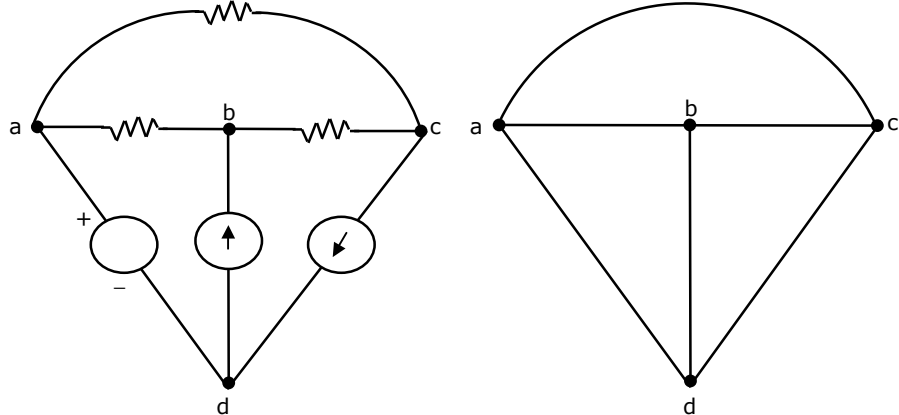## SECTION - A

1. Each statement below is accompanied by several answers of which only one is correct. Indicate the correct answer. Each question carries ONE mark.

1.1 Figure below shows a d.c. resistive network and its graph is drawn aside. A 'proper tree' chosen for analyzing the network will contain the edges.

(a) ab, bc, ad

(b) ab, bc, ca

(c) ab, bd, cd

(d) ac, bd, ad

1.2 At resonance, the parallel circuit of figure (below) constituted by an iron-cored coil and a capacitor behaves like

(a) an open-circuit

(b) a short-circuit

(c) a pure resistor of value R

(d) a pure resistor of value much higher than R
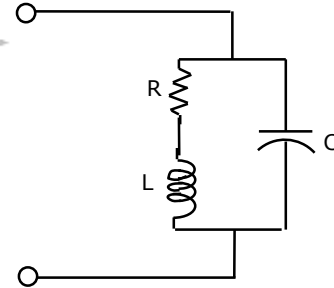
1.3 If a two-port network is passive, then we have, with the usual notation, the following relationship

(a) $h_{12} = h_{21}$

(b) $h_{12} = -h_{21}$

(c) $h_{11} = h_{22}$

(d) $h_{11}.h_{22} - h_{12}.h_{21} = 1$

1.4 When a charge is given to a conductor

(a) it distributes uniformly all over the surface

(b) it distributes uniformly all over the volume

(c) it distributes on the surface, inversely proportional to the radius of curvature

(d) it stays where it was placed

1.5 When a transformer winding suffers a short-circuit, the adjoining turns of the same winding experience

(a) an attractive force   (b) a repulsive force

(c) no force   (d) none of the above

1.6 Skew is used in induction motors in order to reduce torque due to

(a) time harmonics   (b) space harmonics

(c) slot harmonics   (d) reverse rotating fields

1.7 Two transformers of identical voltages but of different capacities are operating in parallel. For satisfactory load sharing

(a) impedances must be equal

(b) per unit impedances must be equal

(c) per unit impedances and $\dfrac{X}{R}$ ratios must be equal

(d) impedances and $\dfrac{X}{R}$ ratios must be equal

1.8 In a 400 kV network, 350 kV is recorded at a 400 kV bus. The reactive power absorbed by a shunt rated for 50 MVAR, 400 kV connected at the bus is

(a) 61.73 MVAR   (b) 55.56 MVAR   (c) 45 MVAR   (d) 40.5 MVAR

1.9 HVDC Transmission is preferred to EHV – AC because

(a) HVDC terminal equipment are inexpensive

(b) VAR compensation is not required in HVDC systems

(c) system stability can be improved

(d) Harmonics – problem is avoided

1.10 The matrix of any state-space equations for the transfer function $C(s)/R(s)$ of the system, shown below in figure, is:

(a) $\begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$
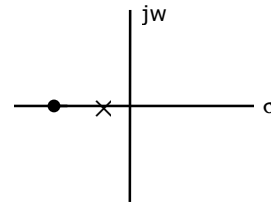
(b) $\begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix}$

