SECTION – A

1. In each of sub question (1.1 to 1.25) four alternatives A, B, C and D are provided of which one is correct. Indicate in your book, at the space provided, the correct answer by writing the alphabet corresponding to the answer.

1.1 A sinusoidal source of voltage V and frequency f is connected to a series circuit of variable resistance, R and a fixed reactance, X. The locus of the tip of the current-phasor, I, as R is varied from 0 to ∞ is:

(a) a semicircle with a diameter of $\frac{V}{X}$.

(b) a straight line with a slop of $\frac{R}{X}$

(c) an ellipse with $\frac{V}{R}$ as major axis.

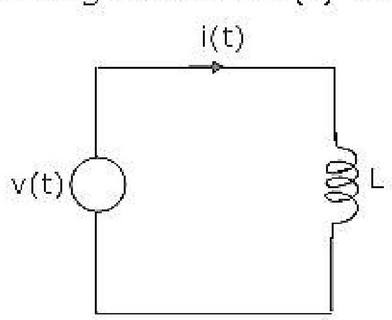
(d) a circle of radius $\frac{R}{X}$ and origin at $\left(0, \frac{V}{2}\right)$.

1.2 A circuit with a resistor, inductor and capacitor in series is resonant of $f_o Hz$. If all the component values are now doubled, the new resonant frequency is:

(a) $2f_o$ (b) still f_o (c) $\frac{f_o}{4}$ (d) $\frac{f_o}{2}$

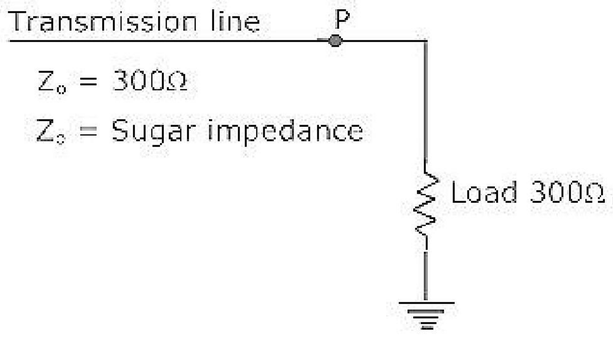
1.3 In the circuit shown in Fig.1.3, it is desired to have a constant direct current i(t) through the ideal inductor L. the nature of the voltage source v(t) must be:

(a) constant voltage
(b) linearly increasing voltage
(c) an ideal impulse
(d) exponentially increasing voltage



1.4 The reflection coefficient for the transmission line shown in Fig.1.4 at P is:

(a) +1
(b) -1
(c) 0
(d) 0.5



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1.5 The laws of electromagnetic induction (Faraday's and Lenz's law) are summarized in the following equation:

(a) e = iR

(b) $e = L\frac{di}{dt}$

(c) $e = -\frac{d\psi}{dt}$

(d) None of the above

1.6 A synchronous generator connected to an infinite bus is overexcited. Considering only the reactive power, from the point of view of the system, the machine acts as

(a) a capacitor

(b) an inductor

(c) a resistor

(d) None of the above

1.7 A 3 phase squirrel cage induction motor has a full load efficiency of 0.8 and a maximum efficiency of 0.9. It is operated at a slip of 0.6 by applying a reduced voltage. The efficiency of the motor at this operating point is:

(a) less than 0.4

(b) greater than 0.6

(c) in the range of 0.8 ±0.1

(d) None of the above

1.8 The efficiency of a 100 KVA transform is 0.98 at full as well as at half load. For this transformer at full load the copper loss.

(a) is less than core loss

(b) is equal to core loss

(c) is more than core loss

(d) None of the above

1.9 The magnetizing current in a transformer is rich in

(a) 3^{rd} harmonic (b) 5^{th} harmonic (c) 7^{th} harmonic (d) 13^{th} harmonic

1.10 Series capacitive compensation in EHV transmission lines is used to

(a) reduce the line loading

(b) improve the stability of the system

(c) reduce the voltage profile

(d) improve the protection of the line

1.11 Bulk power transmission over long HVDC lines are preferred, on account of

(a) low cost of HVDC terminals

(b) no harmonic problems

(c) minimum line power losses

(d) simple protection

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1.12 The output of a linear time invariant control system is c(t) for a certain input r(t). If r(t) is modified by passing it through a block whose transfer function is e^{s} and then applied to the system, the modified output of the system would be

(a) $\frac{c(t)}{1+e^{t}}$ (b) $\frac{c(t)}{1+e^{-t}}$

(c) $c(t-1)u(t-1)$ (d) $c(t)u(t-1)$

1.13 None of the poles of a linear control system lie in the right half of s-plane. For a bounded input, the output of this system

(a) is always bounded (b) could be unbounded

(c) always tends to zero (d) None of the above

1.14 The phase lead compensation is used to

(a) increase rise time and decrease overshoot

(b) decrease both rise time and overshoot

(c) increase both rise time and overshoot

(d) decrease rise time and increase overshoot

1.15 A set of linear equations is represented by the matrix equation Ax=b. the necessary condition for the existence of a solution for this system is:

(a) A must be invertible

(b) b must be linearly depended on the columns of A

(c) b must be linearly independent of the columns of A

(d) None of the above

1.16 The vector $\begin{bmatrix}1\\2\\-1\end{bmatrix}$ is an eigen vector of $A=\begin{bmatrix}-2 & 2 & -3\\2 & 1 & -6\\-1 & -2 & 0\end{bmatrix}$. One of the given values of A is:

(a) 1 (b) 2 (c) 5 (d) -1

1.17 $A=\begin{bmatrix}2 & 0 & 0 & -1\\0 & 1 & 0 & 0\\0 & 0 & 3 & 0\\-1 & 0 & 0 & 4\end{bmatrix}$. The sum of the eigen values of the matrix A is:

(a) 10 (b) -10 (c) 24 (d) 22

1.18 A d.c. voltmeter has a sensitivity of 1000 Ω/volt. When it measures half full scale

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1.19. A moving coil galvanometer is made into a d.c. ammeter by connecting

