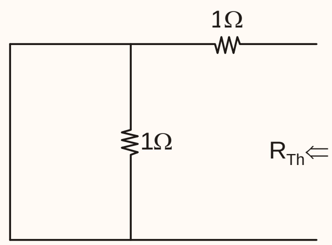
Sol. To find the time constant of the circuit

(i) Eliminate all the active sources i.e. replace the voltage source by a short circuit.

(ii) Calculate equivalent resistance across the capacitor

(iii) Time constant is given by, $\tau = RC$

The circuit can be redrawn as given below by replacing the voltage source by short circuit



$R_{Th} = 1\Omega$

$\therefore$ Time constant, $\tau = RC$ = 1 seconds

16. A parallel-plate capacitor with air between the plates has a capacitance of 10 pF. If the distance between the parallel plates is halved and the space between the plates is filled with a material of dielectric constant 5, the newly formed capacitor will have a capacitance of

(a) 10 pF (b) 50 pF

(c) 100 pF (d) 150 pF

Ans. **(c)**

Sol. For the case when, there is only air between the capacitor plates

$$C = \frac{\varepsilon_0 A}{d} = 10\text{ pF} \quad \text{... (i)}$$

where, A = Area of plate

d = distance between the plates

when d is halved and dielectric with dielectric constant of 5 is inserted

$$C' = \frac{\varepsilon_r \varepsilon_0 A}{d/2} = 2\varepsilon_r \left[\frac{\varepsilon_0 A}{d}\right]$$

where $\varepsilon_r = 5$

$\therefore$ $C' = 2 \times 5\,[C] = 10C$

$C' = 10 \times 10\text{ pF} = 100\text{ pF}$

or $\boxed{C' = 100\text{ pF}}$

17. Which of the following statements are correct regarding uniform plane waves?

1. Uniform plane waves are transverse

2. The relation between E and H is $\frac{E}{H} = \sqrt{\frac{\epsilon}{\mu}}$

3. E × H gives the direction of the wave travel

4. For a uniform plane wave travelling in x direction, E_x = 0

(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. **(b)**

Sol. Statement (2) is wrong as $\frac{E}{H} = \sqrt{\frac{\mu}{\epsilon}}$

Rest of the statements are true.

1. Uniform plane waves are transverse.

3. E×H gives the direction of the the wave travel.

4. For a uniform wave travelling in z-direction, E_z = 0.

18. An energy meter makes 100 revolutions of its disc per unit of energy. The number of

revolutions made by the disc during one hour when connected across 210V source and drawing a current of 20A at 0.8 p.f. leading is

(a) 336 (b) 316

(c) 286 (d) 256

Ans. **(a)**

Sol. Given, 1 kWh = 100 revolutions

Energy consumed by the load in one hour

= Power × time

= $VI\cos\phi \times t$

= 210 × 20 × 0.8 × 1 watt-hour

= 3360 W hr

= 3.36 KWhr

So, total number of revolutions by energy meter

= 3.36 × 100 = 336

19. Consider the following statements regarding Computer Architecture:

1. The advantage with dedicated bus is decrease in size and cost
2. In synchronous timing, the occurrence of events on the bus is determined by the clock
3. Data bus width decides the number of bits transferred at one time

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. **(c)**

Sol. Dedicated bus is permanently assigned either to one function or to a physical outset of computer component. It is used as separate dedicated address line and data line. So it leads to increase in size and cost.

Synchronous timing refers to the way in which events are coordinated on the bus. The occurrence of events on the bus is determined by a clock.

The data bus consists of 32 to hundreds seperate lines. The number of lines is referred as width of the data bus. Bnadwidth of data bus is the number of bits it can transfer in a single operation.

20. Consider the following statements :

1. Better memory utilization is possible with non-contiguous allocation using fixed size pages
2. Associative memory is used for providing fast access to data stored in cache memory.
3. Direct mapping of cache memory is hard to implement

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. **(a)**

Sol.
1. In non-contiguous allocation the logical address space of process is divided into small fixed size chunks called pages. It can be placed in any free frame in the memory. The external fragmentation problem is completely eliminated.
2. Associative memory is used to store the address of the data stored in the cache. So it provides fast access of data stored in cache memory.
3. Direct mapping technique is simplest technique to map main memory with cache.

21. The decimal value 0.5 in IEEE single precision floating point representation has fraction bits of

(a) 000.....000 and exponent value of 0

(b) 000.....000 and exponent value of –1

(c) 100.....000 and exponent value of 0

(d) 100.....000 and exponent value of –1

Ans. **(b)**

Sol. IEEE single precision floating point format :

mantissa × 2^{exponent}

for 0.5

mantissa is 0

exponent is – 1

So representation is

000 .... 000 and exponent value –1

22. What does the following program print?

```
void f(int*p, int*q)
{
    p = q;
    *p=2;
}
int i = 0, j = 1;
int main ( )
{
    f(&i, &j);
    printf("%d %d  \n", i, j);
    getchar ( );
    return 0;
}
```

(a) 2 2 (b) 2 1

(c) 0 1 (d) 0 2

Ans. **(d)**

Sol.

i	j
0	1
1001	2001

In function f $\Rightarrow$ p $\leftarrow$ 1001, q $\leftarrow$ 2001

p = q

p $\leftarrow$ 2001

(*p) = 2

*(2001) = 2

Now 1 is replaced by 2

Now in main function, printf will print (0, 2)

23. Consider the following set of processes with data thereof as given here :

Process	Arrival time	CPU Burst time
P_1	0 ms	12 ms
P_2	2 ms	4 ms
P_3	3 ms	6 ms
P_4	8 ms	5 ms

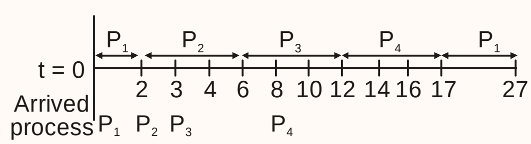
An operating system uses shortest remaining time first scheduling algorithm for pre-emptive scheduling of processes. The average waiting time of the processes is

(a) 7.5 ms (b) 6.5 ms

(c) 5.5 ms (d) 4.5 ms

Ans. **(c)**

Sol. Operating system uses shortest rermaining time first scheduling algorithm. So the process whose remaining CPU burst time is more compare to arrived process will be preempted.



1. P_1 arrived at t = 0 so it execute first. At time t = 2 nsec. P_2 arrived the remaining time of process P_1 is 10 msec. so process P_1 is prempted and process P_2 (burst time = 4 msec) gets CPU and execute entire burst time because it's remaining burst time is less compare to burst time of arrived process.
2. Process P_3 wait for 3 msec, afterthat it complete execution.
3. Process P_4 wait for 4 msec, after that it complete execution.
4. Finally process P_1 complete remaining execution for 10 msec.

w aiting time of P_1 = 0 + (17 – 2) = 15 msec

waiting time of P_2 = 0 msec

waiting time of P_3 = 6 – 3 = 3 msec

waiting time of P_4 = 12 – 8 = 4 msec

Average waiting time = $\frac{15+0+3+4}{4}$

= 5.5 msec

24. The length of cable required for transmitting a data at the rate of 500 Mbps in an Ethernet LAN with frames of size 10,000 bits and for signal speed 2,00,000 km/s is

(a) 2.5 km (b) 2.0 km

(c) 1.5 km (d) 1.0 km

Ans. **(b)**

Sol. Given,

Bandwidth = 500 mbps

Frame size = 10,000 bits

Signal speed = 2,00,000 km/sec

Transmission delay = 2 × propagation delay

$$\frac{\text{frame size}}{\text{Bandwidth}} = 2 \times \frac{\text{length of cable}}{\text{signal speed}}$$

$$\frac{10{,}000 \text{ bits}}{500 \times 10^6 \text{ bits/sec}} = \frac{2 \times \text{length of cable}}{2{,}00{,}000 \text{ km/sec}}$$

$$\frac{10{,}000 \text{ bits} \times 2{,}00{,}000 \text{ km/sec}}{500 \times 10^6 \text{ bits/sec} \times 2} = \text{length of cable}$$

$$\text{length of cable} = \frac{10 \times 2{,}00000}{10^6}\text{km} = 2.0\text{km}$$

25. Consider the following statements :

1. System calls provide the interface between a process and the operating system
2. PERL implementations include direct system call access
3. System calls occur in different ways depending on the computer in use

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. System call is used as an interface between process and operating system. Process can not access operating system directly for read, write operation. So system call act as interface to perform these operation.
2. PERL is used for system programming. This language allow access the system call directly.
3. As per computer design system call can be implemented

(i) Interactive system: prompt message displayed for appropriate input.

(ii) Batch system: Specify the parameter names with control statement.

(iii) Mouse based and icon based systems.

26. What is the effective access time, if the average page-fault service time is 25 ms, memory access time is 100 ns and page-fault rate is P?

(a) 100 + 24,999,900 × P ns

(b) 100 + 25,000,000 × P ns

(c) 100 + 25,000 × P ns

(d) 25,000,000 + 100 P ns

Ans. (a)

Sol. Effective access time = P × (page fault service time) + (1–P) × memory access time

= P × 25 msec + (1 – P) × 100 nsec

= P × 25 msec + 100 nsec – P × 100nsec

= 100 nsec + (25×10^{-3}sec –100 × 10^{-9} sec) × P

= 100 nsec +(25000000 ×10^{-9}–100×10^{-9}) × P

= 100 nsec + 24999900 × 10^{-9} × P sec

= 100 nsec + 24999900 × P nsec.

27. Consider the function fun1 shown below :

```
int fun1 (int num)
{
    int count = 0;
    while (num)
    { count + +;
    num >> = 1;
    }
    return (count);
}
```

The value returned by fun1 (435) is

(a) 10 (b) 9

(c) 8 (d) 7

Ans. (b)

Sol. Binary equivalent of 435 $\rightarrow$ $(110110011)_2$

there are 9 bits.

in while loop;

num >> = 1 $\Rightarrow$ num = num >> 1

1 bit is shifting in each iteration, total number of iteration = 9

So final value of count is 9. So return value will be 9.

Option (b) is correct.

28. Consider the following statements in the relevant context :

1. The two types of currents that flow in semiconductor diodes and transistors are drift and diffusion currents

2. The junction region is called depletion region or space-charge region

3. When currents flow through the diode in forward bias, the depletion region current is mostly of 'diffusion' type

Which 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. (a)

Sol. There exists two types of currents that flow in semiconductor diodes and transistors i.e. drift and diffusion currents.

The region formed between p-type and x-type regions is called space charge region (or) depletion region.

The total current flowing through the depletion region under forward biasing is

SCROLL DOWN

made up of mostly majority carrier diffusion. When the diode is reverse biased diffusion is negligible but drift remains constant. The total current flowing through the depletion region under reverse biasing is made of mostly of minority carrier drift current.

Hence all the statement 1,2,3 are correct.

29. The bandwidth of a control system can be increased by using

(a) Phase-lead network

(b) Phase-lag network

(c) Both Phase-lead network and Phase-lag network

(d) Cascaded amplifier in the system

Ans. **(a)**

Sol. A phase lead network is equivalent to high pass filter, so bandwidth of a control system increases by use of phase lead network.

30. Applications of negative feedback to a certain amplifier reduced its gain from 200 to 100. If the gain with the same feedback is to be raised to 150, in the case of another such appliance, the gain of the amplifier without feedback must have been

(a) 400 (b) 450

(c) 500 (d) 600

Ans. **(d)**

Sol. For a negative feedback amplifier, the gain is given as

$$A_f = \frac{A}{1+A\beta}$$

as the gain reduces from 200 to 100

$$100 = \frac{200}{1+200\beta}$$

$$\Rightarrow \quad 1+200\beta = 2$$

$$\therefore \quad \beta = \frac{1}{200}$$

where, β = feedback factor

$$150 = \frac{A}{1+A+\frac{1}{200}}$$

$$\Rightarrow \quad 1+\frac{A}{200} = \frac{A}{150}$$

$$\Rightarrow \quad 1 = A\left[\frac{1}{150}-\frac{1}{200}\right] = \frac{A}{600}$$

$\therefore$ A = 600

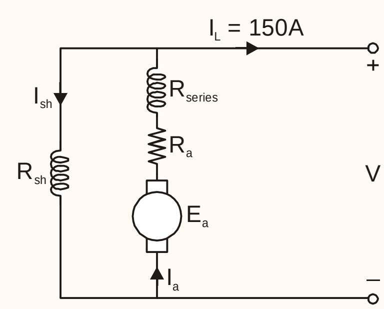
31. A 220V dc compound generator connected in long-shunt mode has the following parameters : R_a = 0.1Ω, R_{sh} = 80Ω, R_{series} = 0.05Ω. For a load of 150A at rated terminal voltage, the induced emf of the generator should nearly by

(a) 233 V (b) 243 V

(c) 251 V (d) 262 V

Ans. **(b)**

Sol. DC compound generator in long shunt mode.



For rated terminal voltage of V = 220 V

$$I_{sh} = \frac{V}{R_{sh}} = \frac{220}{0.80} = 2.75\,A$$

I_a = 150 + 2.75 = 152.75 A

Now,

$E_a = V + I_aR_a + I_a\,R_{series}$

= 220 + 152.75 × 0.1 + 152.75 × 0.05

E_a = 242.91 V

The nearest option is E_a = 243 V

32. The Laplace transform of $f(t) = t^n e^{-\alpha t} u(t)$ is

(a) $\dfrac{(n+1)!}{(s+\alpha)^{n+1}}$ (b) $\dfrac{n!}{(s+\alpha)^{n}}$

(c) $\dfrac{(n-1)!}{(s+\alpha)^{n+1}}$ (d) $\dfrac{n!}{(s+\alpha)^{n+1}}$

Ans. **(d)**

Sol.

We know that $L\{t^n\} = \dfrac{\overline{|n+1}}{s^{n+1}}$

and $u(t) = \begin{cases} 1\ , & t \geq 0 \\ 0\ , & t < 0 \end{cases}$

So $L\{t^n.u(t)\} = \dfrac{\overline{|n+1}}{s^{n+1}}$

Now by using 1st shifting property

$$L\left\{e^{-\alpha t}.t^n u(t)\right\} = \frac{\overline{|n+1}}{(s+\alpha)^{n+1}} = \frac{\overline{|n}}{(s+\alpha)^{n+1}}$$

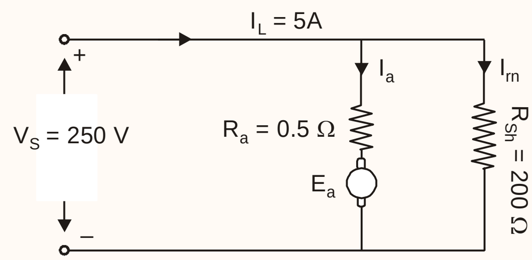
33. A dc shunt motor has the following characteristics, $R_a = 0.5\Omega$, $R_f = 200\Omega$, base speed = 1000 rpm, rated voltage = 250V. On no load it draws a current = 5A. At what speed will this run while delivering a torque of 150 N/m?

(a) 881 rpm (b) 920 rpm

(c) 950 rpm (d) 990 rpm

Ans. **(a)**

Sol. DC shunt motor circuit



At no load,

I_a = 5A, N_0 = 1000 rpm

$$= \frac{1000 \times 2\pi}{60} = 104.72\,\text{rad/sec}$$

Back emf.;

$E_a = V_S - I_aR_a$

where, $I_a = I_L - I_{sh} = 5 - \dfrac{250}{200} = 3.75A$

$\therefore\ E_a = 250 - 3.75 \times 0.5 = 248.125V$

Since, $E_a = K\phi N = K_T N$

where K_T is constant.

$\therefore\ K_T = \dfrac{E_a}{N} = \dfrac{248.125}{104.72} = 2.369$

At load torque, τ = 150 N.m.

Torque, $\tau = K_T I_a$ (as flux is constant)

$\therefore \quad I_a = \frac{\tau}{K_T} = \frac{150}{2.369} = 63.318A$

Now, back emf.

$E_a = V_S - I_aR_a = 250 - 63.18 \times 0.5$

As $E \propto N$

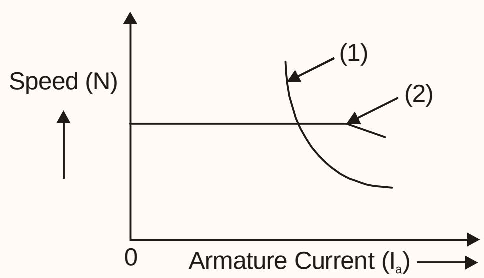
$\therefore \frac{E_a}{E'_a} = \frac{N_0}{N}$ for constant flux which is true for shunt machine

$\therefore \frac{248.125}{218.341} = \frac{1000}{N}$

or N = 879.96 rpm

Nearest option is 881 rpm.

34.



The figure shows plots of speed (N) Vs. armature current (I_a) of a dc motor for two different operating conditions. Which one of the following features is relevant?