(c) $\begin{bmatrix} -1 \end{bmatrix}$
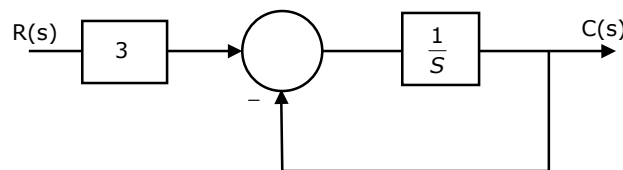
(d) $\begin{bmatrix} 3 \end{bmatrix}$

1.11   The pole-zero configuration of a phase-lead compensator is given by

(a)
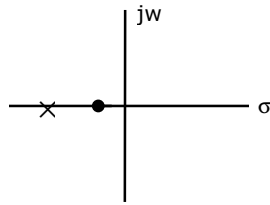
(b)

(c)

(d)
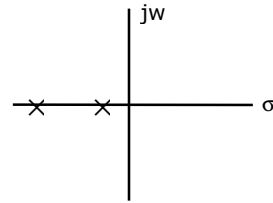

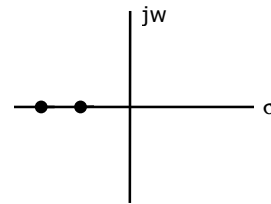
1.12   A 5×7 matrix has all its entries equal to -1. The rank of the matrix is

(a) 7   (b) 5   (c) 1   (d) zero

1.13   The eigen values of the matrix $\begin{bmatrix} a & 1 \\ a & 1 \end{bmatrix}$ are

(a) $(a+1), 0$ (b) $a, 0$ (c) $(a-1), 0$ (d) $0, 0$

1.14   A 0-10 mA PMMC ammeter reads 4 mA in a circuit. Its bottom control spring snaps suddenly. The meter will now read nearly

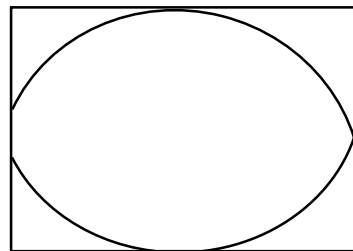(a) 10 mA   (b) 8 mA   (c) 2 mA   (d) zero

1.15   A Lissajous pattern, as shown in figure below, is observed on the screen of a CRO when voltages of frequencies f_x and f_y are applied to the x and y plates respectively. $f_x : f_y$ is then equal to

(a) 3 : 2

(b) 1 : 2

(c) 2 : 3

(d) 2 : 1

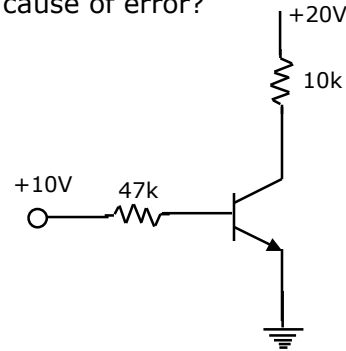1.16   The number of comparisons carried out in a 4-bit flash-type A/D converter is:

(a) 16   (b) 15   c)   4   (d) 3

1.17 In the transistor circuit shown in figure below, collector-to-ground voltage is +20V. Which of the following is the probable cause of error?

(a) Collector-emitter terminals shorted

(b) Emitter to ground connection open

(c) 10kΩ resistor open

(d) collector-base terminal shorted

1.18 The contents of the accumulator in an 8085 microprocessor is altered after the execution of the instruction.

(a) CMPC   (b) CPI 3 A   (c) ANI 5 C   (d) ORA A

1.19. A switched mode power supply operating at 20 kHz to 100 kHz range uses as the main switching element

(a) Thyristor   (b) MOSFET   (c) Triac   (d) UJT

1.20. Referring to the figure below, the type of load is:
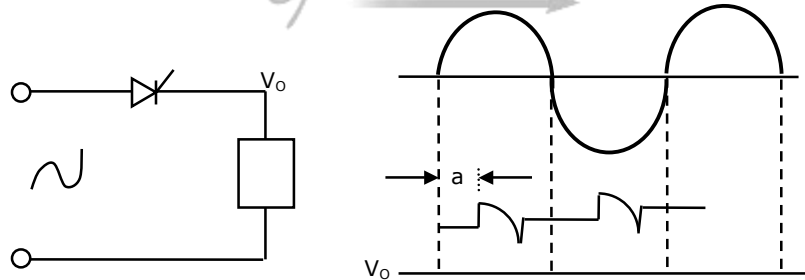
(a) inductive load   (b) resistive load

(c) dc motor   (d) capacitive load

2. Indicate whether the following statements are TRUE or FALSE. Write the indicating work fully and legibly. A 'FALSE' answer must be accompanied by a very brief (preferably one or two sentences) justification. Each correct answer carries ONE mark

2.1 Superposition principle is not applicable to a network containing time-varying resistors.

2.2. In electrostatic field $\Delta \times \vec{E} \equiv 0$

2.3. Static magnetic fields induce current in closed conducting loops.

2.4.   A 3-phase induction motor coupled to a pump is operating at normal speed. If one line gets disconnected, the motor stops.