(a) a low resistance across the meter

(b) a high resistance in series with the meter

(c) a pure inductance across the meter

(d) a capacitor in series with the meter

1.20. The open collector outputs of two 2-inputs NAND gates are connected to a common pull up resistor. If the input to the gates are P, Q and R, S respectively, the output is equal to

(a) $\overline{P.Q}.\overline{R.S}$. (b) $\overline{PQ} + \overline{RS}$ (c) $P.Q + R.S$ (d) $P.Q \ . \ R.S$

1.21. In standard TTL gates, the totem pole output stage is primarily used to

(a) increase the noise margin of the gate

(b) decrease the output switching delay

(c) facilitate a wired OR logic connection

(d) increase the output impedance of the circuit

1.22. One of the applications of current mirror is:

(a) output current limiting

(b) obtaining a very high current gain

(c) current feedback

(d) temperature stabilized biasing

1.23. The uncontrolled electronic switch employed in power electronic converters is:

(a) thyristor (b) bipolar junction transistor

(c) diode (d) MOSFET

1.24. The MOSFET switch in its on-state may be considered equivalent to:

(a) resistor (b) inductor (c) capacitor (d) battery

1.25 In a commutation circuit employed to turn off an SCR, satisfactory turn-off is obtained when

(a) circuit turn-off time < device turn-off time

(b) circuit turn-off time > device turn-off time

(c) circuit time constant > device turn-off time

(d) circuit time constant < device turn-off time

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2. Questions 2.1 to 2.20 are accompanied by four answers of which one is correct. Indicate the correct answer, in the space provided in the answer book, by writing the alphabet A, B, C or D.
For each of questions 2.21 to 2.25, three items are given on the left side and more than three on the right. For each item on the left, match a suitable answer from the items on the right (e.g.A-Q, B-S, C-T). Write your answer in the space provided in the answer book.

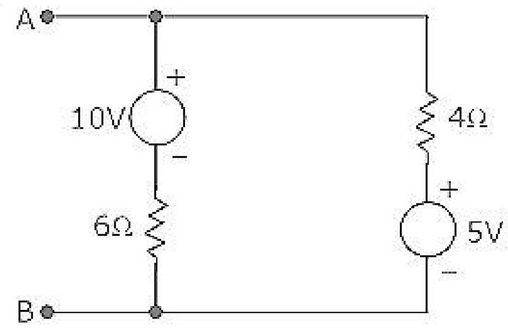
2.1 Viewed from the terminals A, B the following circuit shown in Fig.2.1 can be reduced to an equivalent circuit of a single voltage source in series with a single resistor with the following parameters:

(a) 5 volt source in series with 10Ω resistor

(b) 1 volt source in series with 2.4Ω resistor

(c) 15 volt source in series with 2.4Ω resistor

(d) 1 volt source in series with 10Ω resistor



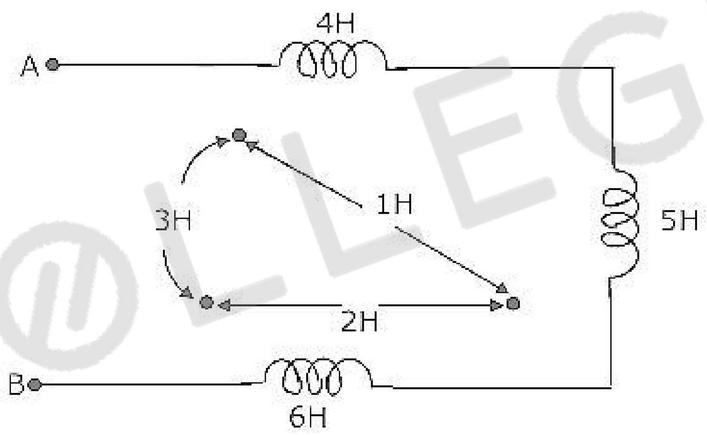
2.2. The effective inductance of the circuit across the terminals A, B in the Fig.2.2 shown below is:

(a) 9 H

(b) 21 H

(c) 11 H

(d) 6 H



2.3. The neutral of 10 MVA, 11 KV alternator is earthed through a resistance of 5 ohms. The earth fault relay is set to operate at 0.75A. The CT's have a ratio of 1000 : 5. What percentage of the alternator winding is protected?

(a) 85% (b) 88.2% (c) 15% (d) 11.8%

2.4. If the length of a wire of resistance R is uniformly stretched to n times its original value, its new resistance is:

(a) nR (b) $\frac{R}{n}$ (c) n^2R (d) $\frac{R}{n^2}$

2.5. A cable has the following characteristics. L =0.201 μH/m and C = 196.2 p/F/m. The velocity of wave propagation through the cable is:

(a) 32 m/s (b) 159.24 μ/ms (c) 0.0312 m/s (d) 159.24 m/s

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2.6. A 50 Hz transformer having equal hysteresis and eddy current losses at rated excitation is operated at 45 Hz at 90% of its rated voltage. Compared to rated operating point, the core losses under this condition:

(a) reduce by 10% (b) reduce by 19%

(c) reduce by 14.5% (d) remain unchanged

2.7. The armature of a single phase alternator is completely wound with T single turn coils distributed uniformly. The induced voltage in each turn is 2V (rms). The emf of the whole winding is

(a) 2T volt (b) 1.11 T volt (c) 1.414 T volt (d) 1.273 T volt

2.8. A 240 V d.c. shunt motor with an armature resistance of 0.5Ω has a full load current of 40 A. Find the ratio of the stalling torque to the full load torque when a resistance of 1Ω is connected in series with the armature?