(a) (1) represents stronger shunt field, and (2) represents stronger series field of a compound motor

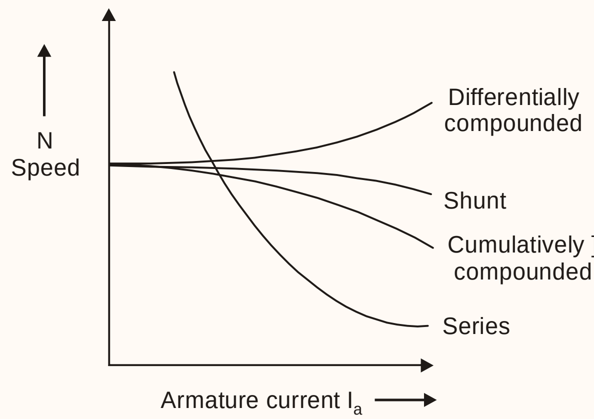
(b) (1) represents stronger series field, and (2) represents stronger shunt field of a compound motor

(c) (1) represents only shunt excitation, and (2) represents only series excitation

(d) (1) represents only series excitation, and (2) represents only shunt excitation

Ans. (d)

Sol.



Note : $N \propto \frac{1}{\phi}$

So in series field winding, as I_a increases ϕ increases, hence speed (N) decreases.

In shunt field winding, voltage applied across it, remains constant (almost), so ϕ remains constant. Thus speed is generally constant. The small drop at high I_a, is due to reduced back emf as $E \propto N$.

In comutatively compounded dc motor,

$\phi_{total} = \phi_{series} + \phi_{shunt}$

while in differentially compounded motor

$\phi_{total} = \phi_{series} - \phi_{shunt}$

35. A 230V, 50 Hz, 4-pole, single-phase induction motor is rotating clockwise (forward) direction at a speed of 1425 rpm. If the rotor resistance at standstill is 7.8Ω, then the effective rotor resistance in the backward branch of the equivalent circuit will be

(a) 2.0Ω (b) 4.0Ω

(c) 78Ω (d) 156Ω

Ans. **(a)**

Sol. For single phase induction motor

N_r (rotor speed) = 1425 rpm

$$N_S \text{ (synchronous speed)} = \frac{120f}{P} = \frac{120 \times 50}{4}$$

$$= 1500 \text{ rpm}$$

$$\text{Hence, slips} = \frac{N_S - N_r}{N_S} = \frac{1500 - 1425}{1500}$$

$$= 0.05$$

Standstill rotor resistance, $R_2 = 7.8\Omega$ (given)

Effective rotor resistance for backward

$$\text{branch} = \frac{R_2}{2(2-s)}$$

$$= \frac{7.8}{2(2-0.05)} = 2\Omega$$

36. A 400 V, 50 Hz, 30 hp, three phase induction motor is drawing 50A current at 0.8 power factor lagging. The stator and rotor copper losses are 1.5 kW and 900 W respectively. The friction and windage losses are 1050 W and the core losses are 1200 W. The air gap power of the motor will be, nearly

(a) 15 kW (b) 20 kW

(c) 25 kW (d) 30 kW

Ans. **(c)**

Sol. For given three phase induction motor

$$P_{input} = \sqrt{3}\,VI\cos\phi$$

$$= \sqrt{3} \times 400 \times 50 \times 0.8 = 27712.81\text{W}$$

or P_{input} = 27.713 kW

Air gap power,

$P_g = P_{input}$ – Stator Cu loss – Core loss

= 27.713 – 41.5 – 1.2 = 25.013 kW

Nearest option is 25 kW

37. When the value of slip of an induction motor approaches zero, the effective resistance

(a) is very low and the motor is under no-load

(b) of the rotor circuit is very high and the motor is under no-load

(c) is zero

(d) of the rotor circuit is infinity and the motor is equivalent to short-circuited two-winding transformer

Ans. **(b)**

Sol. For induction motor,

Effective resistance of rotor is given as $\dfrac{R_{20}}{s}$

Where R_{20} = standstill rotor resistance

s = slip

Under no load, slip $\approx$ 0

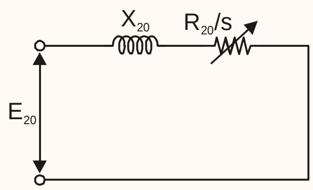
As the load on motor increases, rotor speed decreases, hence slip increases,.

Therefore,

As s approaches to zero, $\dfrac{R_{20}}{s} \approx \infty$

and motor is under no load

By observing the rotor equivalent circuit at line frequency.



as slip approaches zero, $\frac{R_{20}}{s} \simeq \infty$ and secondary i.e. rotor winding acts as open circuit.

38. A 4-pole, 50 Hz, 3-phase induction motor with a rotor resistance of 0.25Ω develops a maximum torque of 25 N.m at 1400 rpm. The rotor reactance x_2 and slip at maximum torque $s_{max,T}$ respectively would be

(a) 2.0 and $\frac{1}{15}$ (b) 3.75 and $\frac{1}{12}$

(c) 2.0 and $\frac{1}{12}$ (d) 3.75 and $\frac{1}{15}$

Ans. **(d)**

Sol. For given $3-\phi$ IM

$$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

Given that, at maximum torque condition,

N_r (rotor speed) = 1400 rpm

$$s_m = \frac{N_s - N_r}{N_s} = \frac{1500 - 1400}{1500} = \frac{1}{15}$$

Also, at maximum torque condition.

$R_2 = s_m X_2$

$$\therefore\ 0.25 = \frac{1}{15} X_2$$

or $X_2 = 15 \times 0.25 = 3.75\Omega$

or $\boxed{X_2 = 3.75\Omega}$

39. A 3-phase, 37 kW induction motor has an efficiency of 90% when delivering full load. At this load the stator copper losses and rotor copper losses are equal and are equal to stator iron losses. The mechanical losses are one-third of no-load losses. Then the motor runs at a slip of

(a) 0.01 (b) 0.02

(c) 0.03 (d) 0.04

Ans. **(c)**

Sol. For given IM,

Output power = 37KW

For efficiency of 90%, power input to motor,

$$P_{input} = \frac{37}{0.9} = 41.11\text{KW}$$

Hence, total tosses = 41.11 –37 = 4.111kw

Now, let stator copper loss = P, then

Rotor copper loss = P

Stator iron loss = P and

Mechanical loss = $\frac{P}{3}$

$\therefore$ Total losses $P_{Loss} = P + P + P + P/3 = \frac{10P}{3}$

Therefore, $\frac{10P}{3} = 4.11$

or P = 1.23KW

Now, air gap power;

$P_g = P_{input} -$ Stator iron loss – stator copper loss

= 41.11 – 1.23 –1.23 = 38.64 KW

Mechanical power developed

$P_{nd} = P_{output} +$ mechanical loss

$$= 37 + \frac{1.23}{3} = 37.41KW$$

Also, $P_{md} = (1-s)Pg$

$$\therefore \quad 37.41 = (1-s)\times 37.64$$

or s = 0.318

40. The rotor of a 4-pole ac generator is wound with a 200 turns coil. If the flux per pole is 5 m Wb and the rotor runs at a speed of 1500 rpm, the rms value of the induced voltage for this ac generator is nearly

(a) 140 V (b) 157 V

(c) 164 V (d) 200 V

Ans. (d)

Sol.

For given ac generator,

N_s = 1500 rpm (synchronous speed)

Poles, P = 4

$$\therefore \quad \frac{120f}{P} = N_s$$

$$\text{or} \quad \frac{120\times f}{4} = 1500$$

or f = 50 Hz

Given that,

flux per pole, ϕ = 5 mWb = 5×10^{-3} Wb

Number of turns in rotor, T = 200

Induced emf is given y

$E = 4.44\ f\phi T$

$= 4.44 \times 50 \times 5 \times 10^{-3} \times 200$

or E = 222 V

Nearest option is 200 V

41. A 3-MVA, 6-pole, 50 Hz, 3-phase synchronous generator is connected to an infinite bus of 3300 V; and it is run at 1000 rpm. The synchronous reactance of the machine is 0.915Ω per phase. The synchronizing torque for 1° mechanical displacement of the rotor is

(a) 7500 N.m (b) 7000 N.m

(c) 6000 N.m (d) 4500 N.m

Ans. (c)

Sol. As we know that

$$E_f = V_t + I_a Z_s$$

$$\Rightarrow E_f = V_t + jI_a X_S$$

$$\text{Here, } V_t = \frac{3300}{\sqrt{3}}$$

$$I_a = \frac{3\times 10^6}{\sqrt{3}\times 3300} = 524.8$$

$X_s = 0.915\ \Omega/\text{phase}$

$$\therefore \quad E_f = 1964.8\angle 14.14^\circ$$

Now, synchoronous torque

$$\tau = \frac{P_{syn}}{\omega_m} = \frac{3E_f V_t}{X_s}\cdot\frac{1}{\omega_m}\cdot \cos\delta.\Delta\delta$$

$$= \frac{3 \times 1964.8 \times 3300}{0.915 \times \sqrt{3}} \times \frac{1}{\left(\frac{2\pi \times 1000}{60}\right)}$$

$$\times \cos 14.14 \times 3 \times \frac{\pi}{180} \text{N-m}$$

$\cong 6000$ N-m

42. The second-harmonic component of the power P versus load angle δ characteristic of a synchronous machine, operating at a terminal voltage V_t and having the d- and q-axis reactance per phase of X_d and X_q, respectively, is

(a) $\frac{V_t^2}{2} \cdot \frac{X_d X_q}{X_d + X_q} \sin 2\delta$

(b) $\frac{V_t^2}{2} \cdot \left(\frac{1}{X_q} - \frac{1}{X_d}\right) \sin 2\delta$

(c) $\frac{V_t^2}{2} \cdot \frac{X_d X_q}{X_d + X_q} \cos 2\delta$

(d) $\frac{V_t^2}{2} \cdot \left(\frac{1}{X_q} - \frac{1}{X_d}\right) \cos 2\delta$

Ans. **(b)**

Sol. The real power for a salient pole machine is given by

$$P_{1\phi} = \frac{V_t E_f}{X_d} \sin\delta + \frac{V_t^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right) \sin 2\delta$$

The second harmonic component is

$$\frac{V_t^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right) \sin 2\delta$$

43. The term Synchronous condenser refers to

(a) A synchronous motor with a capacitor connected across the stator terminal to improve the power factor

(b) A synchronous motor operating at full-load with leading power factor

(c) An over-excited synchronous motor partially supplying mechanical load and also improving the power factor of the system to which it is connected

(d) An over-excited synchronous motor operating at no-load with leading power factor used in large power stations for improvement of power factor

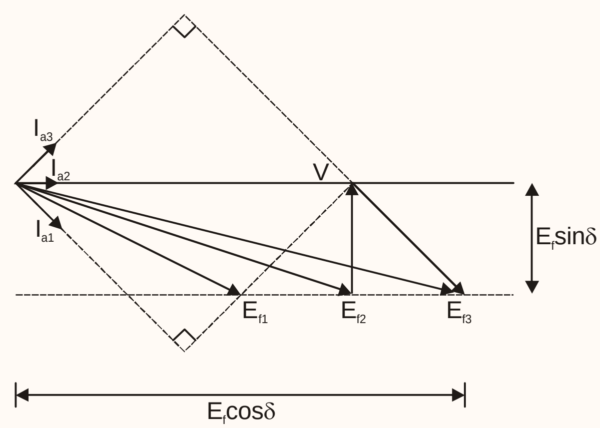
Ans. **(d)**

Sol.

Synchronous condenser is an over excited synchronous motor at no load.

Overexcited means, $E_f \cos\delta > V$

By phasor diagram



When $E_f \cos\delta > V$, pf is leading, as for current I_{a3}

SCROLL DOWN

Synchronous condenser is used in large power stations. It is not cost effective for small power stations.

44. Which of the following operating aspects necessitate the computation of Regulation of an alternator?

1. When load is thrown off
2. For designing of an automatic voltage-control equipment
3. For determination of steady-state and transient stability
4. For parallel operation of alternators

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

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

Ans. **(d)**

Sol. Need for voltage regulation computation.

1. To know the voltage drop when load is thrown off.
2. For designing automatic voltage-control equipment.
3. For parallel operation.
4. For determination of steady-state and transient stability

45. A 2-phase ac servomotor has a tendency to run as a single-phase induction motor, if the voltage across the control winding becomes zero. To prevent this

(a) Rotor having high mass and moment of inertia is to be used

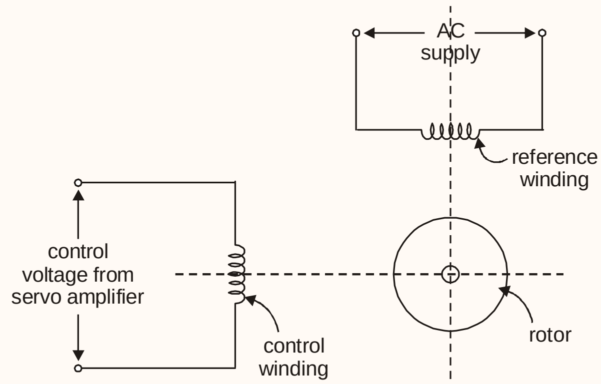
(b) Drag-cup type of light rotor and high resistance is to be used

(c) A low resistance rotor is to be used

(d) The number of turns in the control winding is to be kept lesser than in the main reference winding

Ans. **(b)**

Sol.



A two phase ac servomotor has reference winging supplied by constant AC voltage supply and control winding supplied by variable control voltage obtained from servo amplifier. If the voltage across the control winding becomes zero then servo motor acts as a $1-\phi$ induction motor. In order to prevent this a light rotor and high resistance is to be used. This can be done by a drag-cup type servomotor as shown below:

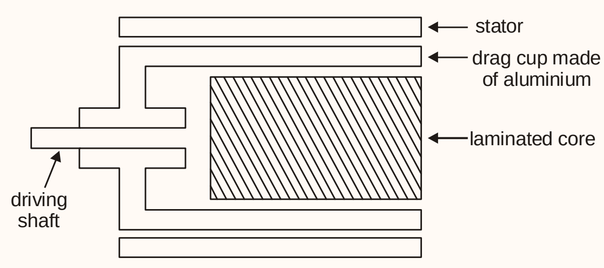


Fig: Drag cup 2 phase servo motor.

46. A single-stack, 8-phase (stator), multiple-step motor has 6-rotor teeth. The poles are excited one at a time. If excitation frequency is 120 Hz, the speed of the motor is

(a) 3 rps (b) 5 rps
(c) 10 rps (d) 15 rps

Ans. **(b)**

Sol. Given that,

stator poles, $N_s = 8$

rotor teeth, $N_r = 6$

As, step size, $\alpha = \dfrac{N_s - N_r}{N_s N_r} \times 360$

$$= \frac{8-6}{8\times 6}\times 360 = 15°$$

Shaft speed is given by

$$n = \frac{\alpha f}{360}$$

$$= \frac{15 \times 120}{360}$$

or $\boxed{n = 5\,\text{rps}}$

47. An extra high voltage transmission line of length 300 km can be approximated by a lossless line having propagation constant β = 0.00127 rad/km. The percentage ratio of line length to wavelength will nearly be

(a) 24% (b) 19%
(c) 12% (d) 6%

Ans. **(d)**

Sol. line length = 300 km

Propagation constant; $\beta = 0.00127\,\text{rad/km}$

The wavelength for one complete sinusoidal variation will be,

$$\lambda = \frac{2\pi}{\beta} = 4947.4$$

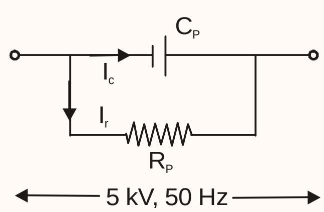
$$\lambda = \frac{2\pi}{0.00127} = 0.0606 \text{ or } 6.06\%$$

48. A lossy capacitor C_x, rated for operation of 5 kV, 50 Hz is represented by an equivalent circuit with an ideal capacitor C_p in parallel with a resistor R_p. C_p is 0.102 μF; and R_p = $1.25\ \text{M}\Omega$. The power loss, and $\tan\delta$, of this lossy capacitor when operating at the rated voltage are, respectively

(a) 20 W and 0.04 (b) 10 W and 0.04
(c) 20 W and 0.025 (d) 10 W and 0.025

Ans. **(c)**

Sol. Lossy capacitor



where $C_P = 0.102\,\mu\text{F}$

$R_P = 1.25\ \text{M}\Omega$

$\tan\delta$ is given by

$$\tan\delta = \frac{I_r}{I_c} = \frac{\dfrac{5\times 10^3}{1025\times 10^6}}{\dfrac{5\times 10^3}{\left(\dfrac{1}{2\pi\times 50\times 0.102\times 10^{-6}}\right)}}$$

$$= 0.025$$

Power loss, P = $V^2 C\omega\tan\delta$

$= (5\times10^3)^2 0.102\times10^{-6}\times2\pi\times50\times0.025$

$= 20.028\,W$

49. The time interval needed for a surge to travel to the end of a 600 km long overhead transmission line is

(a) 6 s (b) 2 s

(c) 20 ms (d) 2 ms

Ans. (d)

Sol. Given length of the transmission line = 600km

We know velocity of the wave(V) = $\frac{1}{\sqrt{LC}}$

$$V = \frac{1}{\sqrt{LC}} \quad ...(1)$$

$$\alpha = \frac{\mu_0}{2\pi} ln\left(\frac{d}{r}\right)$$

$$C = \frac{2\pi \in_0}{ln\left(\frac{d}{r}\right)}$$

$$V = \frac{1}{\sqrt{\frac{\mu_0}{2\pi} ln\left(\frac{d}{r}\right)\times\frac{2\pi\in_0}{ln\left(\frac{d}{r}\right)}}}$$

$$= \frac{1}{\sqrt{\mu_0 \in_0}}$$

$= 3\times10^8$ m/s

$\therefore$ Time taken to travel (t) = $\frac{L}{V}$

$$t = \frac{600\times10^3}{3\times10^8}$$

$$= \frac{6}{3\times10^3}$$

$= 2\times10^{-3}$

t = 2msec.