2.5.   In a power system, the 3-phase fault MVA is always higher than the single-line-to-ground fault MVA at a bus.

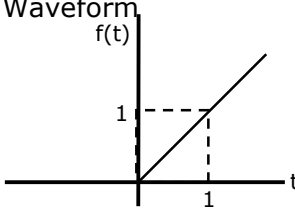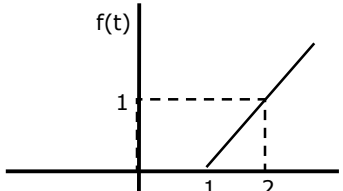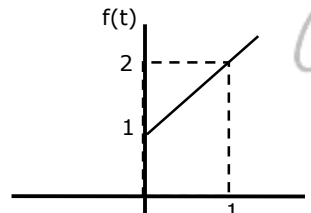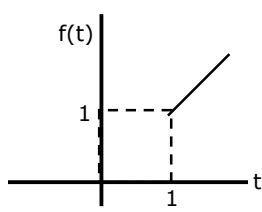2.6.   The charging current of a 400 kV transmission line is more than that of a 220 kV line of the same length.

2.7.   The closed loop system, of figure shown below, is stable if the transfer function $T(s) = \dfrac{C(s)}{R(s)}$ is stable.
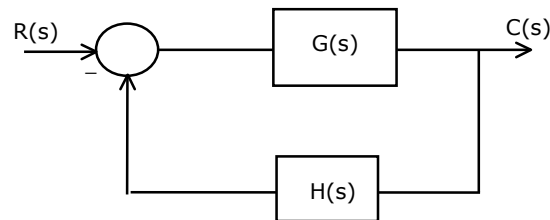
2.8.   If two vectors u and v in a plane are linearly independent, then, they can not be collinear.

2.9.   The value of X, after the execution of the last line of the following Fortran routine is 2.0.

$$X = 2.0 \qquad I = 3/(4 - x) + 1.2 \qquad X = 1$$

2.10.   A precise measurement guarantees accuracy of the measured quantity.

2.11.   A piezo-elecric pickup is an example for an active transducer.

2.12.   A practical R-C sinusoidal oscillator is built using a positive feedback amplifier with a closed loop gain slightly less than unity.

2.13.   An analog comparator is a high-gain amplifier whose output is always either in positive or in negative saturation.

2.14.   A line-commutated inverter changes dc voltage to ac voltage.

2.15.   The output voltage of a six-pulse double star rectifier is the same as that of a three phase half-wave rectifier.

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3.   In each of the following problems, there are Four items on the left hand side (marked A, B, C, D) and Six items on the right hand side (marked P, Q, R, S, T, U). Pick the items from the right hand side which match properly with the items on the left hand side and write as a matched pair (such as B → T). Each proper matching carries one mark. (Note that in each problem, there will be only four such pairs).

3.1.   Match the waveforms on the left-hand side with the correct mathematical description listed on the right hand side.

Waveform $f(t)$

(a)

(P) $t.u(t-1)$

(b)

(Q) $(t+1).u(t-1)$

(c)

(R) $t.u(t)$

(d)

