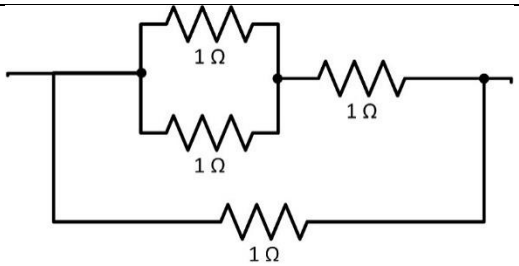
SASTRA DEEMED TO BE UNIVERSITY (U/S 3 OF THE UGC ACT, 1956) THINK MERIT | THINK TRANSPARENCY | THINK SASTRA	**School of Electrical and Electronics Engineering** **CIA III Examinations January 2023** Course Code: EEE104 (CSBS) Course Name: Principles of Electrical Engineering Duration: 90 minutes Max Marks: 50

PART A **10 x 2 = 20 Marks**

1.	**Using only 470 Ω resistors, synthesize an equivalent resistance of 282 Ω. Use no more than four 470 Ω resistors. Draw the circuit diagram.**
	 Use 470 in place of 1 Ω
2.	**A balanced three-phase system with a line voltage of 300 V is supplying a balanced Y-connected load with 1200 W at a leading power factor of 0.8. Find the line current and the per-phase load impedance.**
	$P = VI\cos\theta$ $\frac{1200}{3} = \frac{300}{\sqrt{3}} \times I \times 0.8$ $I = 2.89A$ **(1 mark)** Phase angle $\theta = \cos^{-1}(0.8) = 36.86°$(lagging) Load Impedance $\lvert Z_p \rvert = \frac{V}{I_L} = 60\ \Omega$ **(1 mark)**
3.	**A transformer steps up the voltage from primary to secondary in the ratio of 1:10. Can we expect the output power to be the same as the input power?**
	Output power will be same as input power for an ideal transformer.
4.	**Classify secondary measurement instruments based on their functions.**
	• Indicating instruments • Integrating instruments • Recording instruments
5.	**If 5A, 10A and 13A fuses are available, state which is most appropriate for the following appliances which are both connected to a 240V supply.** **(a) Electric toaster having a power rating of 1kW** **(b) Electric heater having a power rating of 3kW.**

(a) For the toaster,

$$\text{current } I = \frac{P}{V} = \frac{1000}{240} = \frac{100}{24} = 4.17\text{ A}$$

Hence a **5A fuse** is most appropriate

(b) For the fire,

$$\text{current } I = \frac{P}{V} = \frac{3000}{240} = \frac{300}{24} = 12.5\text{ A}$$

Hence a **13A fuse** is most appropriate

PART B **3 x 10 = 30 Marks**

6.

A.) The core of a 100kVA, 11000/550 V, 50 Hz, single phase core-type transformer has a cross section of $20cm \times 20cm$. Find the following:

a. Number of primary turns per phase

$$E_p = 4.44 \times f \times N \times B \times A$$

$$11000 = 4.44 \times 50 \times N_1 \times 1.3 \times 400 \times 10^{-4}$$

$\boldsymbol{N_1 = 1060}$ **(3 marks)**

b. Voltage and current transformation ratio

$$k_v = \frac{V_2}{V_1} = \frac{550}{11000} = \mathbf{0.05}$$

Primary current $I_1 = \frac{100*10^3}{11000} = 9.09\ A$

Secondary current $I_2 = \frac{100*10^3}{550} = 181.82\ A$

$k_I = \frac{I_1}{I_2} = \frac{9.09}{181.82} = \mathbf{0.05}$ **(3 marks)**

c. EMF per turn if the maximum core density is not to exceed 1.3 Tesla

EMF/turn = $\frac{11000}{1060} = \frac{550}{53} = \mathbf{10.4\ V}$ **(3 marks)**

B.) Write short notes on types of earthing. (5 marks).