50. At what power factor will a lossless line with a reactance of 0.6 pu exhibit zero regulation given that the sending-end voltage is 1.0 pu?

(a) 0.800 lag (b) 0.800 lead

(c) 0.954 lead (d) Unity p.f.

Ans. (c)

Sol. The zero voltage regulation is always obtained at leading power factor so, let the current be $1\angle\phi$ receiving end voltage, $V_r = 1\angle0°$

Sending end voltage for zero voltage regulation, will be, $V_s = 1\angle\delta°$

$$\vec{V}_s = \vec{V}_r + \vec{I}_r.jX_s$$

$$\therefore 1\angle\delta = 1\angle0° + (1\angle\phi)(0.6\angle90°)$$

$$1\angle\delta = 1\angle0° + 0.6\angle90+\phi$$

$$1\angle\delta = 1+0.6\cos(90+\phi)+j0.6\sin(90+\phi)$$

$$1\angle\delta = 1-0.6\sin\phi + j0.6\cos\phi \quad ...(1)$$

$$\therefore 1 = (1-0.6\sin\phi)^2+(0.6\cos\phi)^2$$

$1 = 1 + 0.36 - 1.2\sin\phi$

$$\sin\phi = \frac{0.36}{1.2} = 0.3$$

$\cos\phi = \sqrt{1-\sin^2\phi} = \sqrt{1-(0.3)^2}$

$\boxed{\cos\phi = 0.954 \text{ lead}}$

51. An 11 kV, 3-phase transmission line has resistance of 1.5Ω and reactance of 4Ω per phase. The efficiency of the line when supplying the load of 4 MW at 0.8 lagging power factor is nearly

(a) 99% (b) 95%

(c) 92% (d) 90%

Ans. **(c)**

Sol. The load current

$$I_r = \frac{4\times10^6}{\sqrt{3}\times11\times10^3\times0.8} = 262.43\text{A}$$

Total line losses will be those occuring in resistance only.

$$\therefore \quad P_{loss} = 3I_r^2.R_\phi$$

$$P_{loss} = 0.31 \text{ MW}$$

$\therefore \quad P_{out} = 4$ MW

$P_{in} = P_{out} + P_{loss}$

$= 4.31$ MW

$$\text{efficiency}(\eta) = \frac{P_{in}}{P_{out}} = 92.8\% \approx 92\%$$

52. The dielectric loss in the insulation of a lossy underground cable, due to leakage current is (using standard notations)

(a) $\omega CV^2 \cos\delta$ (b) $\omega CV \tan\delta$

(c) $\omega CV^2 \tan\delta$ (d) $\omega CV \sin\delta$

Ans. **(c)**

Sol. The dielectric loss in the insulation of a lossy underground cable due to leakage correct is

$$\text{dielectric loss} = \frac{V^2}{X_c}\tan\delta$$

$$= \frac{V^2}{(1/\omega c)}\tan\delta$$

$$= V^2\omega c\tan\delta$$

53. A 3-phase, 100 MVA, 11 kV generator has the following p.u. constants. The generator neutral is solidly grounded. $X_1 = X_2 = 3X_0 = 0.15\Omega$. The ratio of the fault current due to three-phase dead-short-circuit to that due to L-G fault would be nearly

(a) 0.33 (b) 0.56

(c) 0.78 (d) 1.0

Ans. **(c)**

Sol. $X_1 = X_2 = 3X_0 = 0.15\Omega$

E_a = phase voltage generated = $\frac{11}{\sqrt{3}}$kV

For $3-\phi$ deal short circuit, fault current

$$(I_f)_1 = \frac{E_a}{jX_1} \quad \text{...(i)}$$

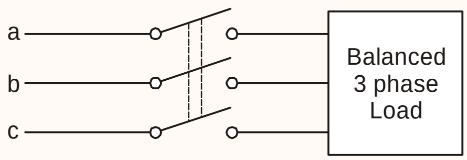
For L-G fault, fault current

$$(I_f)_2 = \frac{3E_a}{jX_1 + jX_2 + jX_0} \quad \text{...(ii)}$$

$$\frac{\text{eq.(i)}}{\text{eq.(ii)}} \Rightarrow \frac{I_{f_1}}{I_{f_2}} = \frac{j(X_1+X_2+X_0)}{3jX_1}$$

$$\frac{I_{f_1}}{I_{f_2}} = \frac{0.15+0.15+0.05}{3\times 0.15} = 0.78$$

54.



Triple-pole switch

A balanced 3-phase load is supplied from a 3-phase supply. The contact in line c of the triple-pole switch contactor fails to connect when switched on. If the line-currents in lines a and b record 25A each, then the positive-sequence component of the current is

(a) $14.4\angle+30°\text{A}$ (b) $25.0\angle-30°\text{A}$

(c) $14.4\angle-30°\text{A}$ (d) $25.0\angle+30°\text{A}$

Ans. **(c)**

Sol. The current I_a and I_b will be such that,

$I_a + I_b = 0$ or $I_a = -I_b$

$I_a = 25\underline{|0°}$

$I_b = 25\underline{|180°}$

$\alpha = 1\underline{|120°}$

The positive sequence current will be

$$I_{a_1} = \frac{1}{3}\left(I_a + \alpha I_b + \alpha^2 I_c\right)$$

$$= \frac{1}{3}\left(25\underline{|0°} + 25\underline{|300°}\right)$$

$$\boxed{I_{a_1} = 14.4\underline{|-30°}}$$

55. In a circuit-breaker, the arc is produced due to

1. Thermal emission
2. High temperature of air
3. Field emission

Which of the above statements are correct?

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

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

Ans. **(d)**

Sol. In a circuit breaker arc is produced

(1) Electronic (emission/field emission): As field is emitting high amount of electrons between the contacts.

(2) Thermionic emission: This heat will continue to liberate the electrons which further increases the heat. Hence statement 1,3 are correct.

56. The line reactances of a power network are as follows :

Line No.	From Bus	To Bus	Reactance
1	0	1	0.2 p.u.
2	1	2	0.4 p.u.

The bus impedance matrix with '0' as ref-bus is

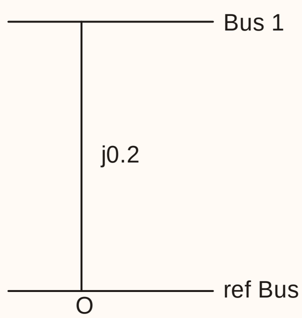
(a) $\begin{bmatrix} 0.2 & 0.4 \\ 0.4 & 0.6 \end{bmatrix}$ (b) $\begin{bmatrix} 0.4 & 0.2 \\ 0.2 & 0.6 \end{bmatrix}$

(c) $\begin{bmatrix} 0.2 & 0.2 \\ 0.2 & 0.6 \end{bmatrix}$ (d) $\begin{bmatrix} 0.6 & 0.2 \\ 0.2 & 0.4 \end{bmatrix}$

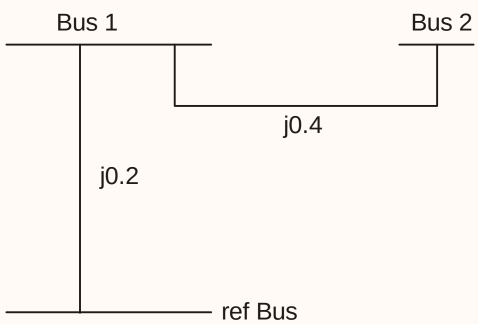
Ans. **(c)**

Sol. • First considering only line 1 $\Rightarrow$

$$Z_{Bus} = [j0.2]$$



- Now, if we add a new line of impedance j 0.4, between Bus 1 and Bus 2 then,



$$Z_{Bus} = \begin{bmatrix} j0.2 & j0.2 \\ j0.2 & j0.2 + j0.4 \end{bmatrix}$$

$$Z_{Bus} = \begin{bmatrix} j0.2 & j0.2 \\ j0.2 & j0.6 \end{bmatrix}$$

57. An alternator is

(a) A polyphase synchronous machine operated with DC exciter

(b) A polyphase synchronous machine operated with AC exciter

(c) A three-phase induction machine with prime mover

(d) Any AC generator

Ans. (a)

Sol. An alternator is a polyphase synchronous machine in which excitation is provided by rotor winding connected to dc supply.

58. The stability of a system, when subjected to a disturbance, is assessable by which of the following methods?

1. Swing curve
2. Equal-area criterion
3. Power-angle diagram
4. Power-circle diagram

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

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

Ans. (d)

Sol. The stability of a system when subjected to a disturbance is assesable by

1. swing curve
2. equal area criterion
3. power angle diagram

From the power-circle diagram Liariour types of losses, torques etc can be found in a induction machine.

Hence statements 1,2,3 are correct and statements-4 is false.

59. Power transmission capacity of a high voltage line can be increased by

(a) Increasing the resistance of the line

(b) Increasing the inductive reactance of the line

(c) Reducing the effective series reactance of the line

(d) Reducing the shunt admittance of the line

Ans. (c)

Sol. Power transmission capacity of a high voltage line can be increased by reducing the effective series reactace of the line.

$$\uparrow P = \frac{V_1V_2}{(X)\downarrow}\sin\delta$$

60. A 40 MVA, 11 kV, 3-phase, 50 Hz, 4-pole turbo-alternator has an inertia constant of 15 sec. An input of 20 MW developed 15 MW of output power (Neglecting losses). Then the acceleration is

(a) $60°/s^2$ (b) $65°/s^2$

(c) $70°/s^2$ (d) $75°/s^2$

Ans. **(d)**

Sol. Given data:

S = 40 MVA (rating of the machine)

V = 11 kv

f = 50 Hz

P = 4 (no of poles)

H = 15 sec (inertia constant)

P_i = 20 MW (input power)

P_o = 15 MW (output power)

Acceleration power $P_a = (P_i - P_o)$

$P_a = (20 - 15)$ MW

$P_a = 5$ MW

We know $P_a = M\frac{d^2\delta}{dt^2}$

$$P_a = M\alpha \qquad \left[\alpha = \frac{d^2\delta}{dt^2}\right]$$

$$P_a = \left(\frac{SH}{180f}\right)\alpha$$

$$5M = \left(\frac{40M\times 15}{180\times 50}\right)\alpha$$

$$\alpha = \frac{180\times 50}{8\times 15} = \frac{180\times 50}{120} = \frac{150}{2} = 75°$$

Acceleration is $\alpha = 75°/\sec^2$

61. In a Progressive Simplex Lap Winding for a 4-pole, 14-slot, 2 coil-sides per slot d.c. armature, the back pitch y_b and front pitch y_f will be respectively

(a) 7 and 5 (b) 5 and 5

(c) 7 and 7 (d) 5 and 7

Ans. **(a)**

Sol. **Progressive simplex lap winding**

Number of conductor = Number coil sides

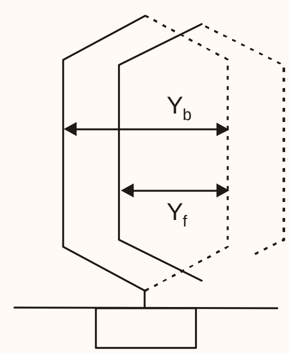
$\therefore$ $Z = 2\times 14 = 28$

Pole pitch = $\frac{Z}{P} = \frac{28}{4} = 7$

For simplex lap winding, back pitch Y_b and front pitch Y_f must be odd and differ by 2.

$\therefore$ $Y_b = 7$

$\therefore$ $Y_f = 7 - 2 = 5$



62. The starting current in an induction motor is 5 times the full-load current while the full load slip is 4%. The ratio of starting torque to full-load torque is

(a) 0.6 (b) 0.8

(c) 1.0 (d) 1.2

Ans. (c)

Sol. Starting current,

$I_{st} = 5I_{fl}$ (given)

Now,

$$\frac{\text{Starting torque}}{\text{Full load torque}} = \frac{\tau_{st}}{\tau_{fl}} = \left(\frac{I_{st}}{I_{fl}}\right)^2 \times s_{fl}$$

$$\therefore \quad \frac{\tau_{st}}{\tau_{fl}} = \left(\frac{5I_{fl}}{I_{fl}}\right)^2 \times 0.04$$

$$= 25 \times 0.04$$

or $\boxed{\frac{\tau_{st}}{\tau_{fl}} = 1}$

63. When bundle of conductors are used in place of single conductors the effective inductance and capacitance will, respectively

(a) Increase and decrease

(b) Decrease and increase

(c) Decrease and remain unaffected

(d) Increase and remain unaffected

Ans. (b)

Sol. When a bundle conductors are used in transmission line the self GMD of teh conductors is increased, so the inductance per phase of the conductor decreases.

Bundled conductors will have higher capacitance to neutral when compared to single lines.

64. A buck regulator has an input voltage of 12V and the required output voltage is 5V. What is the duty cycle of the regulator?

(a) $\frac{5}{12}$ (b) $\frac{12}{5}$

(c) $\frac{5}{2}$ (d) 6

Ans. (a)

Sol. For a buck converter with duty cycle α, the output voltage is given by

$$V_0 = \alpha V_s$$

where, $V_s = 12v$

$V_0 = 5V$

$$\therefore \quad \alpha = \frac{5}{12}$$

Directions :

Each of the next **Twenty Six (26)** items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below :

Codes :

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

(b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)

(c) Statement (I) is true; but Statement (II) is false.

(d) Statement (I) is false; but Statement (II) is true.

65. **Statement (I) :** An electrolytic capacitor consists of two electrodes immersed in an electrolyte with a chemical film on one of the electrodes acting as the dielectric.

Statement (II) : The electrolytic capacitor may be operated with any one of the electrodes as anode positive with respect to the other.

Ans. **(c)**

Sol. Statement 1 is true $\rightarrow$ Anode electrode has an etched surface and a this film of dielectric (usually aluminium oxide) acts as dielectric for the capacitor.

Statement 2 is wrong $\rightarrow$ Only the surface with the dielectric can be used as anode.

66. **Statement (I) :** Two ideal current sources with currents I_1 and I_2 cannot be connected in series.

Statement (II) : Superposition Theorem cannot be applied to current sources when one terminal of each of these sources is connected to a common node.

Ans. **(b)**

Sol.

- Statement (I) is correct : Two ideal current sources with unequal current values can't be connected in series as two different currents can't flow in the same conductor at the same time.

- Statement (II) is correct : If two sources have a terminal of each connected to a common node then opening one source will open-circuit the other source too and hence superposition theorem can't be applied.

Statement (II) is not the correct explanation of statement (I).

67. **Statement (I) :** Both Coupling capacitance and Emitter bypass capacitance affect the low frequency response of an R-C-coupled amplifier.

Statement (II) : Both Stray capacitances and Emitter-to-base diffusion capacitance have a profound effect on the low frequency response of an R-C-coupled amplifer.

Ans. **(c)**

Sol. Stray capactiance and emitter-to-base diffusion capacitance will effect at high frequency response. So, statement (II) is wrong.

68. **Statement (I) :** A 'bedding' is provided over to the metallic sheath in an underground cable.

Statement (II) : The bedding protects the metallic sheath against corrosion.

Ans. **(c)**

Sol.

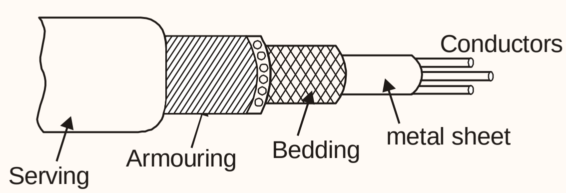


Fig: Cable Cross sectional view

Bedding in provided over to the metalic sheet in and an underground cable. Hence statement-I is true.

The purpose of bedding is to protect the sheath from mechanical injury due to armouring. You can think a shock absorber and hence statement-I is false.

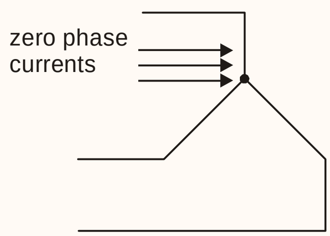
Hence statement-I is true and statement-II is false.

69. **Statement (I) :** Zero-sequence currents are, by definition, in phase with each other in the three windings of any three-phase apparatus.