(S) $(t+1).u(t)$

(T) $(t-1).u(t)$

(U) $(t-1).u(t-1)$

3.2.   Match the appropriate item from the right hand side with those on the left hand side.

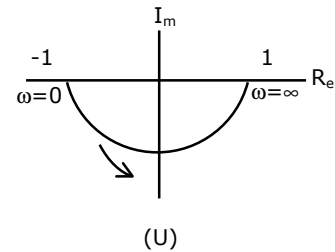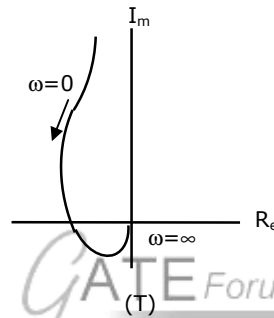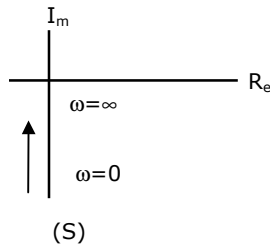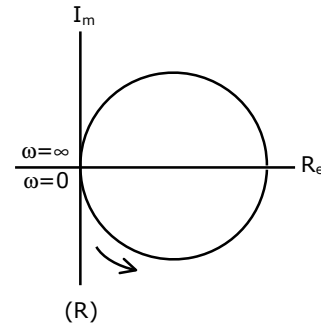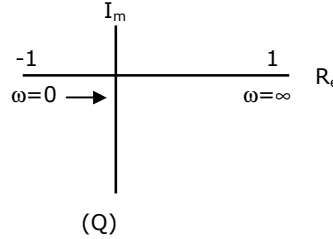| (A) Line charge	(P) Maxwell
(B) Magnetic Flux Density	(Q) Poynting's Vector
(C) Displacement current	(R) Transmission line conductors
(D) Power flow	(S) Biot-Savart's law
	(T) Gauss's law
	(U) Faraday's law

3.3.   Match the polar plots for the following functions with the below given figures.

(a) $\dfrac{s}{(s+1)(s+2)}$ (b) $\dfrac{s^2+1}{s^3}$ (c) $\dfrac{s^2-1}{S^2+1}$ (d) $\dfrac{1}{s^2+10}$

(P)

(Q)

(R)

(S)

(T)

(U)
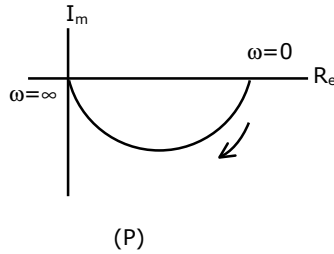
3.4.   Figure below shows a two-stage small signal transistor feedback amplifier. Match the defective component (listed on the left hand side below) with its probable effect on the circuit (listed on the right hand side below)

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(A) capacitor C_1 is open

(B) Capacitor C_3 is open

(C) Capacitor C_4 is open

(D) RC_2 is shorted

(P) All dc voltages normal, v_o increases marginally

(Q) Collector of TRZ is at $V_{CC}, v_o = 0$

(R) All dc voltages normal, gain of 2nd stage increases, v_o decreases

(S) All dc voltages normal, $v_o = 0$

(T) All dc voltages normal, overall gain of the amplifier increases, v_o increases

(U) No change

3.5.   Match the items on the right hand side with those on left hand side

(A) Communication

(B) V-Curves

(C) Free wheeling diode

(D) Overlap

(P) Resistive load

(Q) Inductive load

(R) Capacitive load

(S) Interpole

(T) Source Inductance

(U) Synchronous motor

4.   Fill in the blanks with the correct answer.

4.1.   In the circuit below, the voltage $\overline{V}_s$ has a phase angle of _____ with respect to $\overline{V}_s$.
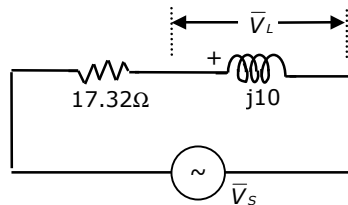
4.2.   A set of 3 equal resistors, each of value R_x, connected in star across RYB of figure below consumes the same power as the unbalanced delta-connected load shown. The value of R_x is _____
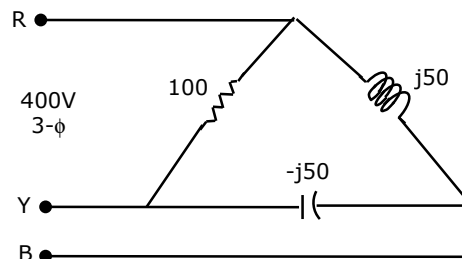
4.3.   A hallow conductor is at a potential V. The potential at any point inside the hollow is _____

4.4.   The inductance of a coil is proportional to the _____ of the number of turns, all other parameters remaining the same.

4.5.   A six pole 50 Hz induction motor rotating at 1400 rpm is in _____

4.6.   In a variable frequency induction motor drive, the voltage must be varied _____ to the frequency.

4.7.   In a system, there are two generators operating in parallel. One generator, of rating 250 MVA, has an inertia-constant of 6 MJ/MVA while the other generator of 150 MVA has an inertia-constant of 4 MJ/MVA. The inertia-constant for the combined system on 100 MVA common base is _____ MJ/MVA.