(a) 4 (b) 12

(c) 6 (d) None of the above

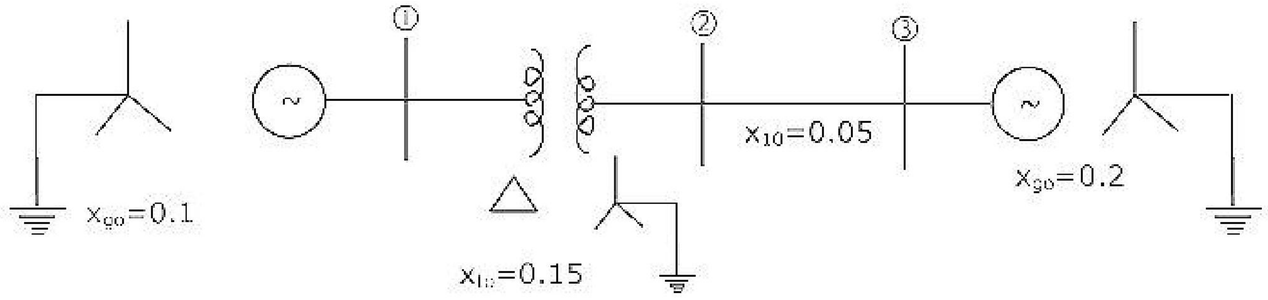
2.9. A shunt reactor of 100 MVAr is operated at 98% of its rated voltage and at 96% of its rated frequency. The reactive power absorbed by the reactor is:

(a) 98 MVAr (b) 104.02 MVAr (c) 96.04 MVAr (d) 100.04 MVAr

2.10. A power station consists of two synchronous generators A and B of ratings 250 MVA and 500 MVA with inertia 1.6 p.u. and 1 p.u., respectively on their own base MVA ratings. The equivalent p.u. inertia constant for the system on 100 MVA common base is:

(a) 2.6 (b) 0.615 (c) 1.625 (d) 9.0

2.11. For the network shown in Fig.2.11, the zero sequence reactance's in p.u. are indicated. The zero sequence driving point reactance of the node 3 is:



(a) 0.12 (b) 0.30 (c) 0.10 (d) 0.20

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2.12. The Laplace transform of $(t^2 - 2t)u(t-1)$ is:

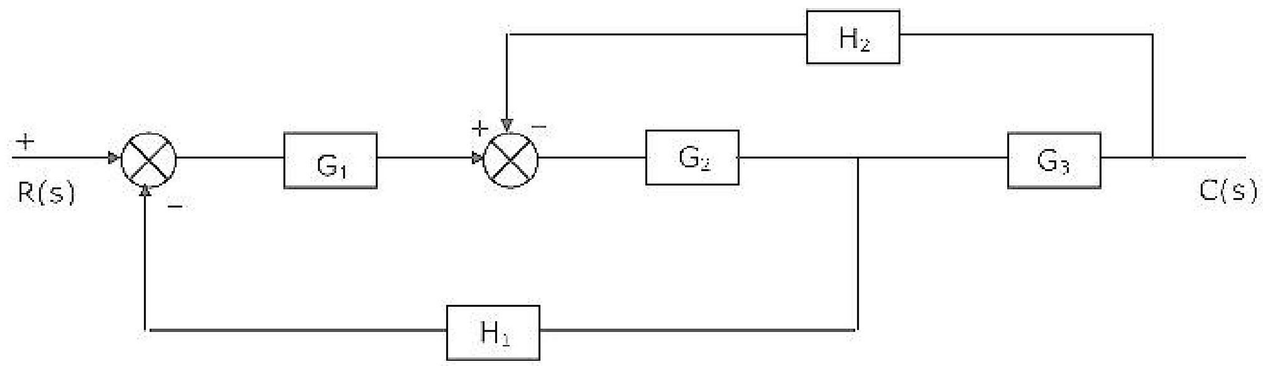
(a) $\frac{2}{s^3}e^{s} - \frac{2}{s^2}e^{s}$

(b) $\frac{2}{s^3}e^{2s} - \frac{2}{s^2}e^{s}$

(c) $\frac{2}{s^3}e^{s} - \frac{2}{s}e^{s}$

(d) None of the above

2.13. For block diagram shown in Fig.2.13 $\frac{C(s)}{R(s)}$ is given by



(a) $\frac{G_1G_2G_3}{1 + H_2G_2G_3 + H_1G_1G_2}$

(b) $\frac{G_1G_2G_3}{1 + G_1G_2G_3H_1H_2}$

(c) $\frac{G_1G_2G_3}{1 + G_1G_2G_3H_1 + G_1G_2G_3H_2}$

(d) $\frac{G_1G_2G_3}{1 + G_1G_2G_3H_1}$

2.14. The number of roots on the equation $2S^4 + S^3 + 3S^2 + 5S + 7 = 0$ that lie in the right half of S plane is:

(a) zero (b) one (c) two (d) three

2.15. $A = \begin{bmatrix} 5 & 0 & 2 \\ 0 & 3 & 0 \\ 2 & 0 & 1 \end{bmatrix}$. The inverse of A is:

(a) $\begin{bmatrix} 1 & 0 & -2 \\ 0 & \frac{1}{3} & 0 \\ -2 & 0 & 5 \end{bmatrix}$ (b) $\begin{bmatrix} 5 & 0 & 2 \\ 0 & -\frac{1}{3} & 0 \\ 2 & 0 & 1 \end{bmatrix}$ (c) $\begin{bmatrix} \frac{1}{5} & 0 & \frac{1}{2} \\ 0 & \frac{1}{3} & 0 \\ \frac{1}{2} & 0 & 1 \end{bmatrix}$ (d) $\begin{bmatrix} \frac{1}{5} & 0 & -\frac{1}{2} \\ 0 & \frac{1}{3} & 0 \\ -\frac{1}{2} & 0 & 1 \end{bmatrix}$