Statement (II) : They may be caused by magnetic saturation in the transformers.

Ans. **(b)**

Sol. Zero-sequence currents are in phase which each other in any three phase system.



They are present in the transformers due to magnetic saturation and they may shift the neutral point in the transformer called floating neutral.

Hence. both the statements are true individually.

70. **Statement (I) :** 'High resistance' method is used for arc extinction in DC circuit breakers.

Statement (II) : Very little energy is dissipated in the arc in high resistance method of arc extinction.

Ans. **(c)**

Sol. High resistance method is used in dc circuit breakers and low capacity ac circuit breakers because heat dissipation is very large.

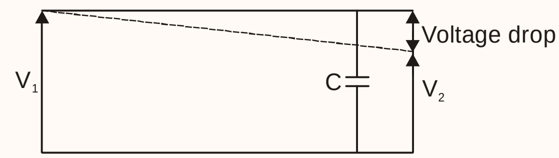
Hence statement-I is true but statement-II is false.

71. **Statement (I) :** A radial main system, circuit experiences a low voltage at the far end under heavy load conditions.

Statement (II) : The voltage at the far end under heavy loading can be corrected by connecting a shunt capacitor compensator there.

Ans. **(b)**

Sol. A radial main system circuit experiences a low voltage at the far end due to voltage drop in the line. Hence statement-I is true.



the voltage at the far end under heavy loading can be corrected by connecting a shunt capacitor hence statement-II is true.

Hence both statement-I and statement-II are individually true.

72. **Statement (I) :** In an HVDC system, the steady-state power transfer from a generator to the infinite bus is dependent on the power angle and the line impedance intervening between them.

Statement (II) : In an HVDC system, the power transfer between the two stations connected by a dc link is much larger than that in a corresponding EHV ac system.

Ans. **(d)**

Sol. In a HVDC system, the concept of power angle (δ) does not come into picture as there is no concept of stability in HVDC system and statement-I is false.

The amount of power transfer between the two stations connected by a dc link is much larger than that of EHV AC system because there are only two lines in DC compared to three lines EHV AC where losses are more in AC system. Hence statement-II is true.

73. **Statement (I) :** Conventional diode rectifier circuits have low frequency harmonics.

Statement (II) : Passive techniques used to reduce the current THD in conventional rectifiers require large transformers and/or reactors.

Ans. (b)

Sol. Conventional diode rectifiers have low frequency harmonics, due to switching action of diodes.

Passive techniques, using filters require large values of reactors and transformers.

74. **Statement (I) :** Resonant inverters are used as electronic ballasts for gas discharge lamps, induction heating, etc.

Statement (II) : A DC to high frequency AC resonant inverter may be obtained by applying the square wave voltage obtained from a DC source and switch network operating at frequency f_s to a tuned tank circuit designed for frequency f_o, so as to obtain variable magnitudes of v(t) and i(t) by matching f_s with f_o.

Ans. (a)

Sol. Statement I is true $\rightarrow$ This type of inverter produces an approximately sinusoidal waveform at a high output frequency ranging from 20 kHz to 100 MHz and is commonly used for induction heating, sonar transmitters, fluoroscent lightining etc.

Statement 2 is true

Statement (2) is correct explanation of statement (1) as due to high frequency, the size of the resonating components is small.

75. **Statement (I) :** In linear commutation, the magnitude of the current in the coils under each pole in a DC generator on a given load remains constant.

Statement (II) : The magnitude of the emfs induced in the coils under each pole of a DC generator on load remains constant.

Ans. (a)

76. **Statement (I) :** A very efficient method of speed control of an induction motor is to vary both V and f in such a way that $\frac{V}{f}$ ratio remains constant.

Statement (II) : Keeping $\frac{V}{f}$ constant allows the magnetic flux to remain constant and a reduced V reduces the inrush of starting current.

Ans. (a)

Sol. Since, induced emf

$$E = Kf\phi T$$

$$\therefore \quad \phi \alpha \frac{E}{f} \text{ or } \phi \propto \frac{V}{f}$$

if ratio $\frac{V}{f}$ is kept constant ϕ remains constant.

So in $\frac{V}{f}$ method of speed control, flux in air gap remains constant.

This method can be used to start IM at lower voltage to avoid large inrush current without affecting the air gap flux.

77. **Statement (I) :** Windings of most power transformers are immersed in a tank of oil.

Statement (II) : Convection currents in the insulating oil help carry the heat away from the windings and the core.

Ans. (a)

78. **Statement (I) :** A large gate pulse is required to turn on a GTO thyristor.

Statement (II) : This thyristor does not need a commutation circuit.

Ans. (b)

Sol.

Statement (I) is true $\rightarrow$ GTO has a higher value of holding current and hence, a larger gate pulse is required.

Statement (2) is true $\rightarrow$ GTO can be turned of by applying a negative gate pulse and hence a separate commutation circuit is not required.

But, statement (2) is not the correct explanation of statement (1).

79. **Statement (I) :** The decimal-to-BCD encoder digital logic circuit chip IC 74147, is a priority encoder.

Statement (II) : In this circuit, priority is given to the lowest-order input.

Ans. (c)

Sol.

The decimal to BCD encoder digital logic circuit chip IC 74147 is a priority encoder. Statement I is correct.

In priority encoder, priority is given to highest order input. Hence statement II is wrong.

80. **Statement (I) :** Analog to digital conversion is essentially a sampling process.

Statement (II) : A hold element is digital to analog converter.

Ans. (d)

Sol. In sampling process, continous time signal is converted to discrete time signal. In an analog to digital converter, sampling is followed by quantization. So, analog to digital conversion process consists of sampling followed by quantization. So, it is wrong to say that analog to digital converter is essentially a sampling process.

Reconstruction of a signal from its samples is done by using interpolation. There can be two type of interpolation–

1. Zero order hold interpolation
2. First order hold interpolation.

The process of interpolation converts an analog signal to a digital signal. So, we can say that hold element can be used as digital to analog converter.

81. **Statement (I) :** High-level programming languages preferred by the scientific community as they are user friendly.

Statement (II) : High level programming languages provide ways of detailing instruction for problem-solving that are translated into low-level language via compilers and interpreters before being executed by the computer.

Ans. (a)

Sol. High level programming language such as C, C++ is user friendly and it translated into low level language via compilers and interpreters before being executed by the computer.

82. **Statement (I) :** The conductivity of an intrinsic semi-conductor increases exponentially with temperature.

Statement (II) : As the temperature rises, more and more covalent bonds are broken resulting in more electron hole pairs.

Ans. (a)

Sol. The relation between temperature and concentrative of charge carriers in a pure (or) intrinsic semiconductor is gives as

$$n_{01}^2 = A_0 T^3 e^{\frac{-E_{GO}}{kT}}$$

from the equation it is clear that charge carriers in semiconductor exponeutially increases very rapidly with increase of temperature hence the conductivity increases exponeutially.

As the temperature increases more covalent bonds are broken and more electron hole pairs are generated. The increase in the numbers of free electrons and holes results in increases in the conductivity.

Hence statement-I and statement-II are true and statement-II is correct explanation of statement-I.

83. **Statement (I) :** Light is capable of transferring electrons to the free-state inside a material, thus increasing the electrical conductivity of the material.

Statement (II) : The increased electrical conductivity produced by light is called photo-conductivity.

Ans. **(b)**

Sol. Light is capable of transferring electrons to the free state inside a material thus increasing the conductivity of the material. When the energy imparted to the electrons is quite large the latter may be emitted from material into the surrounding medium. This phenomenon is known as the photoemissive effect (or) photoemissivity where as the increased electrical conductivity produced by light is called photo conductive effect (or) photo conductivity.

Hence both the statement-I and II are individually true but statement-II is not the reason for statement-I.

84. **Statement (I) :** A general purpose dynamometer type wattmeter does not read accurately at low power factors.

Statement (II) : The presence of self-inductance of the pressure coil introduces an error.

Ans. **(a)**

Sol. A general purpose dynamometer type wattmeter does not read accurately at low power factors because :

1. Deflecting torque of the wattmeter is small at low power factor.

$T_d \propto VI\cos\phi$

$T_d \propto \cos\phi$

2. At lower power factor, error due to presence of inductance of the pressure coil becomes high.

Error = $\tan\phi.\tan\beta$

At low power factor, $\cos\phi$ is low

$\Rightarrow \phi$ is large

$\Rightarrow \tan\phi$ is high

So, error is large.

Sol. Secondary emission is a phenomenon where prmiary incident particles of sufficient energy when bitting a surface (or) passing through some material, induce the emission of secondary particles. The term often refers to the emission of electrons when charged particles like electrons (or) ions in a vaccum tube strike a metal surface there are called secondary electrons. Hence statement-I is true.

The secondary emission is used in pentodes for voltage amplification and statement-II is true.

Hence both statement-I and statement-Ii are individually true.

85. **Statement (I) :** A dynamometer type wattmeter has a linear scale while a dynamometer type voltmeter has a non-linear scale.

Statement (II) : Deflecting torque developed in a dynamometer type wattmeter is proportional to the power and that developed in a dynamometer type ammeter is proportional to the square of the current.

Ans. (a)

Sol. **Dynamometer type Wattmeter**

Deflecting torque,

$$T_d \propto P.\frac{dM}{d\theta}$$

where, P is the power measured.

i.e. by making the mutual inductance between fixed coil and moving coil vary linearly, the scale of dynamometer type wattmeter can be linear. By suitable design, mutual inductance is made vary linearly over an angle range of 40° to 50° on either side of zero mutual inductance position. Hence, the scale can be made uniform over 80° to 100° keeping position of zero mutual inductance at the midscale.

Dynamometer type Voltmeter/Ameter

Deflecting torque,

$$T_d = I^2\frac{dM}{d\theta} = \frac{V^2}{Z^2}.\frac{dM}{d\theta}$$

Although, keeping $\frac{dM}{d\theta}$ = constant, i.e. M varies with θ linearly, deflecting torque is directly proportional to the square of current. So, the scale in dynamometer type ammeter or voltmeter is non-linear.

86. **Statement (I) :** The rotating disc in an energy meter is made of a magnetic material.

Statement (II) : Braking takes place due to eddy current generated by the braking magnet.

Ans. (d)

Sol.
- The rotating disc in an energy meter is made of a non-magnetic materials. e.g. Aluminium, copper etc. For making disc, Aluminium is preferred over copper as resistance per unit weight of Aluminium is smaller than copper.
- For braking torque, a permanent magnet called braking magnet is used to induce eddy currents in some part of disc. These eddy current produces a braking torque which is proportional to the speed of rotating disc.

Braking torque, $T_B = k\phi\, ir$

where, k = constant

ϕ = flux of the permanene magnet

i = eddy current

r = resistance of eddy current path

So, statement (I) is incorrect and statement (II) is correct

87. **Statement (I) :** When a solid surface is bombarded by electrons of appreciable energy, secondary emission occurs from the surface.

Statement (II) : The major application of the secondary emission is in voltage amplification.

Ans. (b)

88. **Statement (I) :** Electromagnetic flow meter is preferred for flow velocity measurement of slurries in pipes as long as the slurry has adequate electrical conductivity.

Statement (II) : Electromagnetic flow meter does not insert any instrument parts into the body of the fluid flow to cause obstruction as in most of other flowmeters.

Ans. (a)

Sol.

- Electromagnetic flow meter is preferred for flow velocity measurement of slurries, sludge, or, only electrically conducting liquid.
- In electromagnetic flow meter, a pair of insulated electrodes buried flush in the

opposite sides of an non-conducting, non-magnetic pipe carrying the liquid whose flow is to be measured. The pipe is surrounded by an electromagnet which produces a magnetic field.

- Electromagnetic flow meter has an advantage over other types of flow meter as it does not insert any instrument parts into the body of the fluid flow to cause obstruction.

i.e. Statement (I) is correct and Statement (II) is correct explanation of Statement (I).

89. **Statement (I) :** Direct access method is based on a disk model of a file.

Statement (II) : Disks allow random access to any file block.

Ans. **(a)**

Sol. Direct file organization is used where file has to access randomly. When a process has to access a particular record from the disk then access method module of direct file organization calculate the address of the record.

90. **Statement (I) :** Variables that are defined inside subprograms are local variables.

Statement (II) : Their scope is in the body of the subprogram in which they are defined.

Ans. **(a)**

Sol. Local varibles are defined in the subprogram which is not accessable outside of the subprogram.

91. Consider the following statements for a network graph, if B_f is its fundamental tie set matrix, and B_t and B_l are its sub-matrices corresponding to twigs and links, respectively:

1. B_t is a unit matrix
2. B_l is a rectangular matrix
3. Rank of B_f is $(b - n - 1)$

where b is the number of branches and n is the number of nodes.

Which of the above statements are correct?

(a) 1 and 2 only

(b) 1 and 3 only

(c) 2 and 3 only

(d) None of the above

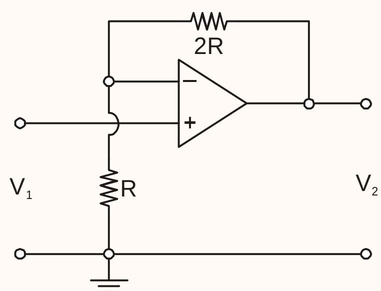
Ans. **(c)**

Sol.
- Statement 1 is wrong $\rightarrow$ sub-matrix is not a unit matrix.
- Statement 2 is correct $\rightarrow$ sub-matrix is a rectangular matrix.
- Statement 3 is correct $\rightarrow$ rank of the fundamental tie-set is (b–n–1)

where, b = number of branches

n = number of nodes.

92.



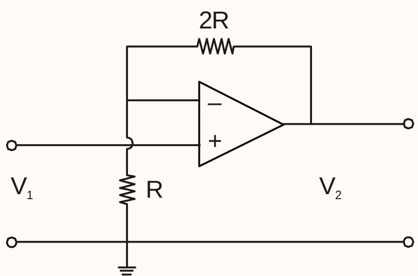
An ideal operational amplifier is connected as shown in figure. What is the output voltage V_2?

(a) $3V_1$ (b) $2V_1$

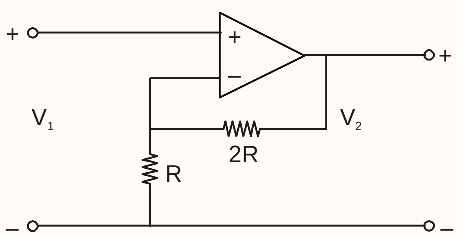
(c) $1V_1$ (d) $\frac{V_1}{3}$

Ans. (a)

Sol.



This can be re-drawn as



by virtual node concept the voltage at –ve terminal is v_1

Applying nodal analysis at v_1 we get

$$\frac{v_1}{R}+\frac{v_1-v_2}{2R} = 0$$

$$\frac{v_1}{R}+\frac{v_1}{2R} = \frac{v_2}{2R}$$

$$v_1\left(\frac{1}{R}+\frac{1}{2R}\right) = \frac{v_2}{2R}$$

$$v_1\left(\frac{2+1}{2R}\right) = \frac{v_2}{2R}$$

$$\frac{3v_1}{2R} = \frac{v_2}{2R}$$

$$\boxed{v_2 = 3v_1}$$

93. The modulating index of an AM-signal is reduced from 0.8 to 0.5. The ratio of the total power in the new modulated signal to that of the original signal will nearly be

(a) 0.39 (b) 0.63

(c) 0.85 (d) 1.25

Ans. (c)

Sol. Detail Solution

Total power in modulated signal

$$P_T = A_C\left(1+\frac{\mu^2}{2}\right)$$

For μ = 0.8 $P_1 = A_c\left(1+\left(\frac{0.8}{2}\right)^2\right) \to$ original

modulated signal

For μ = 0.5 $P_2 = A_c\left(1+\left(\frac{0.5}{2}\right)^2\right) \to$ New

modulated signal

$$\boxed{\frac{P_2}{P_1}=\frac{2+(0.5)^2}{2+(0.8)^2}=0.85}$$

94. The Truth table for the function f(ABCD) = $\Sigma m(0,1,3,4,8,9)$ is

A	B	C	f
0	0	0	W
0	0	1	X
0	1	0	Y
0	1	1	0
1	0	0	Z
1	0	1	0
1	1	0	0
1	1	1	0

where W, X, Y, Z are given by (d is the complement of D)

(a) D, d, 1, 1 (b) 1, d, D, 1

(c) 1, 1, D, d (d) 1, D, d, 1

Ans. (d)

Sol.

The function 'f' may be obtained when we use an 8 × 1 MUX, with using A, B, C as select lines.