4.8.   The increase in resistance due to non-uniform distribution of current in a conductor is known as _____ effect.

4.9.   The number of positive real roots of the equations $s^3 - 2s + 2 = 0$ is_____

4.10.   If $f(t)$ is the step-response of a linear time-invariant system, then its impulse response is given by _____.

4.11.   The number of linearly independent solutions of the system of equations
$$\begin{bmatrix} 1 & 0 & 2 \\ 1 & -1 & 0 \\ 2 & -2 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = 0, \text{ is equal to } \rule{3cm}{0.4pt}$$

4.12.   The value of the integral $\int\limits_{-5}^{+6} e^{-2t}\partial(t-1)dt$ is equal to _____

4.13.   The light load adjustment is carried out on a single-phase house-service energy meter under _____power factor conditions.

4.14.   _____ torque is not provided in an electromagnetic flux meter.

4.15. Figure below, shows a non-inverting op-amp summer with $V_1 = 2V$ and $V_2 = -1V$. The output voltage $V_0 = $ _____
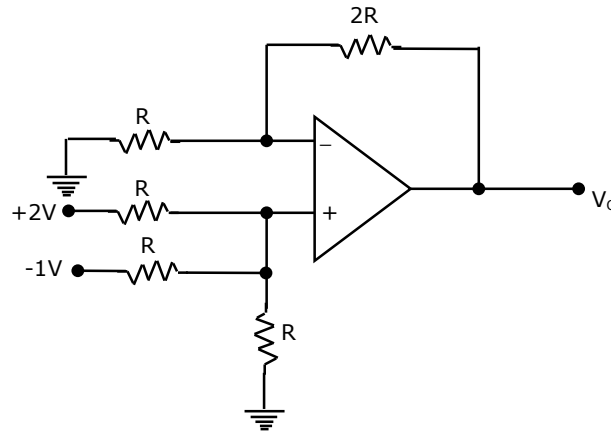
4.16. The stack pointer of a microprocessor is at A$\phi\phi$1. At the end of execution of following instructions, the value of stack pointer is _____.

PUSH	PSW
X	THL
PUSH	D
JMP FC	70 H

4.17. A triac can be triggered by a gate pulse of _____ polarity.

4.18. Thyristor circuits that directly convert polyphase ac voltages from one frequency to another frequency are called _____.

6. There are two concentric conducting spherical surfaces of radii, a, b, (a < b). the inner spherical surface carries a charge Q and the outer surface is grounded. What is the potential of the inner spherical surface?

7. A 440 V, dc shunt motor has a no-load $(I_a = 0)$ speed of 2000 rpm. It is running at 1000 rpm at full load torque, reduced armature voltage and full field. If load torque is reduced to 50% of rated value with armature voltage and field voltage held constant at previous values, the speed increases to 1050 rpm. Find the armature voltage drop at full load. (Neglect effect of armature reaction.

8. A function $f(x)$ has values at distinct points $x_i, i = 0,1,2,3...$ as shown in the table below:

x	$x_0 = 1$	$x_1 = 2$	$x_2 = 3$	$x_3 = 4$
$f(x)$	1	0	-1	-2

Construct the forward difference table from this data and find the value of $f(x)$ at $x = 1.5$ using the Newton's forward difference form.

9.   (a) The circuit, shown below, shows a feedback amplifier. Let $R_s = R_e = 1 \text{ k}\Omega$, $R_c = 4 \text{ k}\Omega$. The transistor parameters are $h_{ie} = 2 \text{ k}\Omega$, $h_{fe} = 200$ and $h_{re} = h_{oe} = 0$. Assume that the inverting amplifier input resistance is infinite and gain $A_V = -2000$. Let the feedback factor $\beta = \dfrac{1}{150}$. Find the gain of amplifier $A_{vf} = \dfrac{V_o}{V_s}$.
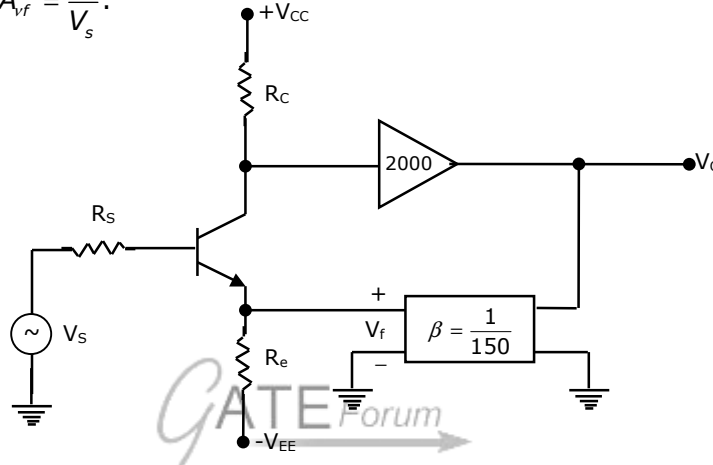