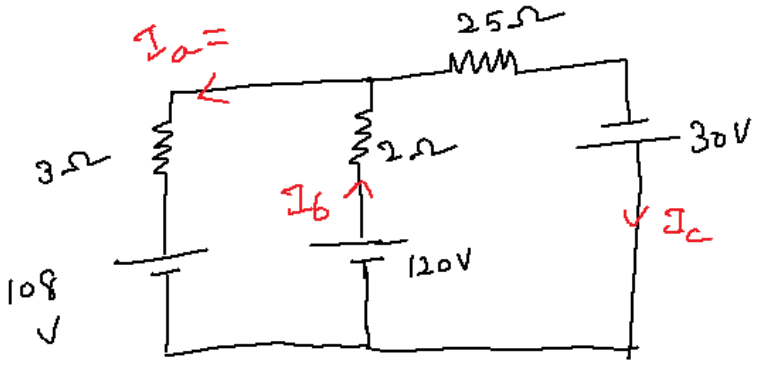
- Plate earthing
- Pipe earthing
- Rod earthing

Explanation of each type basic components used**.**

7. State Kirchhoff's laws as applied to an electrical circuit. Two batteries A and B are joined in parallel. Connected across the battery terminals is a circuit consisting of a battery C in series with a 25 Ω resistor, the negative terminal of C being connected to the positive terminals of A and B. Battery A has an e.m.f. of 108 V and internal resistance of 3 Ω, and the corresponding values for battery B are 120 V and 2 Ω. Battery C has an e.m.f. of 30 V and a negligible internal resistance. Determine:

i. the value and direction of the current in each battery (5 Marks)

ii. the terminal voltage of battery A. (5 Marks)



$I_a = 0.183\ A$ $\quad V_a = 108.55\ V$

$I_b = 5.73\ A$

$I_c = 5.54\ A$

8. **A.)** It has been observed that two different circuits have the same time constant of 0·005 second. The first circuit is an R-L series circuit, and the second one is an R-C series circuit with a known resistance of 2 $M\Omega$. With the constant DC supply of 10 V applied to the two circuits, it is found that the steady-state current of the circuit is 2000 times the initial current of the circuit. Find unknown resistor, inductor and capacitor values. (5 Marks)

Solution. The time constant for both the circuits is 0·005 s.

$$\therefore \quad R_2C = 0{\cdot}005 \quad \text{or} \quad C = \frac{0.005}{R_2}$$

$$\therefore \quad C = \frac{0.005}{2\times10^6} = 0{\cdot}0025 \times 10^{-6}\ \text{F} = \mathbf{0{\cdot}0025\ \mu F}$$

Steady state current in Fig. 9.41 $(i) = V/R_1 = 10/R_1$

Initial current in Fig. 9.41 $(ii) = V/R_2 = 10/2 \times 10^6 = 5 \times 10^{-6}$ A

As per statement of the problem, we have,

$$10/R_1 = 2000 \times (5 \times 10^{-6}) \quad \therefore \quad R_1 = \mathbf{1000\ \Omega}$$

Now $\quad L/R_1 = 0{\cdot}005 \quad \therefore \quad L = 1000 \times 0{\cdot}005 = \mathbf{5\ H}$

B.)Write short notes on different transducers used to measure electrical signals. (5 marks)

Explanation on capacitive, LVDT inductive, potentiometric, and piezoelectric transducer - any two with explanation

9. **A.) Compare moving coil and moving iron instruments.(5 marks)**

Particular	**Moving coil**	**Moving iron**
Construction	Delicate construction	Simple
Cost	Very high	Low
Power consumption	Very low	Less than dynamometer type
Scale	Uniform	Non-uniform
Torque-weight	High	More than dynamometer
Suitable for	D.C. only	D.C. as well as A.C.
Effect of stray	Not affected	Not affected

magnetic fields			
Accuracy and Sensitivity	High	Reasonable	

B.) A homeowner consumes 700 kWh in January. Determine the electricity bill for the month using the following residential rate schedule:

Base monthly charge of 45.00 rupees
First 100 kWh per month at 2.50 rupees/kWh.
Next 200 kWh per month at 3.5 rupees/kWh.
Over 300 kWh per month at 5 rupees/kWh.