If A is MSB, and C is LSB, then

	$\bar{A}\bar{B}\bar{C}$	$\bar{A}\bar{B}C$	$\bar{A}B\bar{C}$	$\bar{A}BC$	$A\bar{B}\bar{C}$	$A\bar{B}C$	$AB\bar{C}$	ABC
$\bar{D}$	$\boxed{0}$	2	$\boxed{4}$	6	$\boxed{8}$	10	12	14
D	$\boxed{1}$	$\boxed{3}$	5	7	$\boxed{9}$	11	13	15
	1	D	$\bar{D}$	0	1	0	0	0

So, we can write that,

$$W = 1$$

$$X = D$$

$$Y = \bar{D} \text{ (or d)}$$

$$Z = 1$$

95. An 8-bit DAC uses a ladder network. The full-scale output voltage of the converter is +10V. The resolution expressed in percentage and in volts is, respectively

(a) 0.25% and 30 mV

(b) 0.39% and 30 mV

(c) 0.25% and 39 mV

(d) 0.39% and 39 mV

Ans. (d)

Sol.

Number of bits of DAC (n) = 8

Percentage resolution of DAC is given by

$$\% \text{ Resolution} = \left(\frac{100}{2^n - 1}\right)$$

$$= 0.392\%$$

$$\text{Resolution in volts} = \frac{\text{Full scale output}}{2^n - 1}$$

$$= 0.039 \text{ V}$$

$$= 39 \text{ mV}$$

96. Consider the following statements :

1. Flash type ADCs are considered the fastest

2. In successive approximation type ADCs, conversion time depends upon the magnitude of the analog voltage

3. Counter-type ADCs work with fixed conversion time

4. Dual slope ADCs are considered the slowest

Which of the above statements are correct?

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

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

Ans. (c)

Sol.

- The flash type ADC_s are considered fastest, as the time taken for conversion of analog quality to digital quantity only depends on the delays of comparator and encoders, which are generally negligible.
- For a n-bit successive approximation type ADC,

$$t_{conversion} = n.T_{clk}$$

where, T_{clk} = clock period

The conversion time is independent of magnitude of analog voltage

- The conversion time of counter type ADC is given by,

$$t_{conversion} = T_{clk} \text{ (decimal equivalent of digital output)}$$

So, the conversion time of counter type ADC is not fixed.

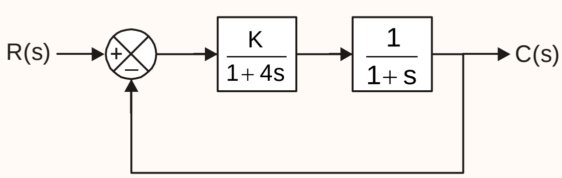
- For Daul slope ADC, conversion time,

$$t_{conversion} = (2^n + m) \cdot T_{clk}$$

Where, $m = 2^n \cdot \left(\frac{V_{analog}}{V_{ref.}}\right)$

So, the dual slope ADC are the slowest ADC.

97.



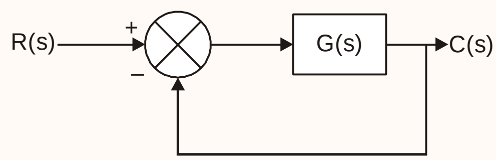
For the feedback control system shown, if the steady state error is 20% for the unit step input signal, then the value of K must be

(a) 80 (b) 40

(c) 20 (d) 4

Ans. (d)

Sol. The given control can be simplified to



where, $G(s) = \dfrac{K}{(1+s)(1+4s)}$

steady state error is given by

$$e_{ss} = \lim_{s\to 0} \frac{sR(s)}{1+G(s)H(s)}$$

For unity feedback system, H(s) = 0

and for unit step input, $R(s) = \dfrac{1}{s}$

$$e_{ss} = \lim_{s\to 0} \frac{s \times \frac{1}{s}}{1+\frac{K}{(1+s)(1+4s)}}$$

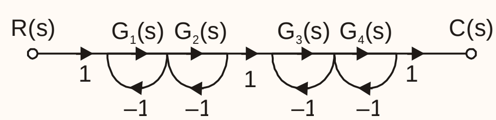
or $e_{ss} = \dfrac{1}{1+\frac{K}{1}} = \dfrac{1}{1+K}$

e_{ss} = 20% = 0.2 (given)

$$\therefore \frac{1}{1+K} = 0.2$$

$$\boxed{K = 4}$$

98.



The closed-loop transfer function $\frac{C(s)}{R(s)}$ of the system represented by the signal flow graph as shown in figure is

(a) $\frac{G_1G_2G_3G_4}{(1+G_1+G_2)}$

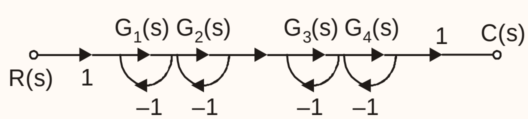
(b) $\frac{G_1G_2G_3G_4}{(1+G_3+G_4)}$

(c) $\frac{G_1G_2G_3G_4}{(1+G_1+G_2)(1+G_3+G_4)}$

(d) $\frac{G_1G_2G_3G_4}{(1+G_1G_2)(1+G_3G_4)}$

Ans. (c)

Sol.



By mason gain formula

Transfer function,

$$\frac{C(s)}{R(s)} = \frac{\Sigma P_K \Delta_K}{\Delta}$$

where, P_K = path gain of K^{th} forward path

Δ = 1 – [sum of loop gains of all individual loops] + [sum of gain products of two non-touching loops] – [sum of gain products of 3 non touching loops] + ...

Δ_K = Value of Δ obtained by removing all the loops touching K^{th} forward path

Therefore,

$P_K = G_1G_2G_3G_4$

$\Delta = 1\ (-G_1 - G_2 - G_3 - G_4) + (G_1G_3 + G_1G_4 + G_2G_3 + G_2G_4)$

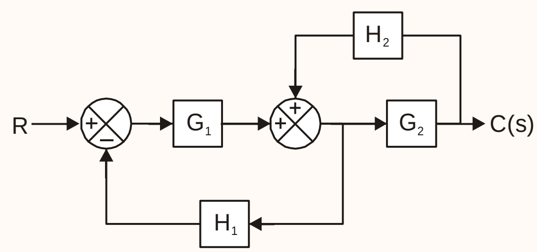
$\Rightarrow\ 1 + G_1 + G_2 + G_3 - G_4 + G_1G_3 + G_1G_2 + G_2G_3 + G_2G_4$

$\Delta_1 = 1$

$$\therefore\ \frac{C(s)}{R(s)} = \frac{G_1G_2G_3G_4}{(1+G_1+G_2+G_3+G_4+G_1G_2+G_1G_3+G_2G_3+G_2G_4)}$$

$$= \frac{G_1G_2G_3G_4}{(1+G_1+G_2)(1+G_3+G_4)}$$

99.



For the block diagram as shown in figure, the overall transfer function $\frac{C}{R}$ is

(a) $\frac{G_1G_2H_1}{(1-G_1H_1-G_2H_2)}$

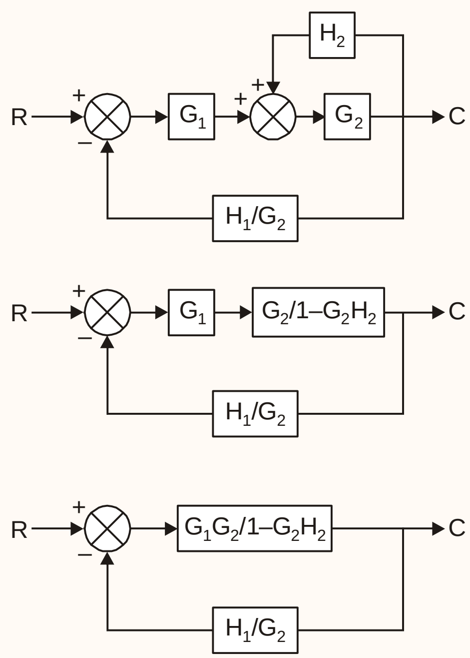
(b) $\frac{G_1G_2}{(1-G_1H_1+G_2H_2)}$

(c) $\frac{G_1G_2H_2}{(1+G_1H_1+G_2H_2)}$

(d) $\dfrac{G_1G_2}{(1+G_1H_1-G_2H_2)}$

Ans. **(d)**

Sol. By block diagram rduction method,

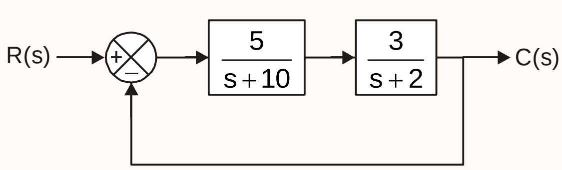


$$\therefore \quad \frac{C}{R}=\frac{\left(\dfrac{G_1G_2}{1-G_2H_2}\right)}{1+\left(\dfrac{G_1G_2}{1-G_2H_2}\right)\left(\dfrac{H_1}{G_2}\right)}$$

or $\boxed{\dfrac{C}{R}=\dfrac{G_1G_2}{1-G_2H_2+G_1H_1}}$

Hence option ‘d’ is correct.

100.



The block diagram shows a unity feedback closed-loop system. The steady state error in the response to a unit step input is

(a) 14% (b) 28%

(c) 42% (d) 57%

Ans. **(d)**

Sol. For given block diagram

$$G(s)=\left(\frac{5}{s+10}\right)\left(\frac{3}{s+2}\right)=\frac{15}{(s+2)(s+10)}$$

H(s) = 1 for unity feedback system

Steady state error

$$e_{ss}=\lim_{s\to 0}\frac{sR(s)}{1+G(s)H(s)}$$

For unity step input, $R(s)=\dfrac{1}{s}$

$$\therefore \quad e_{ss}=\lim_{s\to 0}\frac{s\times\dfrac{1}{s}}{1+\dfrac{15}{(s+2)(s+10)}\times 1}$$

$$=\frac{1}{1+\dfrac{15}{2\times 10}}=\frac{20}{35}=0.5714$$

or $\boxed{e_{ss}=57.14\%}$

Hence, option ‘d’ is correct.

101. The open-loop transfer function of a negative feedback is

$$G(s)H(s) = \frac{K}{s(s+5)(s+12)}$$

For ensuring system stability the gain K should be in the range

(a) $0 < K < 60$ (b) $0 < K < 600$
(c) $0 < K < 1020$ (d) $K > 1020$

Ans. **(c)**

Sol. Open loop transfer function

$$G(s)H(s) = \frac{K}{s(s+5)(s+12)}$$

Characteristics equation is given by

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

$$1+\frac{K}{s(s+5)(s+12)} = 0$$

or $s^3 + 17s^2 + 60s + K = 0$

Now, by routh hurwitz method

s^3	1	60
s^2	17	K
s^1	$\frac{17 \times 60 - K}{17}$	
s^0	K	

For stability

$$\frac{17\times 60 - K}{17} > 0 \text{ and } K > 0$$

or $K < 17 \times 60$ or $K < 1020$

Thus, for stability,

$$\boxed{0 < K < 1020}$$

102. The characteristic polynomial of a feedback control system is given by

$R(s) = s^5 + 2s^4 + 2s^3 + 4s^2 + 11s + 10$

For this system, the numbers of roots that lie in the left hand and right hand s-plane respectively, are

(a) 5 and 0 (b) 4 and 1
(c) 3 and 2 (d) 2 and 3

Ans. **(c)**

Sol. Characteristics equation

$$R(s) = s^5 + 2s^4 + 2s^3 + 4s^2 + 11s + 10$$

By Routh Hurwitz Method

s^5	1	2	11
s^4	2	4	10
s^3	$0 \approx \in$	6	
s^2	$\frac{4\in -12}{\in}$	10	
s^1	$\frac{\frac{6(4\in -12)}{\in} - 10\in}{\left(\frac{4\in -12}{\in}\right)}$		
s^0	10		

$\in$ is very small positive number.

To check the number of sign changes.

$\lim\limits_{\in\to 0^+} \frac{4\in -12}{\in}$ will be a negative number

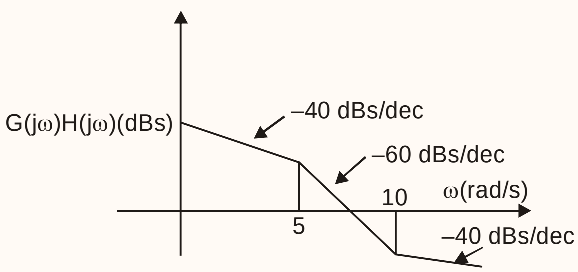
$\lim\limits_{\in\to 0^+} \frac{\frac{6(4\in -12)}{\in} - 10\in}{\left(\frac{4\in -12}{\in}\right)}$ will be a positive number

Thus number of sign changes is 2.

$$\in(+)$$
$\downarrow$ ⟶ 1 sign change
$$\frac{4\in-12}{\in}(-1)$$
$\downarrow$ ⟶ 1 sign change
$$\frac{\frac{6(4\in-12)}{\in}-10\in}{\left(\frac{4\in-12}{\in}\right)}(+)$$

Therefore 2 roots will lie in RHS of s-plane so, correct option is (c).

103.



The open loop transfer function G(s)H(s) of a Bode's plot for feedback system as shown in figure is

(a) $\dfrac{K(s+5)}{s^2(s+10)}$ (b) $\dfrac{K(s+5)}{s(s+10)}$

(c) $\dfrac{K(s+10)}{s^2(s+5)}$ (d) $\dfrac{K(s+10)}{s(s+5)}$

Ans. (c)

Sol. From the bode plot:

Initial slope = –40dB/dec

$\therefore$ 2 ploes at s = 0 $\Rightarrow \dfrac{1}{s^2}$

At corner frequency of $\omega=5$, slope further increases by –20 db/dec

$\therefore$ Pole at s = 5 $\Rightarrow \dfrac{1}{\left(1+\frac{s}{5}\right)}$

At corner frequency of $\omega=10$, slope of 20 db/dec is added

$\therefore$ Zero at s = 10 $\Rightarrow \left(1+\frac{s}{10}\right)$

$$\text{T.F.} = G(s)\ H(s) = \frac{K'\left(1+\frac{s}{10}\right)}{s^2\left(1+\frac{s}{5}\right)}$$

$$= \frac{K(s+10)}{s^2(s+5)}$$

104. A system with characteristic equation

$s^4 + 2s^3 + 11s^2 + 18s + 18 = 0$,

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) All poles lie in the right half of the s-plane

(c) Two poles lie symmetrically on the imaginary axis of the s-plane

(d) All four poles lie on the imaginary axis of the s-plane

Ans. (c)

Sol. Given characteristic equation

$s^4 + 2s^3 + 11s^2 + 18s + 18 = 0$

By Routh Hurwitz stability criteria

s^4	1	11	18
s^3	2	18	
s^2	2	18	
s^1	0	0	$\leftarrow$ Complete row is zero

So by auxiliary equation,

$2s^2 + 18 = 0$

$$\frac{d}{ds}\left(2s^2 + 18\right) = 4s$$

s^4	1	11	18
s^3	2	18	0
s^2	2	18	0
s^1	4	0	0
s^0	18	0	0

On solving auxiliary equation

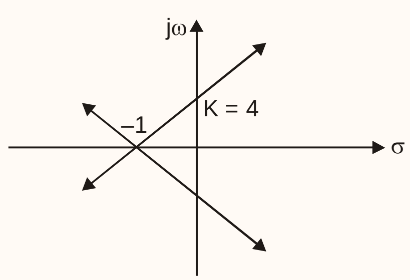
$2s^2 + 18 = 0$

or $s^2 = -9$

$$\boxed{s = \pm j3}$$

Hence, two poles are symmetrically placed on imaginary axis.

105.



The open-loop transfer function G(s)H(s) of a root locus plot of a system as shown in figure is

(a) $\dfrac{4}{(s+1)^1}$ (b) $\dfrac{4}{(s+1)^2}$

(c) $\dfrac{4}{(s+1)^3}$ (d) $\dfrac{4}{(s+1)^4}$

Ans. (d)

Sol. In given root locus plot, there are four branches of root locus emanating from s = –1 and ending at infinity.