(b) Figure below shows an op-amp amplifier. Find the output voltage in steady state condition where

(i)   switch S is open

(ii) switch S is closed
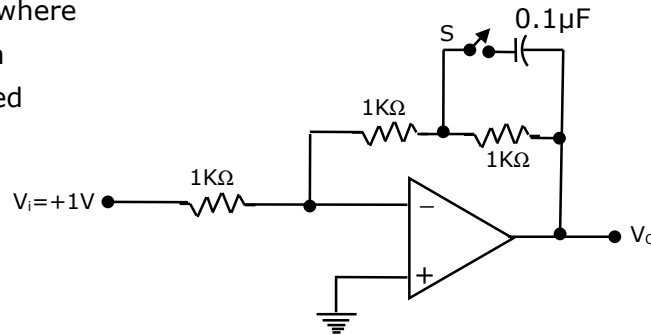
SECTION – B
Answer any TEN questions in this section.

10. A 159.23μF capacitor is in parallel with a resistance R draws a current of 25A from 300 V, 50 Hz mains. Using phasor diagrams, find the frequency f at which this combination draws the same current from a 360 V mains.

11. The network N, in figure (a) and (b) is passive and contains only linear resistors. The port currents in figure (a) are as marked. Using these values and the principles of superposition and reciprocity, find I_x in figure (b).

(a)   (b)
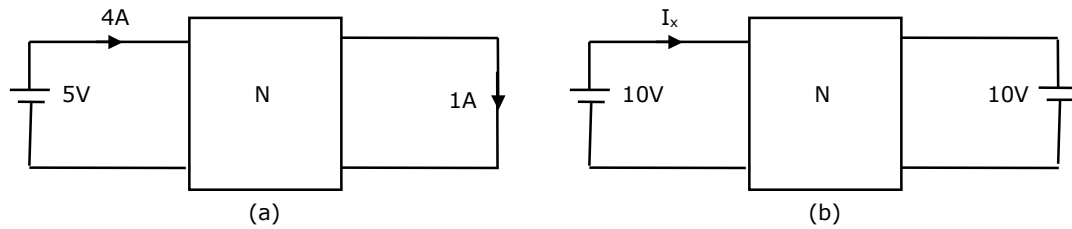
12. Find the rms value of the voltage $v_{ab}(t)$ in the circuit of figure. If $v_s = \left(240\sqrt{2}\sin t + 70\sqrt{2}\cos 3t\right)$ volts.
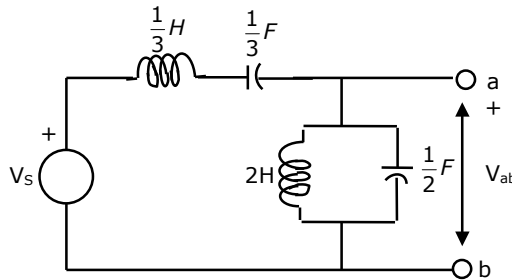
13. (a) State Faraday's law of induction.
   (b) A rectangular loop of sides a, b has its plane normal to a magnetic flux density of strength $B_0 \sin \omega t$. What is the voltage induced in the above loop?

14. A charge Q is uniformly distributed along a circular filament of radius a. Deduce the electric field intensity at the centre.

15. Short circuit test is conducted on a 5 kVA, 400 V/100 V single phase transformer with the 100 V winding shorted. The input voltage at full load current is 40 V. The wattmeter on the input side reads 250 W. Find the power factor for which regulation at full load is zero.

16. A three phase induction motor rated at 400 V, 50 Hz, coupled to a pump, is running at a low power factor of 0.6. The input is 4.5 kVA. It is proposed to improve the power factor to 0.8 by connecting a delta connected capacitor bank. Find the value of the capacitor per phase.