2.16. The value of $\int_1^2 \left(\frac{1}{x}\right) dx$ computed using Simpson's rule with a step size of h = 0.25 is:

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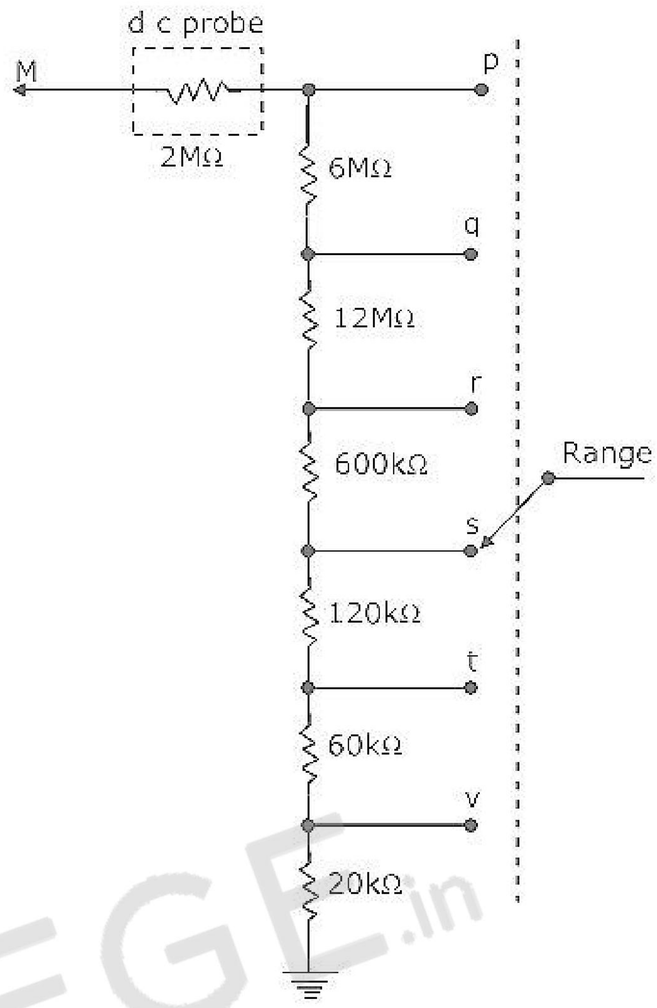
2.17. Fig. 2.17 shows the input attenuator of a multimeter. The meter reads full scale with 12 V at M, with the range switch at position 'q'. What is the required voltage at M to obtain full-scale deflection with the range switch at position 's'?

(a) 1 V (b) 150 V

(c) 120 V (d) 147 V



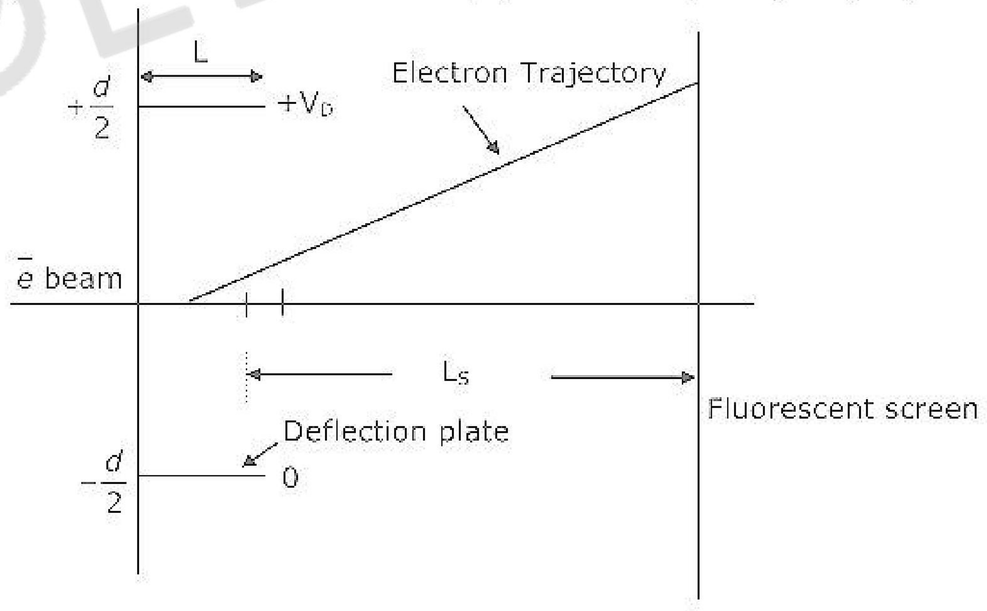
2.18. Fig.2.18 shows the electrostatic vertical deflection system of CRT. Given that V_A is the accelerating voltage, the deflection sensitivity (deflection/volt) is proportional to:

(a) $\frac{LL_S}{dV_A}$

(b) $\frac{LL_SV_D}{dV_A}$

(c) $\frac{LL_S}{d}V_A$

(d) $\frac{dL_S}{LV_A}$



2.19. When the firing angle α of a single phase, fully controlled rectifier feeding constant d.c. current into a load is 30°, the displacement power factor of the rectifier is:

(a) 1 (b) 0.5 (c) $\frac{1}{\sqrt{3}}$ (d) $\frac{\sqrt{3}}{2}$

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2.20. A 3-phsae, fully controlled, converter is feeding power into a d.c. load at a constant current of 150 A. The rms current through each thyristor of the converter is:

(a) 50A (b) 100A (c) $\frac{150\sqrt{2}}{\sqrt{3}}$ (d) $\frac{150}{\sqrt{3}}$

2.21.

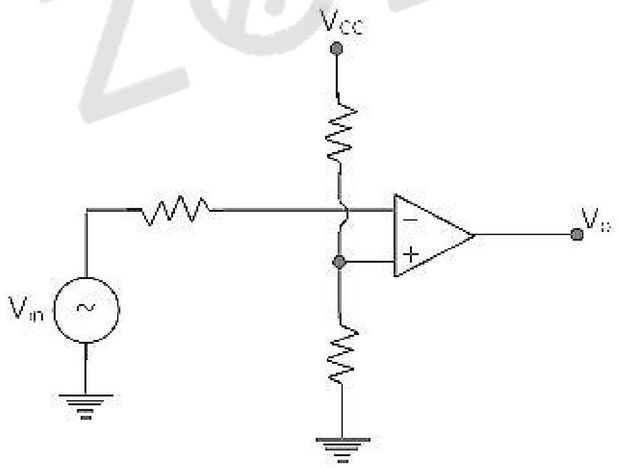
Measurement	**Instrument used**
(A) Transients	(P) Signal generator
(B) Frequency	(Q) Spectrum analyzer
(C) Harmonic content	(R) Digital storage oscilloscope
	(S) Pulse counter

2.22.