Calculate the average cost per kWh if only 350 kWh are consumed in July when the family is on vacation most of the time. (10 marks)

Ans:

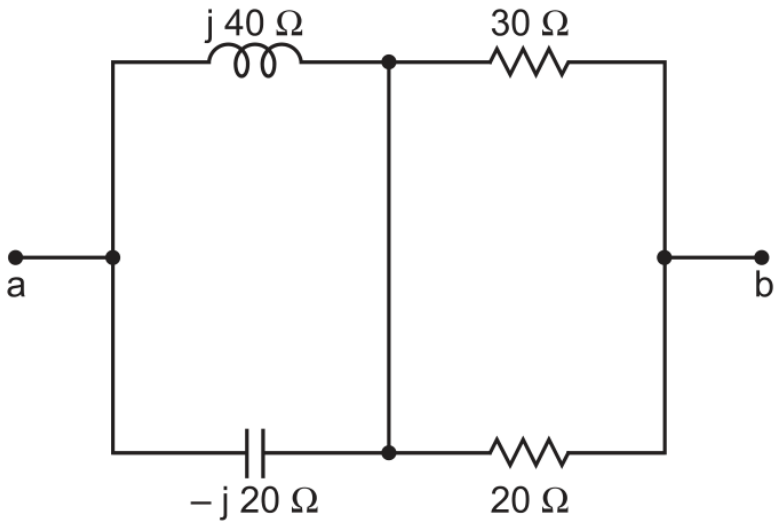
Case (i) (5 marks)

- Base monthly charge =45 rupees
- First 100 kWh @ **2.50 rupees/kWh** = 250 rupees
- Next 200 kWh @ **3.5 rupees/kWh** =700 rupees
- Remaining 400 kWh @ **5 rupees/kWh=**2000 rupees
- Total charge = 45+250+700+2000= 2995 rupees

Case (i) (5 marks)

- Base monthly charge =45 rupees
- First 100 kWh @ **2.50 rupees/kWh** = 250 rupees
- Next 200 kWh @ **3.5 rupees/kWh** =700 rupees
- Remaining 50 kWh @ **5 rupees/kWh=**250 rupees
- Total charge = 45+250+700+250= 1245 rupees

10. A service technician attending an appliance failure at home accidentally short-circuited two terminals left open during wiring. The short circuit eventually led to the tripping of the miniaturized circuit breaker in the lab. After tracing the wiring in the home, the service technician identified the equivalent circuit for the home connection, as shown in **Error! Reference source not found.**, where the terminals 'a-b' is the exact point which was short-circuited. Assume yourself as a service technician and deploy a suitable network theorem to identify the magnitude of the short circuit current between the terminals 'a-b'. Comment on the rating of the circuit breaker to handle the short-circuit current. (10 marks)



$$V_a = \frac{250\angle 0°}{j40 - j20} \times (-j20) = -250\angle 0° \text{ V}$$

$$V_b = \frac{250\angle 0°}{30 + 20} \times 20 = 100\angle 0° \text{ V}$$

$$V_{Th} = V_a - V_b = -250\angle 0° - 100\angle 0° = -350\angle 0° \text{ V}$$

$$Z_{Th} = (j40 \| -j20) + (30 \| 20)$$

$$= \frac{(j40)(-j20)}{j40 - j20} + \frac{30 \times 20}{30 + 20} = (12 - j40)\ \Omega$$

$$I_{sc} = \frac{V_{Th}}{Z_{Th}} = \frac{-350}{12 - j40} = \frac{-350}{41.76\angle -73.3°}$$

$$= \mathbf{8.38\angle 73.3° \text{ A } \textit{from b to a}}$$