17. The single line diagram of a network is shown in figure. The line series reactance is 0.001 p.u. per km and shunt susceptance is 0.0016 p.u. per km. Assemble the bus admittance matrix (Y_{Bus}) of the network, neglecting the line resistance.
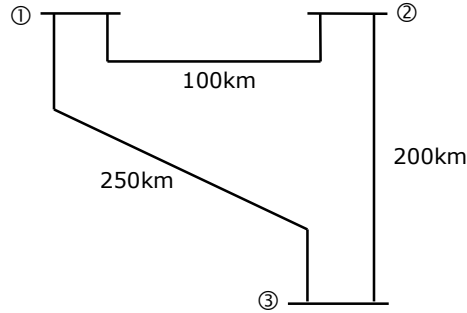
18.   A 250 MVA, 11 kV, 3 phase generator is connected to a large system through a transformer and a line as shown in figure below.
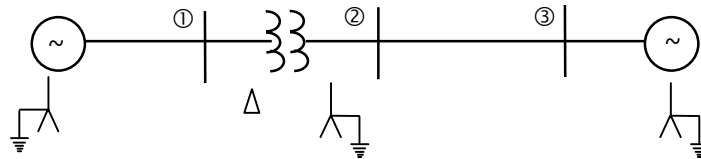
The parameter, on 250 MVA base, are as follows:

Generator   : $X_1 = X_2 = 0.15$ p.u, $X_0 = 0.1$ p.u

Transformer   :   11/220 kV, 250 MVA

$X_1 = X_2 = X_0 = 0.12$ p.u.

Line   : $X_1 = X_2 = 0.25$ p.u., $X_0 = 0.75$ p.u.

Equivalent system : $X_1 = X_2 = X_0 = 0.15$ p.u.

(a) Draw the sequence network diagram for the system and indicate the p.u. reactance values.

(b) Find the driving point impedances of node 2.

(c) Find the fault MVA for a single line to ground fault at node 2. assume the pre-fault voltages at all the nodes to be 1.0 p.u.

19.   The following is the state space dynamic model of a linear system whose eigen values are -3, -2, -1.

$$X = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$$

Given that $u = 0, x(0) = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}^T$. Find $x(t)$.

20. The asymptotic Bode plot of a minimum phase linear system is given in figure below. Determine its transfer function.
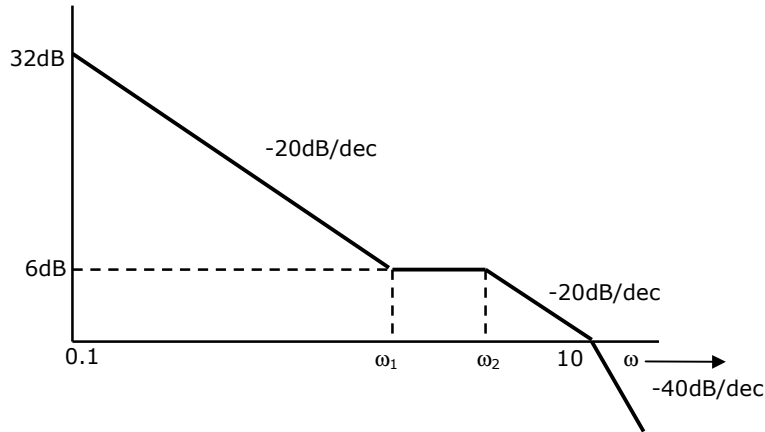
21. When does a linear system of equations. Ax = b (Where A is an n $\times$ n matrix, x and b are n $\times$ 1 vectors) has

    (1) a unique solution

    (2) no solution; and

    (3) an infinite number of solutions?

    Find all the solutions of the equations:

$$x_2 - x_3 - x_4 = 1$$
$$2x_1 - x_4 = 0$$
$$x_1 + 2x_2 + x_4 = 0$$
$$x_2 - x_4 = 1$$

    Use only the Gaussian elimination method on the rows, to simplify the system to triangular form.

22. Consider the function $f(x) = \sin x + x + 0.1$

    Write a flow chart on an algorithm or steps of a computer program to locate a root of $f(x)$ between $-\dfrac{\pi}{2}$ and 0 correctly upto 3 decimal places.

23. The following data refer to measurement in a single phase ac load.

| Instrument	Reading	Full scale value	Maximum uncertainty as % of full scale
Voltmeter	200 V	240 V	1
Ammeter	2 A	2A	0.5
Wattmeter	320 A	480 A	1.0

    Find the power factor of the load and estimate the maximum percentage uncertainty in the value obtained.

24. A $4\frac{1}{2}$ digit, 0 – 2 VDVM employs an 8-bit successive approximation register.
Trace the contents of the register at the end of each comparison when a voltage of 0.85 V is applied. What is the final reading?