Test	**Machine**
(A) No load and blocked rotor test	(P) Transformer
(B) Sumpner's test	(Q) Induction machine
(C) Swinburn's test	(R) Synchronous machine
	(S) DC machine

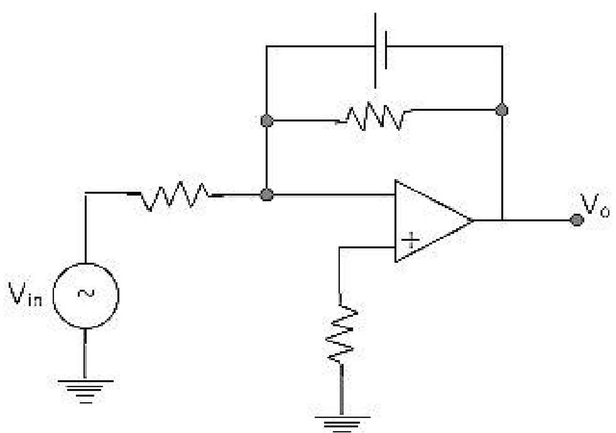
2.23. **Circuit**

(a)



(P) High-pass filter

(b)



(Q) Amplifier

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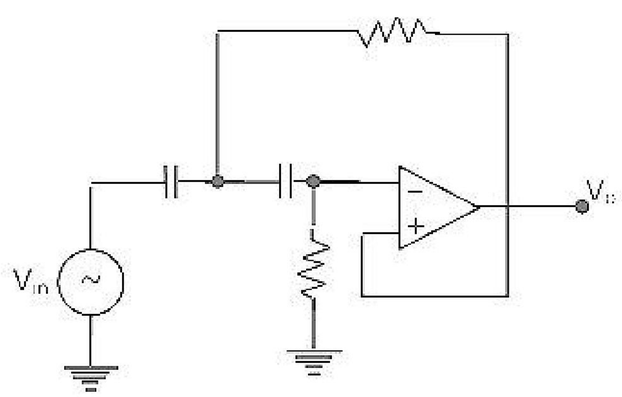
(c)



(R) Comparator

(S) Low-pass filter

2.24.

Logic	Function
(A) $\overline{X}+\overline{Y}$	(P) Sum
(B) XY	(Q) NAND
(C) $\overline{X}\ \overline{Y}$	(R) Carry
	(S) NOR

2.25. A NPN, silicon transistor is meant for low-current audio amplification. Match its following characteristics against their values:

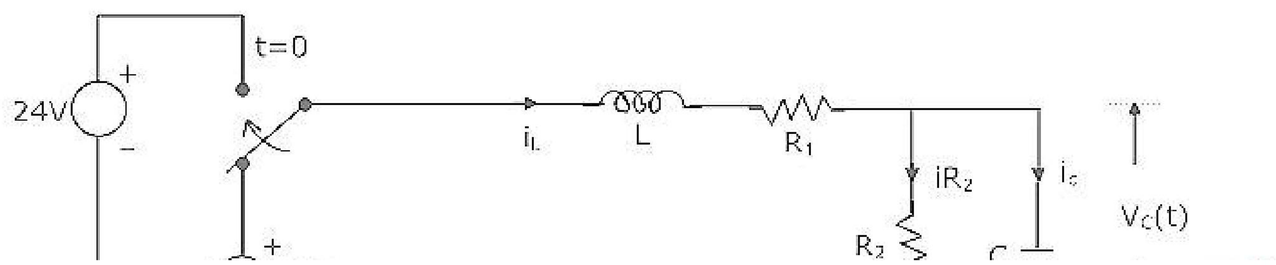
Characteristics	Values
(A) V_{EB}, max	(P) 0.7 V
(B) V_{CB}, max	(Q) 0.2 V
(C) V_{CE}, *sat*	(R) 6 V
	(S) 50 V

3. The Switch in the following circuit, shown in Fig.3, has been connected to the 12 V source for a long time. At t = 0, the switch is thrown to 24 V.

(a) Determine i_L (o) and V_c (o)

(b) Write the differential equation governing $V_c(t)$ for $t > 0$

(c) Compute the steady state value of $V_c(t)$.



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4. A 50 hp, 6 pole, 50 Hz slip-ring induction motor runs at 960 rpm on full load with a rotor current of 40 A. allowing 300 W for the copper loss in the short circuiting gear and 1200 W for mechanical losses, find the resistance R_2 per phase of the 3 phase rotor winding.

5. Each conductor of a 33 KV, 3-phase system is suspended by a string of three similar insulars. The ratio of shunt capacitance to mutual capacitance is 0.1. Calculate the voltage across each insulator, and the string efficiency.

6. Find the value of S at the end of the execution of the following program segment. (given in FORTRAN CODE as well as C code).

FORTRAN CODE

```
C    Function MOD (A,B) Returns the value
C    (A modulo B)
     S = 0
     DO 1 1 = 1,100
     IF (MOD) (1,7). EQ.0) GO TO 1
     IF (MOD) (1,10). EQ.7) GO TO 1
     S = S +1
1    CONTINUE
```

C CODE

```
S = 0;
for (i'=1; i≤100;)
{
if (!(i%7)) go to skip;
if ((i%10)==7) go to skip;
S = S+i;
Skip: i++;
}
```

7. In a digital combinational circuit with 4 inputs (A, B, C, D), it is required to obtain an output of logical 1 only for the input combination (A = 1; B = C = D = 0). It is known that the following combinations of input are forbidden:

   ABCD = 1010, 1011, 1100, 1101, 1110, 1111

   Evaluate the logical expression for the output and realize the same with two input NAND gates. Assume that complements of inputs are not available.

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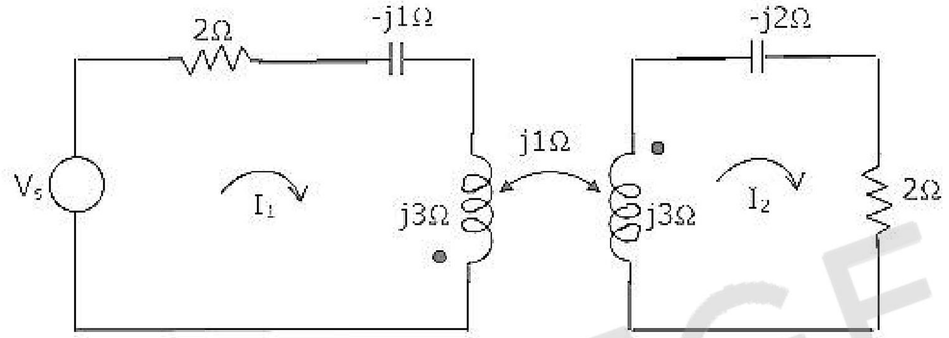
SECTION – B

(50 Marks)

Answer any TEN questions from this section. All questions carry equal marks.