Hence, four poles at s = –1

$$\therefore \; G(s)\,H(s) = \frac{k}{(s+1)^4}$$

To find out the point on imaginary axis, where root locus cuts it; characteristic equation

$(s + 1)^4 + k = 0$

or $s^4 + 4s^3 + 6s^2 + 4s + 1 + k = 0$

By Routh Hurtwitz criteria

s^4	1	6	$1+k$
s^3	4	4	
s^2	5	$1+k$	
s^1	$\frac{16-4k}{5}$		
s^0	$1+k$		

For critical stability condition

$$\frac{16-4k}{5} = 0 \quad \text{or } k = 4$$

Now, auxiliary equation

$5s^2 + 5 = 0$

or $s = \pm j1$

$\therefore$ the root locus meet imaginary axis at

$s = \pm j1$

By the property of root locus

$|G(s)\ H(s)| = 1$

$$\therefore \left|\frac{k}{(s+1)^4}\right|_{s=\pm j1} = 1$$

or $k = 4$

106. The transfer function of a compensator is $\frac{(1+3sT)}{(1+sT)}$. The maximum possible phase shift is

(a) 30° (b) 45°

(c) 60° (d) 90°

Ans. **(a)**

Sol. Transfer function; TF = $\frac{1+3sT}{1+sT}$

For maximum phase shift

$$\omega_m = \sqrt{\frac{1}{3T}\times\frac{1}{T}} = \frac{1}{T\sqrt{3}} + \frac{1}{T\sqrt{\alpha}}$$

at $\omega = \omega_m = \frac{1}{T\sqrt{\alpha}}, \phi = \phi_m$

$$\tan\phi = \frac{3\omega T - \omega T}{1+(3\omega T)(\omega T)} = \frac{2\omega T}{1+3\omega^2 T^2}$$

at $\omega = \omega_m = \frac{1}{T\sqrt{3}}$

$$\tan\phi_m = \frac{2\times\frac{1}{T\sqrt{3}}\times T}{1+3\frac{1}{T^2\times 3}\times T^2} = \frac{1}{\sqrt{3}}$$

$$\therefore \phi_m = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

or $\boxed{\phi_m = 30°}$

107. The steady state response c(t) for an input r(t) = sin 2t to a system transfer function $\frac{1}{s+4}$ is

(a) 0.25 sin 2t

(b) sin (2t – 45°)

(c) 0.316 sin(2t – 26.5°)

(d) 0.632 cos 2t

Ans. **(None)**

Sol. r(t) = sin2t

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

$$H(w_0) = \left(\frac{1}{jw_0+4}\right)$$

The output c(t) of an LTI system with impulse response H(s), to an input r(t) = $\sin w_0 t$ is

$$C(t) = |H(w_0)|\cdot\sin\left(w_0 t + \underline{|H(w_0)}\right)$$

Here, $w_0 = 2$

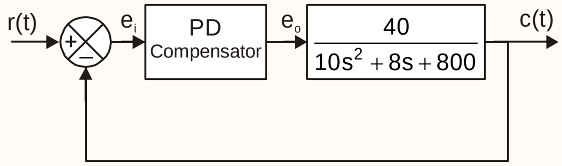
$$|H(w_0)| = \frac{1}{\sqrt{w_0^2+4^2}} = \frac{1}{\sqrt{2^2+4^2}} = 0.223$$

$$\underline{|H(w_0)} = -\tan^{-1}\left(\frac{w_0}{4}\right) = -\tan^{-1}\left(\frac{1}{2}\right)$$

= –26.56°

$$\boxed{C(t) = 0.22\sin(2t-26.5)}$$

108.



Compensation derived from the P-D network whose differential equation is governed by $e_o = 20\left(e_i + T\frac{de_i}{dt}\right)$ as shown in the figure is to be investigated. For what value of T will be closed-loop response be critically damped?

(a) 1.612
(b) 0.806
(c) 0.306
(d) 0.161

Ans. **(c)**

Sol.

The transfer function of P-D network,

$$\frac{E_0(s)}{E_i(s)} = 20(1 + sT)$$

The characteristic equation of the given system is

$$CE : \frac{1+20(1+sT)(40)}{10s^2+8s+800} = 0$$

$10s^2 + 8s + 800 + 800 + 800sT = 0$

$10s^2 + s(8 + 800\,T) + 1600 = 0$

Comparing with standard equation

$$\omega_n = \sqrt{\frac{1600}{10}} = 12.65 \text{ rad/sec}$$

$$\xi = \left(\frac{8+800T}{2\times10\times12.65}\right)$$

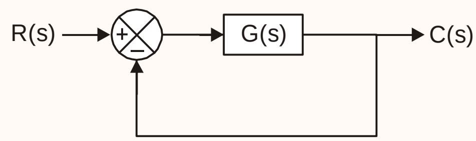
For critically damped system,

$\xi = 1$

$8 + 800\,T = 253$

$\boxed{T = 0.306}$

109.



The unity feedback system as shown in the figure is characterized by $G(s) = \frac{1}{(s+1)^2}$. The output time response will have a damping factor ζ, and natural frequency ω_n, respectively, as

(a) 0.707 and 1
(b) 0.866 and $\sqrt{2}$
(c) 0.707 and $\sqrt{2}$
(d) 0.866 and 1

Ans. **(c)**

Sol. For given unity feedback system

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

Characteristic equation is

$1 + G(s)\,H(s) = 0$

$$1+\frac{1}{(s+1)^2} = 0$$

or $(s + 1)^2 + 1 = 0 = s^2 + 2s + 2$

Comparing with standard equation

$$s^2 + 2\xi\omega_n s + \omega_n^2 = 0$$

$$\omega_n = \sqrt{2}$$

$$2\xi\times\left(\sqrt{2}\right) = 2$$

or $\xi = \frac{1}{\sqrt{2}} = 0.707$

110. For a state model

$X = AX$, where $A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$, the state transition matrix is

(a) $\begin{bmatrix} te^{-t} & 0 \\ e^t & e^t \end{bmatrix}$ (b) $\begin{bmatrix} 0 & t \\ e^t & te^t \end{bmatrix}$

(c) $\begin{bmatrix} e^t & 0 \\ te^t & e^t \end{bmatrix}$ (d) $\begin{bmatrix} t & 0 \\ t^2 & e^t \end{bmatrix}$

Ans. **(c)**

Sol. Given,

$$A = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$$

The state transition matrix is given by

$$\phi(t) = L^{-1}[sI - A]^{-1}$$

$$[sI - A] = \begin{bmatrix} s-1 & 0 \\ -1 & s-1 \end{bmatrix}$$

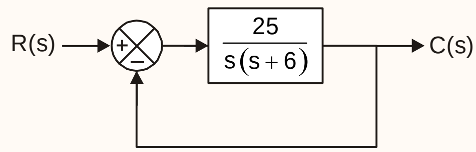
$$[sI - A]^{-1} = \frac{1}{|sI - A|} \text{Adj}[sI - A]$$

$$= \frac{1}{(s-1)^2}\begin{bmatrix} s-1 & 0 \\ 1 & s-1 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{1}{s-1} & 0 \\ \frac{1}{(s-1)^2} & \frac{1}{s-1} \end{bmatrix}$$

$$L^{-1}[sI - A]^{-1} = \begin{bmatrix} e^t & 0 \\ te^t & e^t \end{bmatrix}$$

111.



A unit step input to a unity feedback system is shown in the figure, the time for peak overshoot is, nearly

(a) 0.35 s (b) 0.58 s

(c) 0.79 s (d) 0.96 s

Ans. **(c)**

Sol. The characteristic equation

$s(s + 6) + 25 = 0$

$s^2 + 6s + 25 = 0$

Hence,

$$\omega_n^2 = 25 \text{ or } \omega_n = 5$$

$$2\xi w_n s = 6s$$

$$\therefore \xi = \frac{6}{2 \times 5} = 0.6$$

Peak overshoot time, $t_p = \frac{\pi}{\omega_d}$

where $\omega_d = \omega_n\sqrt{1-\xi^2} = 5\sqrt{1-0.6^2} = 4$

$$t_p = \frac{\pi}{4} = 0.785 \text{ sec}$$

112. The transient response of second order under damped system starting from rest is given by $c(t) = Ae^{-6t}\sin(8t + \theta),\ t \geq 0.$ The natural frequency of the system is

(a) 8 (b) 9

(c) 10 (d) 100

Ans. (c)

Sol. Given that, $C(t) = Ae^{-6t}\sin(8t+\theta)$

Underdamped response of second order system:

$$C(t) = \frac{e^{-\xi\omega_n t}}{\sqrt{1-\xi^2}}[\sin\omega_d t + \theta]$$

Hence,

$$+\xi\omega_n = 6 \quad \text{... (i)}$$

$$\omega_n\sqrt{1-\xi^2} = 8 \quad \text{... (ii)}$$

From eq. (i)

$$\xi = \frac{6}{\omega_n}$$

$$\therefore \omega_n\sqrt{1-\frac{36}{\omega_n^2}} = 8$$

$$\text{or } \omega_n^2\left(1-\frac{36}{\omega_n^2}\right) = 64$$

$$\text{or } \omega_n^2 - 36 = 64$$

$$\therefore \boxed{\omega_n = 10}$$

113. For a feedback control system all the roots of the characteristic equation can be placed at the desired location in the s-plane if and only if the system is

1. Observable
2. Controllable

Which of the above statements are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (b)

114. A second order system with a zero at –2 has its poles located at –3 + j4 and –3 – j4 in the s-plane. The undamped natural frequency and the damping factor of the system respectively are

(a) 3 rad/s and 0.80 (b) 5 rad/s and 0.80

(c) 3 rad/s and 0.60 (d) 5 rad/s and 0.60

Ans. (d)

Sol. Based on given information

$$TF = \frac{s+2}{(s+3-j4)(s+3+j4)}$$

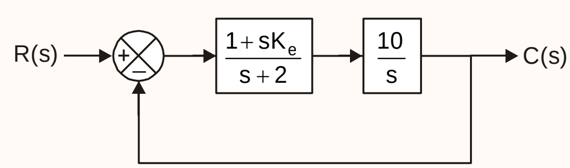
$$= \frac{s+2}{(s+3)^2-(j4)^2} = \frac{s+2}{s^2+6s+9+16}$$

$$TF = \frac{s+2}{s^2+6s+25}$$

Therefore,

$$\omega_n^2 = 25 \Rightarrow \omega_n = 5$$
$$2\xi w_n = 6 \Rightarrow 2\xi\times 5 = 6$$
$$\text{or } \xi = 0.6$$

115.



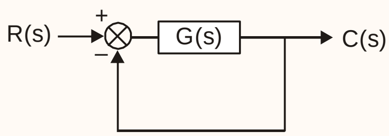
What is the error-rate factor K_e to yield a damping factor of 0.5 for the system shown in the block diagram?

(a) 0.116 (b) 0.232

(c) 0.284 (d) 0.332

Ans. (a)

Sol. The given system can be simplified to



where, $G(s) = \dfrac{(1+s\,k_e)}{s+2} \times \dfrac{10}{s}$

Closed loop transfer function

$$CLTF = \frac{10+10s\,k_e}{s(s+2)+10+10s\,k_e}$$

$$= \frac{10+10s\,k_e}{s^2+s(2+10k_e)+10}$$

Therefore, $\omega_n^2 = 10$ or $\omega_n = \sqrt{10}$

$$2\xi\omega_n = 2+10k_e$$

For $\xi = 0.5$

$$\omega \times 0.5 \times \sqrt{10} = 2+10k_e$$

$$\therefore \boxed{k_e = 0.116}$$

116. An ideal transformer is having 150 turns primary and 750 turns secondary. The primary coil is connected to a 240 V, 50 Hz source. The secondary winding supplies a load of 4A at lagging power factor of 0.8. What is the power supplied by the transformer to the load?

(a) 4200 W (b) 3840 W

(c) 2100 W (d) 1920 W

Ans. (b)

Sol. Primary turns, N_P = 150

Secondary turns, N_S = 750

Primary voltage = 240 (say V_P)

Since, $\dfrac{V_P}{V_S} = \dfrac{N_P}{N_S}$

where V_S = secondary voltage

$$\therefore\ V_S = \frac{V_P \times N_S}{N_P} = \frac{240 \times 750}{150} = 1200\text{V}$$

for load current of 4A at pf = 0.8 lagging

$$P_{output} = VI\cos\phi$$

$$= 1200 \times 4 \times 0.8 = 3840 \text{ W}$$

117. In an induction motor for a fixed speed at constant frequency

(a) Both line current and torque are proportional to voltage

(b) Both line current and torque are proportional to the square of voltage

(c) Line current is proportional to voltage and torque is proportional to the square of voltage

(d) Line current is constant and torque is proportional to voltage

Ans. (c)

Sol. In induction motor

$$I_2 = \frac{sE_{20}}{R_{20}+jsX_{20}} = s\left(\frac{Te_2}{Te_1}\right)E_1 \times \frac{1}{R_{20}+jsX_{20}}$$

$$\left(\because E_{20} = \frac{Te_2}{Te_1}E_1\right)$$

or $I_2 \propto E_1$

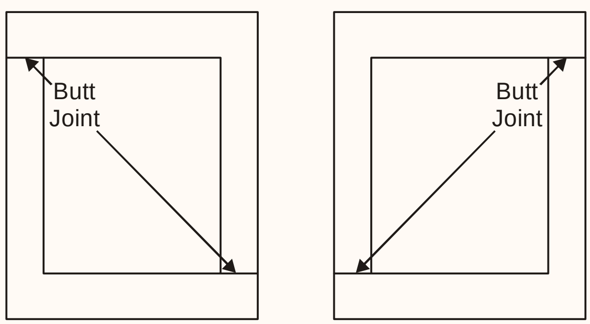
$$\tau_d = \frac{kE_1^2 sR_2}{R_2^2+s^2X_{20}^2}$$

where $K = \frac{3}{2\pi n_s}\left(\frac{Te_2}{Te_1}\right)^2$ = constant for fixed speed.

$\therefore \ \tau_d \propto E_1^2$

Note : At constant frequency, value of X remains constant.

118.



In a core-type single-phase transformer the steel-core is assembled by staggering butt-joint in adjacent layers of laminations vide figures. The purpose served is said to be

1. Avoiding continuous air-gap
2. Preventing loss of mechanical strength
3. Reducing eddy-current loss

Which of the above statement are true?

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

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

Ans. **(a)**

Sol. The staggering of butt joints avoids continuous air gap as the flux can take path from neighbouring layer at the joints.

At the same time staggering maintains mechanical strength of the core. Air gap also avoids magnetic saturation of the core.

Staggering of butt joints does not affect eddy currents. Eddy currents are reduced by laminations. Hence correct option is (a).

119. Which of the following would refer to an ideal transformer?

1. Winding-resistances are negligible
2. Leakage-fluxes are included
3. Core-losses are negligible
4. Magnetization characteristic is linear

(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. **(b)**

Sol. Ideal transformer has following properties :

1. Its primary and secondary winding resistances are negligible.
2. The core has infinite permeability (μ) so that negligible mmf is required to establish the flux in the core.
3. Its leakage flux and leakage inductances are zero. The entire flux is confined to the core and links both windings.
4. There are no losses due to resistance, hysteresis and eddy currents.Thus efficiency is 100 percent.
5. The magnetization characteristics is linear.

120. A 24-slot, 2-pole, lap-would dc machine has 18 turns per coil. The average flux density per pole is 1 Tesla. The effective length of the machine is 20 cm and the radius of the armature is 10 cm. The magnetic poles cover 80% of the armature periphery. For armature angular velocity (ω_m) of 183.2 rad/se, the induced emf in the armature winding is nearly

(a) 585 V (b) 1050 V

(c) 1260 V (d) 1465 V

Ans. (c)

Sol.

B = 1 Tesla

Total area per pole is given by

$$A_p = \frac{2\pi \times 0.2 \times 0.1 \times 0.8}{2}$$

$A_p = 0.05\ m^2$

Number of conductors z = 24 × 18 × 2 = 864

Flux per pole, $\phi = B.A_p = -0.05$ Wb

Number of parallel paths (A) = 2

ω = 183.2 rad/sec

$$N = \frac{60\omega}{2\pi} = 1750 \text{ rpm}$$

$$E = \frac{NP\phi z}{60A} = \frac{1750 \times 2 \times 0.05 \times 864}{60 \times 2}$$

$$\boxed{E = 1260\,V}$$

121. Eigen values of the Matrix

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

(a) 1, 1, 1 (b) 1, 1, 2

(c) 1, 4, 4 (d) 1, 2, 4

Ans. (c)

Sol.

$\because$ sum of eigen values = Trace (A)

$\Rightarrow \lambda_1 + \lambda_2 + \lambda_3 = 9$

Only option (c) is satisfying it

122. The solution of the differential equation

$$\frac{d^2y}{dx^2} - \frac{dy}{dx} - 2y = 3e^{2x},$$

where, y(0) = 0 and y′(0) = –2 is

(a) $y = e^{-x} - e^{2x} + xe^{2x}$

(b) $y = e^{x} - e^{-2x} - xe^{2x}$

(c) $y = e^{-x} + e^{2x} + xe^{2x}$

(d) $y = e^{x} - e^{-2x} + xe^{2x}$

Ans. (a)

Sol.

$$\frac{d^2y}{dx^2} - \frac{dy}{dx} - 2y = 3\,e^{2x}$$

$(D^2 - D - 2)y = 3\,e^{2x}$ ...(1)

AE in $m^2 - m - 2 = 0$

$\Rightarrow (m + 1)(m - 2) = 0$

$\Rightarrow m = -1$ and 2

So CF = $C_1 e^{-x} + C_2 e^{2x}$

$$\text{Now PI} = \frac{1}{f(D)}Q = \frac{1}{D^2 - D - 2}\left(3e^{2x}\right)$$

$$= 3\left[\frac{x}{2D-1}\left(e^{2x}\right)\right] = 3\left[\frac{x}{2\times 2-1}\left(e^{2x}\right)\right] = xe^{2x}$$

General solution of (1) is y = CF + PI

$$\boxed{y = C_1 e^{-x} + C_2 e^{2x} + xe^{2x}}$$

$$\frac{dy}{dx} = y' = -C_1 e^{-x} + 2C_2 e^{2x} + 2xe^{2x} + e^{2x}$$

using y(0) = 0 $\Rightarrow$ 0 = $C_1 + C_2$

using y′(0) = – 2 $\Rightarrow$ $-2 = -C_1 + 2C_2 + 0 + 1$

or $-C_1 + 2C_2 = -3$

On solving $C_2 = -1$, $C_1 = 1$

So solution of (1), $y = e^{-x} - e^{2x} + xe^{2x}$

123. If $Z = e^{ax+by} F(ax - by)$; the value of $b\cdot\frac{\partial Z}{\partial x} + a\frac{\partial Z}{\partial y}$ is

(a) 2Z (b) 2a

(c) 2b (d) 2abZ

Ans. **(d)**

Sol.