25. (a) Write the truth-table for the logic circuit shown in figure below. Write the Boolean equation for the output Y.
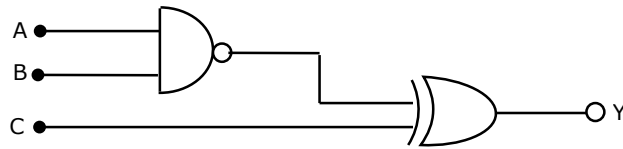

(b) Four J-K Flip-Flops are connected as shown in figure. Write the truth table for the count sequence. Find the modulo counter it represents.
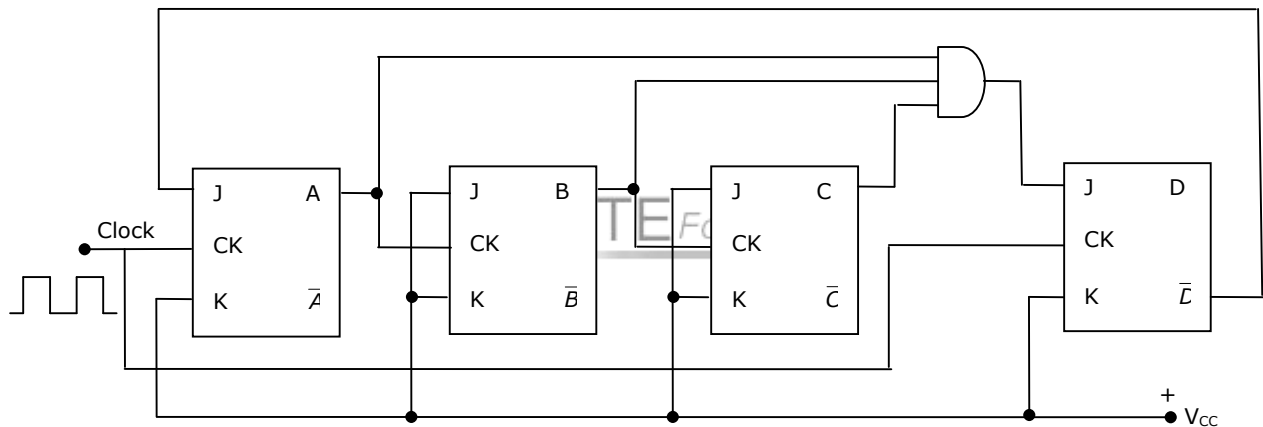
26. Design the Zener voltage regulator, shown in figure below, to meet the following specifications:

Load voltage = 6.8 V, Source Voltage V_s is 20 V ± 20% and Load current is 30 mA ± 50%. The Zener requires a minimum current of 1 mA to break down. The diode D has a forward conducting voltage of 0.6 V.
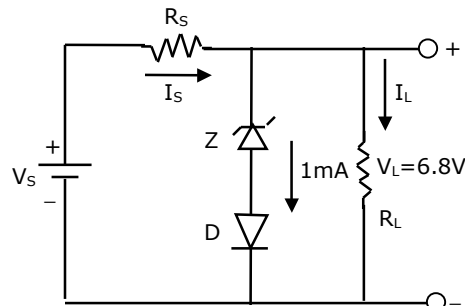
27.   Draw a one-shot mono using 555 linear IC. It is triggered by a 100 Hz ± 1ms pulse. Show the output waveform with a pulse width of 5 ms.

28.   The phase controlled rectifier, shown in figure below, is operating at α = 45° and load current at steady state is constant at I_d. Neglecting source-impedance.
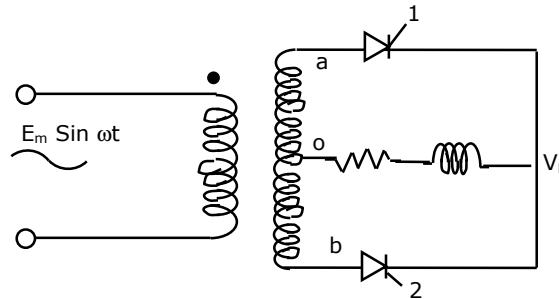
(i)   Draw the output voltage

(ii) Device currents

(iii) Voltage across the thyristor 1

29.   The chopper circuit, shown in figure below, is operating at $K_d = 0.5$ at 100 Hz. The load current is continuous at steady state but varies between 10 A and 3A. Draw the following wave shapes of currents through,

(i)   load (i_L)

(ii) free wheeling diode (i_f)

(iii) commutation capacitor (i_c)

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