8. A circuit consisting of a single resistor R and an inductor L in series is driven by a 25 V rms, 50 Hz sinusoidal voltage source. A capacitor is to be placed in parallel with the source to improve the power factor. Given that the average power dissipated in the R is 100 W and that the reactive power delivered to the L is 75 Var, what value of C will yield a 0.9 p.f. lagging as seen by the source?

9. Determine the impedance seen by the source $V_s = 24\angle 0°$ in the network shown in Fig.9.



10. An infinite number of charges, each equal to 'q' are placed along the x= 1, x = 2, x = 4, x = 8, x = 16 and so on. Find the potential and electron field at point x = 0, due to these system of charges.

11. An electron moves in the X-Y plane with a speed of 10^6 m/s. Its velocity vector makes an angle of 60° with X-axis. A magnetic field of magnitude 10^{-2} T exists along the Y-axis. Compute the magnetic force exerted on the electron and its direction.

12. A DC shunt generator delivers 60 KW at 240 V and 360 rpm. The armature and field resistances are 0.015Ω and 60Ω respectively. Calculate the speed of the machine running as a shunt motor and taking 60 KW input at 240 V. Allow 1 volt per brush for contact drop.

13. In a 50 KVA, 11 KV/400 V transformers, the iron and copper losses are 500 W and 600 W respectively under rated conditions. Calculate the efficiency on unity power factor at full load. Find the load for maximum efficiency and the iron and copper losses corresponding to this load.

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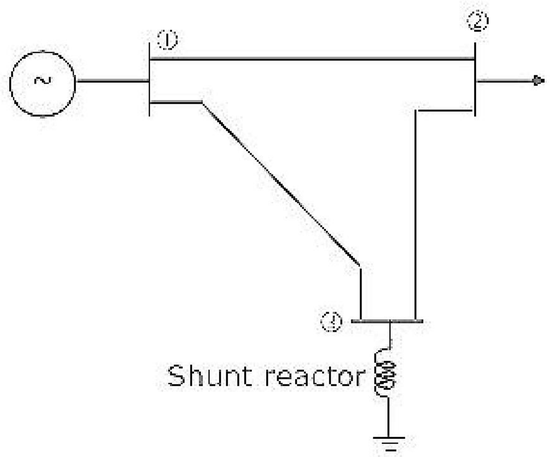
14. For the given network in Fig.14, obtain the bus admittance matrix (Y_{BUS}) using the data given:



Lines between nodes	Impedance p.u.	Half of line charging admittance
1 – 2	0.0 + j0.05	j1.25
1 – 3	0.0 + j0.02	J0.50
2 – 3	0.0 + j0.02	J0.50

Shunt reactor at node	Impedance
1 – 2	0.0 + j2.0

15. In a power system, the fuel inputs per hour of plants 1 and 2 are given as

$F_1 = 0.20\ P_{12} + 30\ P_1 + 100$ Rs per hour

$F_2 = 0.25\ P_{22} + 40\ P_2 + 150$ Rs per hour

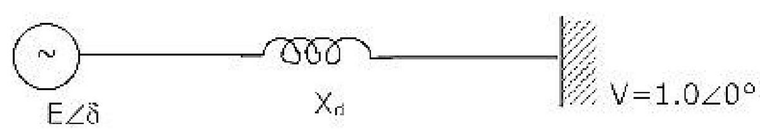
The limits of generators are:

$20 \le P_1 \le 80$ MW

$40 \le P_2 \le 200$ MW

Find the economic operating schedule of generation, if the load demand is 130 MW, neglecting transmission losses.

16. An alternator is connected to an infinite bus as shown in Fig.16. It delivers 1.0 p.u. current at 0.8 pf lagging at V = 1.0 p.u. The reactance X_d of the alternator is 1.2 p.u. Determine the active power output and the steady state power limit. Keeping the active power fixed, if the excitation is reduced, find the critical excitation corresponding to operation at stability limit.



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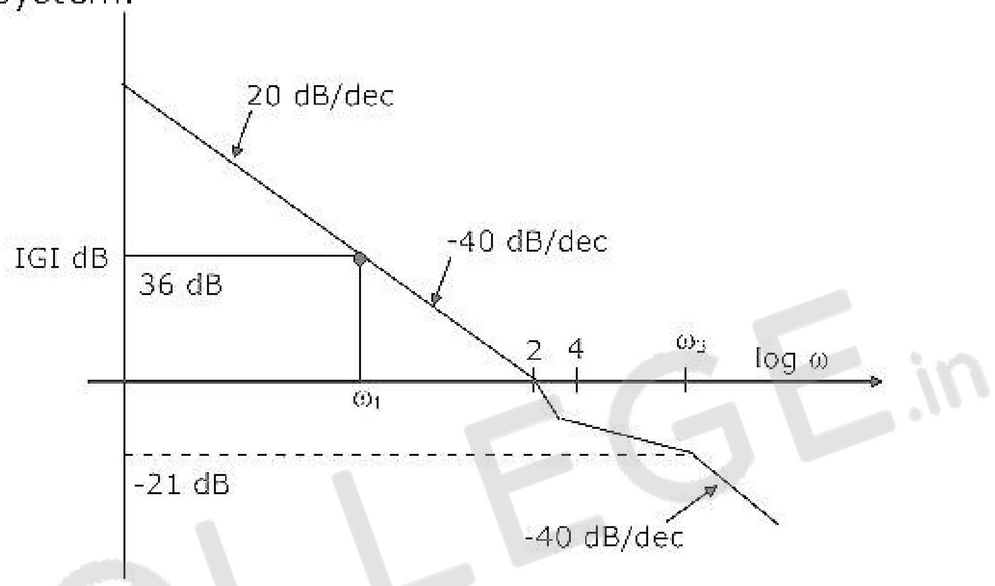
17. The state-space representation of a system is given by:

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-5 & 1\\ -6 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

Find the Laplace transform of the state transition matrix. Find also the value of x_1 at t = 1 if $x_1(0)=1$ and $x_2(0)=0$.