$z = e^{ax+by} F(ax - by)$

$$\frac{\partial z}{\partial x} = ae^{ax+by}F(ax-by) + e^{ax+by}aF'(ax-by)$$

and $$\frac{\partial z}{\partial y} = be^{ax+by}.F(ax-by) + e^{ax+by}$$

$$(-b)F'(ax-by)$$

Now $$b\frac{\partial z}{\partial x} + a\frac{\partial z}{\partial y} = 2abe^{ax+y}.F(ax-by)$$

$= 2ab.\ z$

124. The general integral of the partial differential equation

$y^2p - xyq = x\ (z - 2y)$ is

(a) $\phi(x^2 + y^2, y^2 - yz) = 0$

(b) $\phi(x^2 - y^2, y^2 + yz) = 0$

(c) $\phi(xy, yz) = 0$

(d) $\phi(x + y, \ln x - z) = 0$

Ans. **(a)**

Sol.

$y^2 p - xy\, q = x(z - 2y)$

On comparision with $P.p + Qq = R$

$P = y^2$, $Q = -xy$, $R = x(z - 2y)$

By Lagrange's Auxiliary equation

$$\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$$

i.e. $$\underset{(I)}{\frac{dx}{y^2}} = \underset{(II)}{\frac{dy}{-xy}} = \underset{(III)}{\frac{dz}{x(z-2y)}} = \underset{(IV)}{\frac{xdx+ydy}{0}}$$

Taking I and IV, $$\frac{dx}{y^2} = \frac{xdx+ydy}{0}$$

$\Rightarrow xdx + ydy = 0$

i.e. $x^2 + y^2 = C_1$

Again By II and III, $$\frac{dy}{-xy} = \frac{dz}{x(z-2y)}$$

$zdy - 2ydy = -ydz$

or $ydz + zdy = 2ydy$ or $d(yz) = d(y^2)$

i.e. $yz - y^2 = C$

or $y^2 - yz = C_2$

So General solution is $\phi(C_1, C_2) = 0$

$\Rightarrow \phi\ (x^2 + y^2, y^2 - yz) = 0$

125. If $\frac{d^2y}{dt^2} + y = 0$ under the conditions $y = 1$, $\frac{dy}{dt} = 0$, when $t = 0$ then y is equal to

(a) sin t (b) cos t

(c) tan t (d) cot t

Ans. (b)

Sol.

$$\frac{d^2y}{dt^2}+y = 0 \Rightarrow (D^2+1)\,y = 0 \qquad ...(1)$$

Where $D = \frac{d}{dt}$

AE is $m^2 + 1 = 0 \Rightarrow m = \pm i$

So CF = $e^{ot}(C_1\cos t + C_2\sin t]$ and PI = 0

Hence G. solution is y = CF + PI

$$\boxed{y = C_1\cos t + C_2\sin t} \qquad ...(2)$$

$$\frac{dy}{dx} = -C_1\sin t + C_2\cos t \qquad ...(3)$$

Using $y(0) = 1 \Rightarrow 1 = C_1 + 0 \Rightarrow C_1 = 1$

Using $y'(0) = 0 \Rightarrow 0 = 0 + C_2 \Rightarrow C_2 = 0$

So y = cos t

126. If the system

$2x - y + 3z = 2$

$x + y + 2z = 2$

$5x - y + az = b$

has infinitely many solutions, then the values of a and b, respectively, are

(a) –8 and 6 (b) 8 and 6

(c) –8 and –6 (d) 8 and –6

Ans. (b)

Sol.

$$[A : B] = \begin{bmatrix} 2 & -1 & 3 & \vdots & 2 \\ 1 & 1 & 2 & \vdots & 2 \\ 5 & -1 & a & \vdots & b \end{bmatrix}$$

$$R_1 \leftrightarrow R_2 \sim \begin{bmatrix} \boxed{1} & 1 & 2 & \vdots & 2 \\ 2 & -1 & 3 & \vdots & 2 \\ 5 & -1 & a & \vdots & b \end{bmatrix}$$

$R_2 \to R_2 - 2R_1$ and $R_3 \to R_3 - 5R_1$,

$$[A : B] \sim \begin{bmatrix} 1 & 1 & 2 & \vdots & 2 \\ 0 & -3 & -1 & \vdots & -2 \\ 0 & -6 & a-10 & \vdots & b-10 \end{bmatrix}$$

$R_3 \to R_3 - 2R_2$,

$$[A:B] \sim \begin{bmatrix} 1 & 1 & 2 & \vdots & 2 \\ 0 & -3 & -1 & \vdots & -2 \\ 0 & 0 & a-8 & \vdots & b-6 \end{bmatrix}$$

Which is in Echelon form.

Now for infinite solution

$\rho(A) = \rho(A : B) < 3$

$\Rightarrow a = 8,\ b = 6$

127. Evaluate $\int_c \frac{1}{(z-1)^3\cdot(z-3)}dz$

where c is the rectangular region defined by x = 0, x = 4, y= –1 and y = 1

(a) 1 (b) 0

(c) $\frac{\pi}{2}i$ (d) $\pi(3+2i)$

Ans. (b)

Sol.

$$I = \oint_c \frac{1}{(z-1)^3(z-3)}dz$$

Poles of integrad are

z = 3 (simple pole)

z = 1 (pole of order 3)

$$R_1 = \underset{(z=3)}{\text{Res}}\, F(z) \lim_{z\to 3}(z-3)F(z) = \frac{1}{8}$$

$$R_2 = \underset{(z=1)}{\text{Res}}\, F(z) = \frac{1}{\underline{|3-1}}\left[\frac{d^2}{dz^2}(z-1)^3 F(z)\right]_{z=1}$$

$$= -\frac{1}{8}$$

Now by cauchy-Residue theorem

$$I = \oint_c f(z\,dz) = 2\pi i[R_1 + R_2] = 2\pi i\left[\frac{1}{8} - \frac{1}{8}\right] = 0$$

128. The Fourier Transform of $e^{-\frac{x^2}{2}}$ is

(a) $\frac{1}{2}\cdot e^{-\frac{\omega^2}{2}}$ (b) $e^{-\frac{\omega^2}{2}}$

(c) $\frac{\pi}{2}$ (d) $\sqrt{\pi}$

Ans. (b)

Sol.

We know that standard definition of Fourier Transform and inverse Fourier Transform is

$$F\{f(t)\} = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} e^{j\omega t} f(t)\,dt$$

$$\text{and } f(t) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} F(\omega).e^{-j\omega t}d\omega$$

$$\text{So } F\left\{e^{-\frac{x^2}{2}}\right\} = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} e^{j\omega x}.e^{\frac{-x^2}{2}}\,dx$$

$$= \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} e^{-\left(\frac{x^2}{2} - j\omega x\right)}dx$$

$$= \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty} e^{-\left(\frac{x}{\sqrt{2}} - \frac{j\omega}{\sqrt{2}}\right)^2 - \frac{\omega^2}{2}}.dx$$

$$= \frac{1}{\sqrt{2\pi}} e^{-\frac{\omega^2}{2}}\int_{-\infty}^{\infty} e^{-\left(\frac{x-j\omega}{\sqrt{2}}\right)^2}dx$$

$$= \frac{1}{\sqrt{2\pi}} e^{-\frac{\omega^2}{2}}\int_{-\infty}^{\infty} e^{-t^2}\sqrt{2}dt$$

$$\text{where, } \frac{x - j\omega}{\sqrt{2}} = t \Rightarrow dx = \sqrt{2}\ dt$$

$$= \frac{2\sqrt{2}}{\sqrt{2\pi}} e^{-\frac{\omega^2}{2}}\int_0^{\infty} e^{-t^2}.dt$$

$$= \frac{2}{\sqrt{\pi}} e^{-\frac{\omega^2}{2}}\left(\frac{\sqrt{\pi}}{2}\right) = e^{-\frac{\omega^2}{2}}$$

$$\because \int_0^{\infty} e^{-x^2}dx = \frac{\sqrt{\pi}}{2}$$

129. In a sample of 100 students, the mean of the marks (only integers) obtained by them in a test is 14 with its standard deviation of 2.5 (marks obtained can be fitted with a normal distribution). The percentage of students scoring 16 marks is

(a) 36 (b) 23

(c) 12 (d) 10

(Area under standard normal curve between z = 0 and z = 0.6 is 0.2257; and between z = 0 and z = 1.0 is 0.3413)

Ans. **(b)**

Sol.

N = 100 students,

For single student, x = {marks obtained}

$\mu_x = 14,\ \sigma_x = 2.5$

$$z_x = \frac{x-\mu_x}{\sigma_x} = \frac{16-14}{2.5} = \frac{2.0}{2.5} = 0.8$$

P (X $\le$ 16) = P(z < 0.8) = lies between 0.2257 to 0.3413 (According to question).

So % of students getting marks less than 16 = between 22% to 34%.

So only option satisfying it = 23%

130. Consider a random variable to which a Poisson distribution is best fitted. It happens that $P_{(x=1)} = \frac{2}{3}P_{(x=2)}$ on this distribution plot. The variance of this distribution will be

(a) 3 (b) 2

(c) 1 (d) $\frac{2}{3}$

Ans. **(a)**

Sol.

P (X = r sucess) = $\frac{e^{-\lambda}\lambda^r}{\lfloor r}$ (Poisson Distribution)

ATQ, P(X = 1) = $\frac{2}{3}$P (X = 2)

$$\frac{e^{-\lambda}\lambda^1}{\lfloor 1} = \frac{2}{3}\frac{e^{-\lambda}\lambda^2}{\lfloor 2}$$

$$\Rightarrow \lambda = \frac{\lambda^2}{3}$$

$$\Rightarrow \lambda = 3$$

We know that in poisson distribution,

Mean = Variance

= λ

= 3

131. In Face-Centered Cubic structure (FCC), what number of atoms is present in each unit cell?

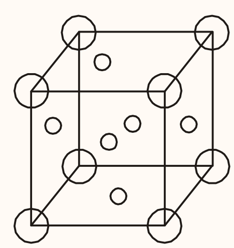
(a) 18 (b) 16

(c) 14 (d) 12

Ans. **(c)**

Sol.

Sol. Face-centered cubic structure (FCC)



In FCC structure, eight atoms are present in all eight corners of the unit cell and six atoms are present in centre of all six faces of unit cell.

So, total number of atoms in an unit cell

= 8 + 6 = 14

Note : Effective numbers of atoms present in an unit cell

$$= \left(\frac{1}{8}\times 8\right) + \left(\frac{1}{2}\times 6\right) = 1 + 3 = 4$$

SCROLL DOWN

132. If (n) is lattice points per unit cell of the cubic system, (N) and (M) are the Avogadro's number and atomic weight, respectively, and (ρ) is the density of the element, then the lattice constant (a) is

(a) $\left(\frac{M\rho}{nN}\right)^{\frac{1}{3}}$ (b) $\left(\frac{NM}{n\rho}\right)^{\frac{1}{3}}$

(c) $\left(\frac{nM}{N\rho}\right)^{\frac{1}{3}}$ (d) $\left(\frac{N\rho}{nM}\right)^{\frac{1}{3}}$

Ans. (c)

Sol. Density $(\rho) = \frac{n \times M}{a^3 \times N_A}$

$$\therefore\ a^3 = \frac{nM}{\rho N}$$

$$\therefore\ a = \left(\frac{nM}{\rho N}\right)^{1/3}$$

133. The magnetic susceptibility of aluminium is 2.1×10^{-5}. The permeability and relative permeability are, respectively

(a) 12.6×10^{-7} and 1.0021

(b) 12.6×10^{-7} and 1.0021

(c) 1.26×10^{-7} and 1.000021

(d) 1.26×10^{-7} and 1.000021

Ans. (c)

Sol. Since, $\chi_m = \mu_r - 1$

where, χ_m is magnetic susceptibility

μ_r is relative permeability

then, $\mu_r = 1 + \chi_m$

$= 1 + (2.1 \times 10^{-5})$

$= 1 + 0.000021$

$= 1.000021$

and, absolute permeability

$$\mu = \mu_o \mu_r$$

$= 4\pi \times 10^{-7} \times 1.000021$

$= 12.6 \times 10^{-7}$

134. An iron rod of $10^{-3} m^3$ volume and relative permeability of 1150 is placed inside a long solenoid wound with 5 turns/cm. If a current of 0.5 A is allowed to pass through th solenoid, the magnetic moment of the rod is

(a) 2.87×10^4 A.m^2 (b) 2.87×10^3 A.m^2

(c) 2.87×10^2 A.m^2 (d) 28.7×10^2 A.m^2

Ans. (none)

Sol. Since, $\chi_m = \frac{M}{H}$

$$\Rightarrow \mu_r - 1 = \frac{M}{H}$$

$$\Rightarrow M = (\mu_r - 1)H = (\mu_r - 1)ni$$

$= (1150 - 1) \times \frac{5}{10^{-2}} \times 0.5$

$= 1149 \times 5 \times 50$ A/m

Now,

Magnetic moment = Magnetisation × Volume

$\Rightarrow$ m = M × V

$= 1149 \times 5 \times 50 \times 10^{-3}$

$= 28725 \times 10^{-2}$ A.m^2

135. When an alternating voltage of a given frequency is applied to a dielectric material, dissipation of energy occurs due to

1. Continual change in the orbital paths of the electrons in the atomic structure.
2. A small conduction current through the dielectric
3. Eddy currents

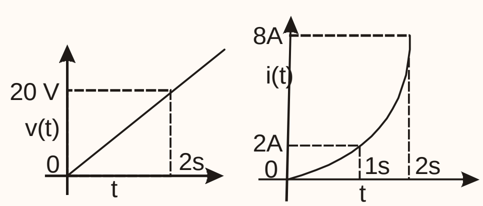
Which of the above statements are correct?

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

Ans. **(b)**

Sol.
- When an alternating voltage is applied to a dielectric material, dissipation of energy occurs due to movement or, rotation of atoms or, molecules in an alternating electric field.
- However, the conduction current in a dielectric is, in fact, the main source of dielectric losses.

136.



The voltage and current characteristic of an element is as shown in figure. The nature and value of the element are

(a) Capacitor of 3.3 μF
(b) Inductor of 2.5 H
(c) Capacitor of 6.7 μF
(d) Inductor of 5.0 H

Ans. **(b)**

Sol.

The given element is an inductor as the graph of current is an integration of that of current.

The voltage in an inductor is given as

$$i = \frac{1}{L}\int V\,dt$$

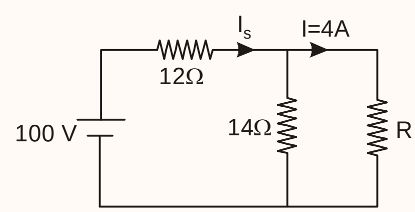
For t = 2 sec

i = 8 A and $\int V\,dt$ = area under the graph of v till 2 seconds.

$$\therefore\ 8 = \frac{1}{L}\times\frac{1}{2}\times 20\times 2$$

$$\Rightarrow L = \frac{20}{8} = 2.5\,\text{H}$$

137.

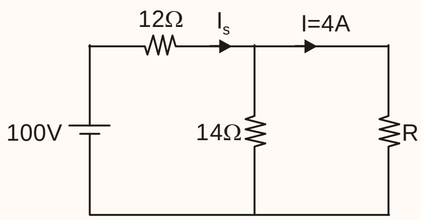


In the circuit shown, what value of R will result in I = 4A?

(a) 9Ω (b) 7Ω
(c) 5.5Ω (d) 3.5Ω

Ans. **(b)**

Sol.



The current through R is given as,

$$I = I_s \times \frac{14}{14+R} \quad \text{... (i)}$$

and $$I_s = \frac{100}{12+\frac{14R}{14+R}} \quad \text{... (ii)}$$

Given, I = 4A

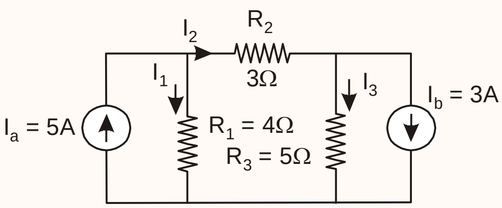
Putting the values in equation (i)

$$4 = \frac{100}{12+\frac{14R}{14+R}} \times \frac{14}{14+R} \quad \text{... (iii)}$$

On solving the equation (iii), we get

$R = 7\Omega$

138.