18. The asymptotic magnitude Body plot of a system is given in Fig.18. Find the transfer function of the system analytically. It is known that the system is minimal phase system.



19. Given the differential equation $y'=x+y; y(0)=0$; find y(0.8) using Adam Moulton's predictor corrector method and using a uniform step size h = 0.2. generate the starting values using the solutions of the equations $y=e^x-(1+x)$. Estimate the error in the computed value of y (0.8).

20. $A=\begin{bmatrix}7 & -1 & -1\\ -1 & \frac{9}{2} & \frac{9}{2}\\ -1 & \frac{3}{2} & \frac{9}{2}\end{bmatrix}$. Find the transformation matrix using the householder's method to tridiagonalize A.

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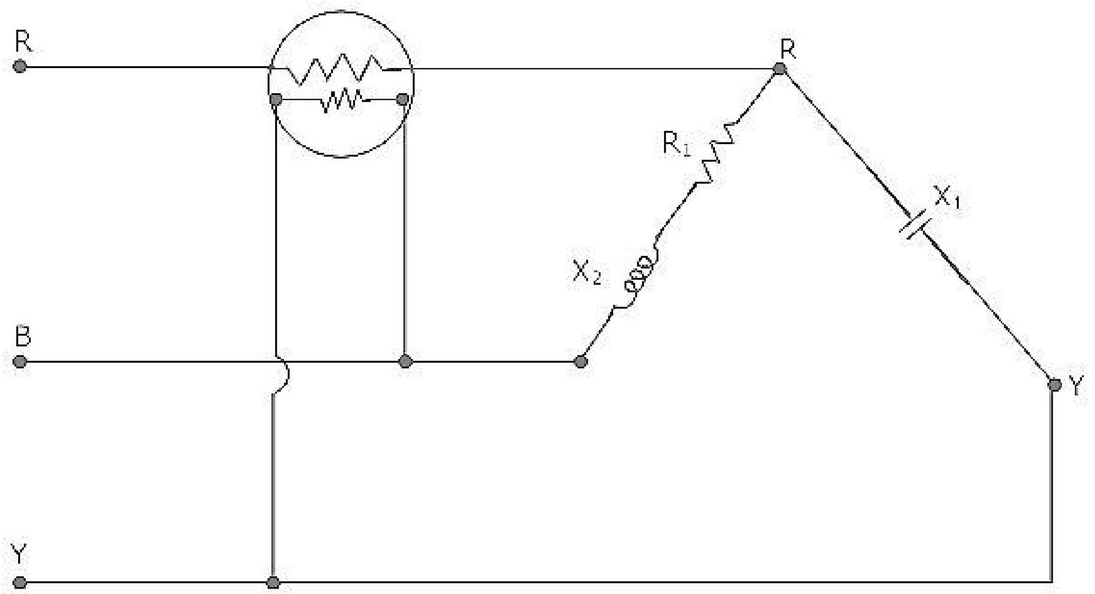
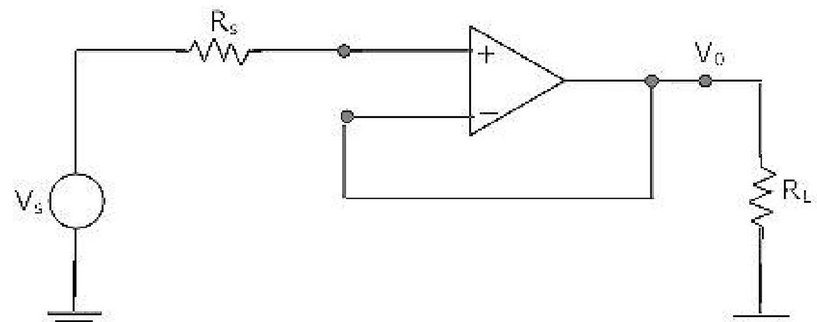
21. A symmetrical 400 V, 3-phase supply is connected to the network shown in Fig.21. the phase sequence is RYB. Find the reading on the wattmeter. $R_1 = 30\Omega; X_1 = 50\Omega$ and $X_2 = 40\Omega$.



22. A moving coil instrument, whose resistance is 5Ω and whose working current (for full-scale deflection) is 0.015 A, is to be used, with a manganin shunt, to measure 100A. Calculate the error caused by a 10° C rise in temperature, if the temperature coefficient of copper and manganin are 0.004 ohm/ohm/°C, and 0.00015 ohm/ohm/°C respectively.

23. In the circuit of Fig.23, R_s = 2kΩ and R = 5Ω. For the op-amp, A = 10^5, R_i = 100 kΩ, and R_0 = 50 Ω.

For V_0 = 10V, calculate v_s and $\frac{V_0}{V_s}$ and estimate the input resistance of the circuit.



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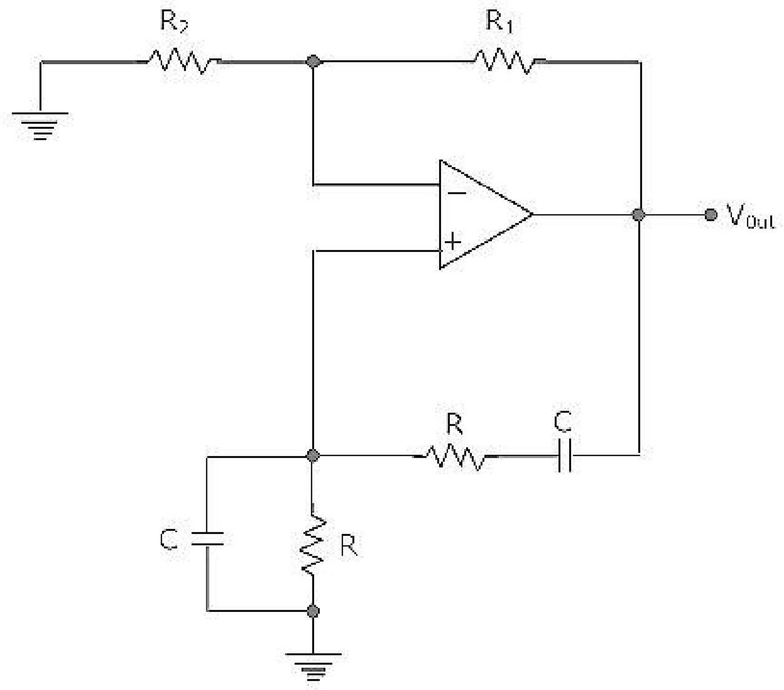
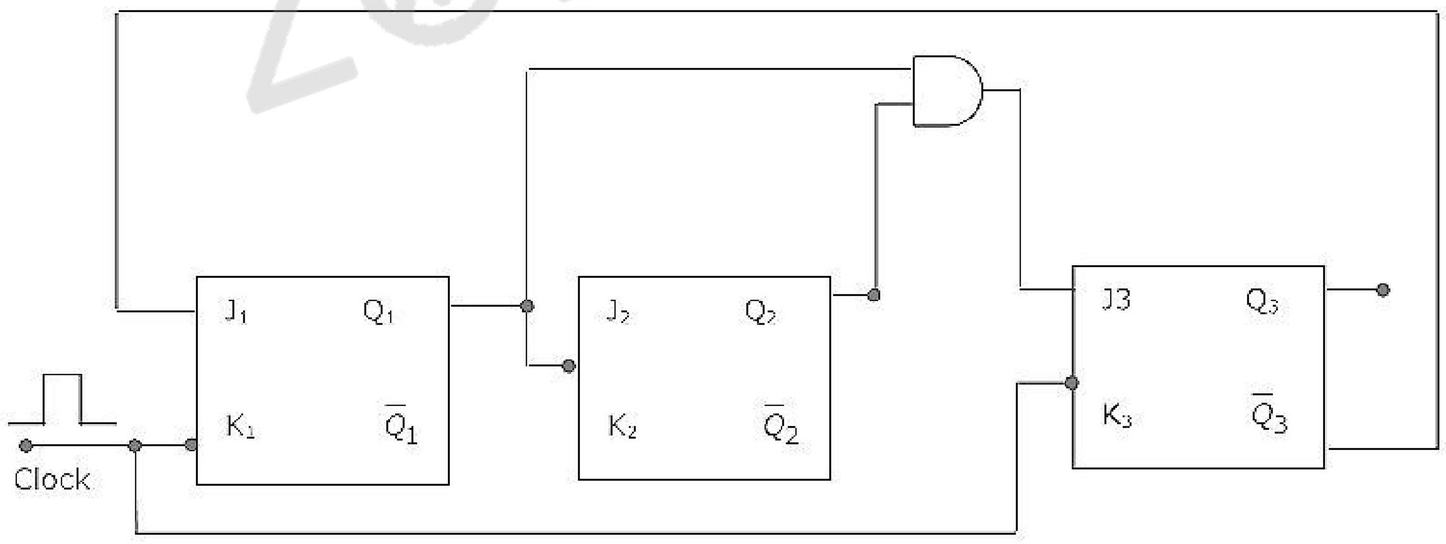
24. Show that the circuit given in Fig.24 will work as an oscillator at $f = \frac{1}{2\pi RC}$, if $R_1 = 2R_2$



25. (a) Construct the truth table for the circuit given in Fig.25. Q_1, Q_2, and Q_3 are outputs and the clock pulses are the inputs. Unused J, K inputs are assumed to be at logic 1. All flip-flops are rest at power ON.

(b) Sketch the output waveforms at Q_1, Q_2, and Q_3.

(c) What function does this circuit perform?



26. In a speed controlled d.c. motor drive, the load torque is 40 Nm. At time t = 0, the operation is under steady state and speed is 500 rpm. Under this condition at $t = 0^+$, the generated torque is instantly increased to 100 Nm. The inertia of the drive is 0.01 Nm sec^2/rad. The friction is negligible.

(a) Write down the differential equation governing the speed of the drive for t>0.

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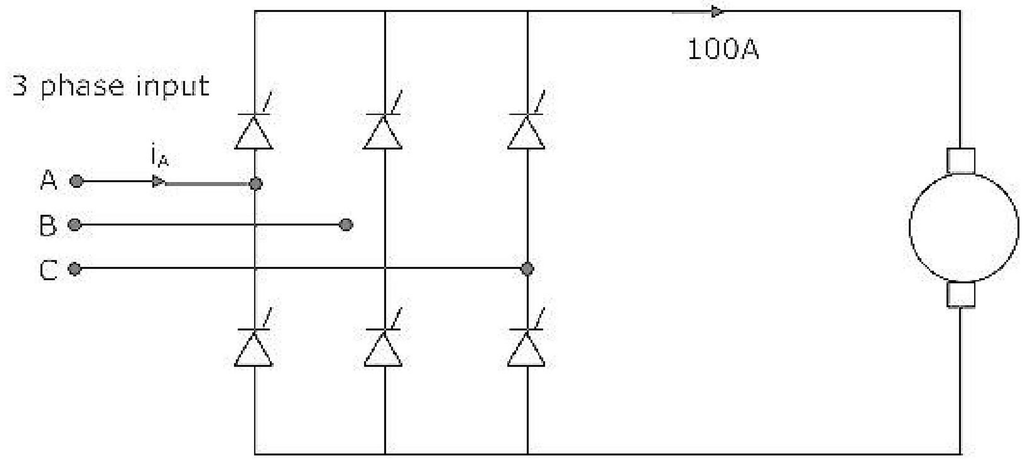
27. A d.c. motor driven from a fully controlled 3 phase converter shown in Fig.27, draws a d.c. current of 100 A with negligible ripple.

(a) Sketch the a.c. line current i_A for one cycle

(b) Determine the 3rd and 5th harmonic component of the line current as a percentage of fundamental current.



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