In the circuit as shown, the currents I_1, I_2 and I_3 through three resistors are, respectively

(a) 2.08 A, 2.92 A and –0.08 A

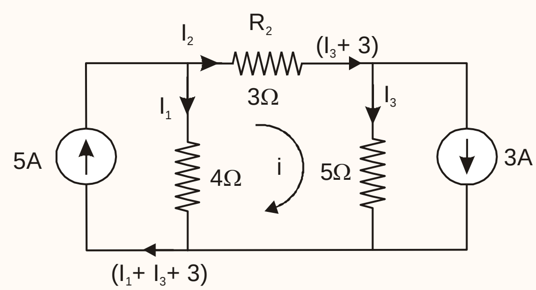
(b) 3.08 A, 2.5 A and –0.06 A

(c) 2.08 A, 2.5 A and –0.08 A

(d) 3.08 A, 2.92 A and –0.06 A

Ans. **(a)**

Sol.



KVL in mesh (i)

$3(I_3+3) + 5I_3 - 4I_1 = 0$

$8I_3 - 4I_1 = -9$ ... (i)

By KCL

$I_1 + I_3 = 2$ ... (ii)

from equation (i) and (ii)

$I_1 = 2.08$ A

$I_3 = -0.083$ A

therefore, $I_2 = 2.917$ A

139. The v-i relationship for a circuit containing R and C and a battery of voltage E, all in series is

1. $\frac{1}{C}\int i\,dt + iR = E$

2. $\frac{1}{RC}i + \frac{di}{dt} = 0$

3. $\frac{1}{C}i + R\int i\,dt = E$

Which of the above relationships are correct?

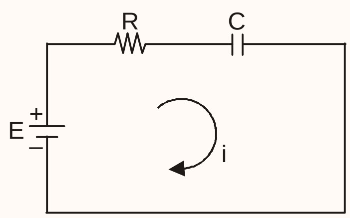
(a) 1 and 2 only (b) 1 and 3 only

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

Ans. **(a)**

Sol.

The v-i relationship of the given circuit can be written as



$$E = iR + \frac{1}{C}\int i\,dt \qquad \text{... (i)}$$

By differentiating equation (i), we get

$$\frac{1}{RC}i + \frac{di}{dt} = 0 \qquad \text{... (ii)}$$

Therefore (i) and (ii) are correct.

The third equation is wrong.

140. The flux-density at a distance of 0.1 m from a long straight wire, carrying a current of 200 A is

(a) 5×10^{-4} Wb/m^2 (b) 4×10^{-4} Wb/m^2

(c) 3×10^{-4} Wb/m^2 (d) 2×10^{-4} Wb/m^2

Ans. **(b)**

Sol. Magnetic field intensity of a long straight wire at a distance d is given by,

$$H = \frac{i}{2\pi d} = \frac{200}{2\pi \times 0.1}$$

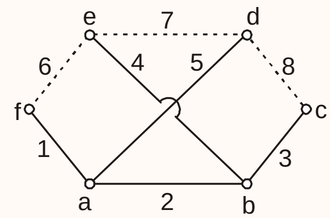
flux-density is given by

$$B = \mu H$$

$$= \mu \times \frac{200}{2\pi \times 0.1}$$

$$= 4 \times 10^{-4} \text{ wb/m}^2$$

141.



A network graph with its tree shown by firm lines is given in the figure. The fundamental cut-set for the tree-branch number 2 is

(a) 1, 2, 3, 4 and 5 (b) 1, 2 and 5

(c) 2, 6, 7 and 8 (d) 2, 3 and 4

Ans. **(c)**

Sol.
- A fundamental cut-set of a graph with respect to a tree is a cut-set formed by one and only one twig and a set of links.
- For a graph having N nodes there will be (N–1) fundamental cut-sets.

For the given twig (2), the links are 6,7 and 8.

142. A bipolar transistor has $\alpha = 0.98$, $I_{CO} = 10\ \mu A$.

If the base current is $100\ \mu A$, then collector current would be

(a) 2.91 mA (b) 3.49 mA

(c) 4.91 mA (d) 5.49 mA

Ans. **(d)**

Sol. Given data

$$\alpha = 0.98,\ I_{C0} = 10\mu A,\ I_B = 100\mu A$$

We know,

$$I_C = \alpha I_E + I_{CO}$$

$$I_C = \alpha(I_C + I_B) + I_{CO}$$

$$I_C(1-\alpha) = \alpha I_B + I_{CO}$$

$$I_C = \left(\frac{\alpha}{1-\alpha}\right) I_B + \frac{I_{CO}}{(1-\alpha)}$$

$$= \left(\frac{0.98}{1-0.98}\right)100\mu + \left(\frac{10\mu}{1-0.98}\right)$$

$$= \frac{0.98}{0.02} \times 100\mu + \frac{10\mu}{0.02}$$

$$= 10\mu\left(\frac{9.8+1}{0.02}\right)$$

$$= 10\mu \times \frac{10.8}{0.02}$$

$$= 10\mu \times \frac{1080}{2}$$

$$= 5400 \times 10^{-6}$$

$$= 5.4 \text{ mA}$$

143. The reduced incidence matrix for a network is given as

$$A = \begin{array}{c} \\ a \\ b \\ c \end{array}\begin{array}{c} \begin{array}{cccccc} 1 & 2 & 3 & 4 & 5 & 6 \end{array} \\ \begin{bmatrix} 1 & -1 & -1 & -1 & 0 & 0 \\ 0 & 1 & 0 & 0 & -1 & 1 \\ 0 & 0 & -1 & 0 & 1 & 0 \end{bmatrix} \end{array}$$

Which of the following sets constitute a tree?

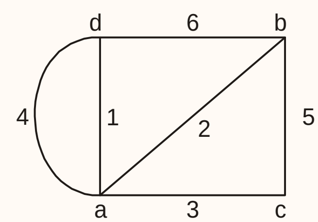
(a) 2, 3 and 5
(b) 1, 2 and 6
(c) 1, 2 and 4
(d) 1, 2 and 3

Ans. **(d)**

Sol. The redueced incidence matrix is first completed.

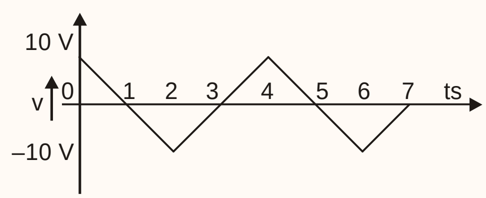
$$A = \begin{array}{c} \\ a \\ b \\ c \\ d \end{array}\begin{array}{c} \begin{array}{cccccc} 1 & 2 & 3 & 4 & 5 & 6 \end{array} \\ \begin{bmatrix} 1 & -1 & -1 & -1 & 0 & 0 \\ 0 & 1 & 0 & 0 & -1 & 1 \\ 0 & 0 & -1 & 0 & 1 & 0 \\ -1 & 0 & 0 & 1 & 0 & 1 \end{bmatrix} \end{array}$$

The corresponding network graph can be drawn as,



Hence, 1, 2 and 3 form the required tree.

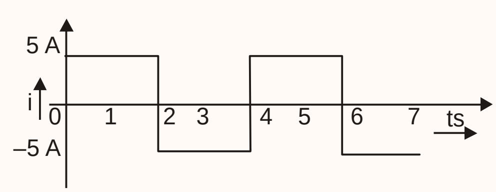
144.

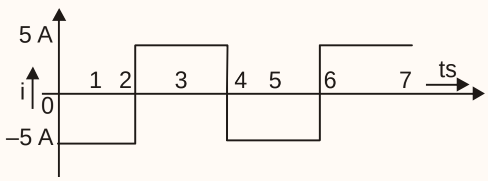


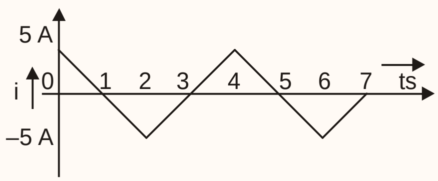
A triangular wave voltage, as shown in figure, is applied across the terminals of a 0.5 F pure capacitor at time t = 0.

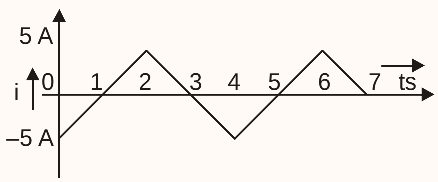
The corresponding current-wave is

(a)



(b) 

(c) 

(d) 

Ans. (b)

Sol.

The current through a capacitor is given by

$$i = C\frac{dv}{dt} \qquad \text{... (i)}$$

The graph of voltage has a negative slope from t = 0 to t = 2 seconds therefore current will be negative in that duration. Option (b) satisfies that condition.

$i = 0.5 \times 10 = 5$ A

Therefore, magnitude of current = 5A and sign will be according to the slope of V

t = 0 to t = 2 seconds $\rightarrow$ –5A

t = 2 sec to t = 4 seconds $\rightarrow$ +5A

The cycle will continue accordingly.

145. Consider the following statements for Norton's theorem :

1. Short the branch resistance through which current is to be calculated.
2. Obtain the current through this short-circuited branch, using any of the network simplification techniques.
3. Develop Norton's equivalent circuit by connecting current source I_N with the resistance R_N in series with it

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.

Third statement is wrong as the Norton's equivalent circuit is completed by connecting current source I_N in parallel to R_N.

Steps to develop Norton's equivalent circuit.

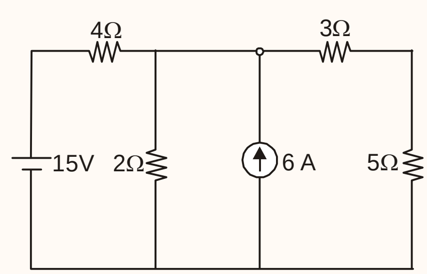
1. Short the branch resistance through which current is calculated.

2. Obtain the current through short circuited branch.

3. Find the equivalent resistance across the branch.

4. Connect the current source I_N in parallel to resistance R_N

146.



For the network shown in the figure, the current flowing through the 5Ω resistance will be

(a) $\frac{37}{25}$ A (b) $\frac{40}{28}$ A

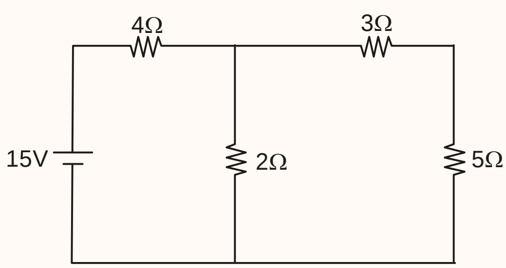
(c) $\frac{39}{28}$ A (d) $\frac{41}{28}$ A

Ans. **(c)**

Sol.

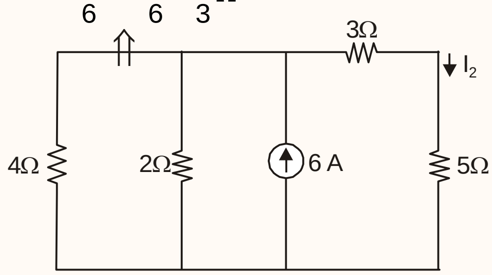
Applying superposition theorem

(i) Taking the voltage sources first and replacing current source by open circuit



(ii) Taking the current source and replacing the voltage source by short circuit.

$$\frac{4\times 2}{6}=\frac{8}{6}=\frac{4}{3}\Omega$$

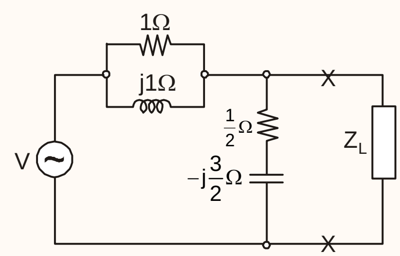


$$I_2 = 6\times\frac{4/3}{4/3+8}$$

$$= 6\times\frac{4}{28}=\frac{24}{28}$$

$$\therefore \quad = \frac{78}{56}=\frac{39}{28}\text{A}$$

147.



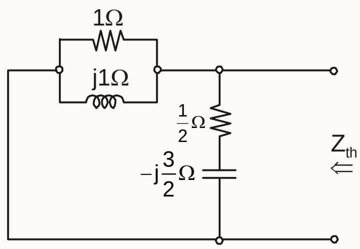
The circuit as shown in figure is connected to a load Z_L across X-X. For a maximum power transfer to the load, Z_L should be

(a) $\frac{3-j}{4}\Omega$ (b) $\frac{3+j}{4}\Omega$

(c) $\frac{3j}{4}\Omega$ (d) $\frac{-3-j}{4}\Omega$

Ans. **(a)**

Sol. According to maximum power transfer theorem, the maximum power is transfered to the load if the load impedance is equal to the complex conjuate of thevenin impedence across the load.



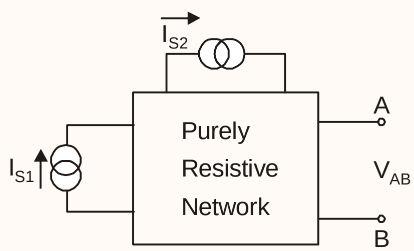
$Z_{th} = (0.75 + 0.25j)$

$Z_L = Z_{th}^*$

$= (0.75 + 0.25j)^*$

$= 0.75 - 0.25j = \frac{3-j}{4}\Omega$

148.



In the network as shown, with I_{S1} = 5A, I_{S2} = 10A, V_{AB} = 120 V, and with I_{S1} = 10A, I_{S2} = 5A, V_{AB} = 15 V. What is the value of k to describe $I_{S1} = k\,I_{S2}$, such that $V_{AB} = 0$?

(a) 2.5 (b) 3.5

(c) 5.5 (d) 6.5

Ans. (a)

Sol.

Let K_1 and K_2 be two constants.

The two equation can be formed as,

$$5K_1 + 10K_2 = 120 \quad \ldots \text{(i)}$$

$$10K_1 + 5K_2 = 15 \quad \ldots \text{(ii)}$$

Solving equation (i) and (ii) for K_1 and K_2,

$$K_1 = -6 \text{ and } K_2 = 15$$

For the given case,

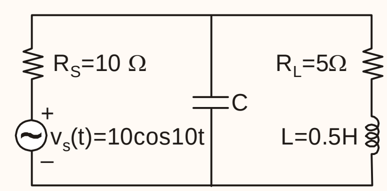
$$-I_{s1} + I_{s2} = 0$$

$$\therefore \quad \frac{I_{s1}}{I_{s2}} = \frac{15}{6} = 2.5$$

$$I_{s1} = 2.5\,I_{s2}$$

$$\therefore \quad K = 2.5$$

149.



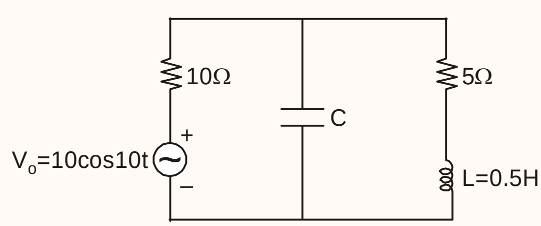
For the circuit as shown, what is the value of C that leads to maximum power transfer to the load, if the value of L is 0.5 H?

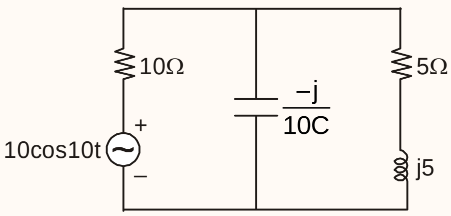
(a) 0.1μF (b) 0.01 F

(c) 0.001 F (d) 0.01μF

Ans. (b)

Sol.





The impedance seen by the source, is

$$Z_{eq} = 10 + \frac{(5+j5)\cdot\left(\frac{-j}{10C}\right)}{5 + j\left(5 - \frac{1}{10C}\right)}$$

$$Z_{eq} = 10 + \frac{-j(5+j5)}{\{50C + j(50C-1)\}}$$

$$= 10 + \frac{5-j5}{[50C + j(50C-1)]}$$

$$= 10 + \frac{(5-j5)\{50C - j(50C-1)\}}{k}$$

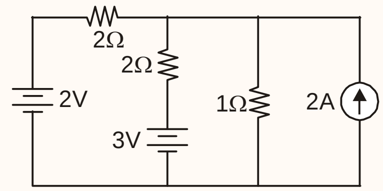
For maximum power transfer, the imaginary part of Z_{eq} will be zero,

250C + 5(50C – 1) = 0

500C – 5 = 0

$C = \frac{5}{500}$ = 0.01 F

150.



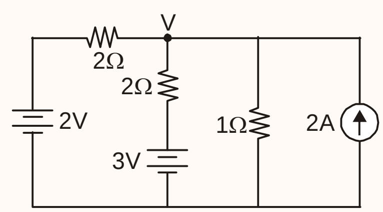
The current in the 1Ω resistor in the network as shown is

(a) 2.00 A (b) 2.25 A

(c) 2.50 A (d) 2.75 A

Ans. (b)

Sol.



KCL at node V

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

$\therefore$ V = 2.25 Volt

Current through 1Ω resistance is

$$i = \frac{V}{R} = 2.25 \text{ A}$$