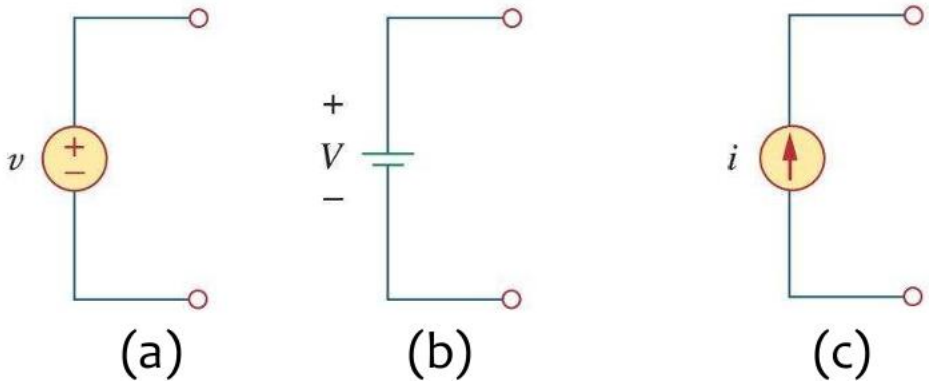
MARKING GUIDE FOR CAT FOR ELECTRICAL CIRCUIT ANALYSIS

SECTION A:

1. A) A **short circuit** is a circuit element with resistance approaching zero, which leads to the over current. An **open circuit** is a circuit element with resistance approaching infinity, which leads to zero current passing (discontinuity).**(/4marks)**

   B) If the $X_c = \frac{1}{2\pi fC}$, where X_c is the capacitive reactance, C is the capacitor and f is the frequency, when f is very large, then the capacitive reactance will be tend to zero, which is a short-circuit case. Contrarily when f is very small, the capacitive reactance will be very high which is an open-circuit case. **(/4marks)**

2. 

(/3marks)

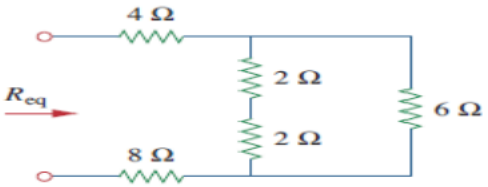
3. $$i(t) = C\frac{dv}{dt}$$
$$i(t) = C\frac{d(\text{Acos}(\omega t)),}{dt}$$
$$i(t) = -\text{A}\omega\sin(\omega t)$$
$$(t) = \text{A}\omega\sin(\omega t + \frac{\pi}{2}) \textbf{ (/4 marks)}$$

4. The number of hours of a light bulb =6 hours per day*30=180 hours.

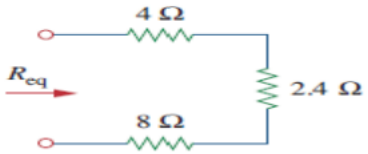
   $$\text{KWh consumed during the month} = \frac{1}{1000}40 * 180kwH = 7.2kwh$$
   Amount to pay per month $= 7.2 * 89$ RWF $= 641$ RWF **(/5marks)**

SECTION B:

1.



fig(b)



fig(c)

To get Req we combine resistors in series and in parallel. The 6 ohms and 3 ohms resistors are in parallel, so their equivalent resistance is

$$6\,\Omega \parallel 3\Omega = \frac{6 \times 3}{6 + 3} = 2\,\Omega$$

Also, the 1 ohm and 5ohms resistors are in series; hence their equivalent resistance is

$$1\,\Omega + 5\,\Omega = 6\,\Omega$$

Thus the circuit in Fig.(b) is reduced to that in Fig. (c). In Fig. (b), we notice that the two 2 ohms resistors are in series, so the equivalent resistance is

$$2\,\Omega + 2\,\Omega = 4\,\Omega$$

This 4 ohms resistor is now in parallel with the 6 ohms resistor in Fig.(b); their equivalent resistance is

$$4\,\Omega \parallel 6\,\Omega = \frac{4 \times 6}{4 + 6} = 2.4\,\Omega$$

The circuit in Fig.(b) is now replaced with that in Fig.(c). In Fig.(c), the three resistors are in series. Hence, the equivalent resistance for the circuit is

$$R_{eq} = 4\,\Omega + 2.4\,\Omega + 8\,\Omega = 14.4\,\Omega$$

(/10 marks)

2.

Calculating the first inductor branch L_A, where an Inductor L_5 in parallel with inductors L_6 and L_7.

$$LA = \frac{L5 \times (L6 + L7)}{L5 + L6 + L7} = \frac{50mH \times (40mH + 100mH)}{50mH + 40mH + 100mH} = 36.8mH$$

Calculating the second inductor branch L_B, where Inductor L_3 in parallel with inductors L_4 and L_A.

$$LB = \frac{L3 \times (L4 + LA)}{L3 + L + LA} = \frac{30mH \times (20mH + 36.8mH)}{30mH + 20mH + 36.8mH} = 19.6mH$$

Calculate the equivalent circuit inductance LEQ, where Inductor L_1 in parallel with inductors $L_2$and L_B.

$$LEQ, = \frac{L1 \times (L2 + LB)}{L1 + L2 + LB} = \frac{20mH \times (40mH + 19.6mH)}{20mH + 40mH + 19.6mH} = 15mH$$

3. In the given circuit 24uF,12uF and 8uF are in series. The equivalent capacitance of this three capacitors is

$$\frac{1}{C_s} = \frac{1}{24\ \mu F} + \frac{1}{12\ \mu F} + \frac{1}{8.0\ \mu F} \qquad \text{or} \qquad C_s = 4.0\ \mu F$$

This 4.0μF capacitance is in parallel with the 4.0μF capacitance. Then the equivalent capacitance is

$$C_p = 4.0\ \mu F + 4.0\ \mu F = 8.0\ \mu F$$

This 8.0μF,5.0uF and 6.0uF are in series .Hence , the overall equivalent capacitance is

$$\frac{1}{C_s} = \frac{1}{5.0\ \mu F} + \frac{1}{8.0\ \mu F} + \frac{1}{6.0\ \mu F} \qquad \text{or} \qquad C_s = \boxed{2.0\ \mu F}$$

(/10marks)

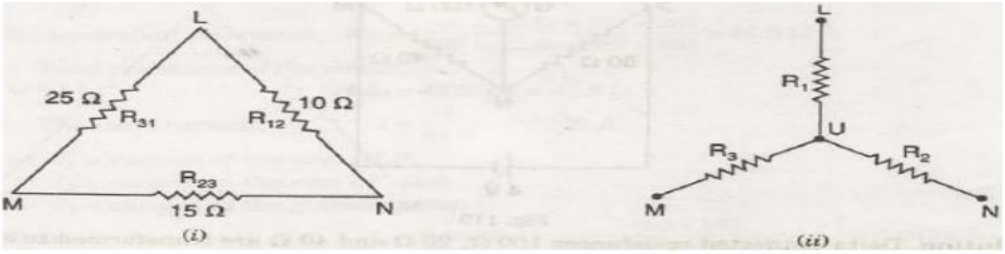
SECTION C

1. Delta connected resistors 25 ohms, 10 ohms and 15 ohms are converted in to star as shown in given figure.

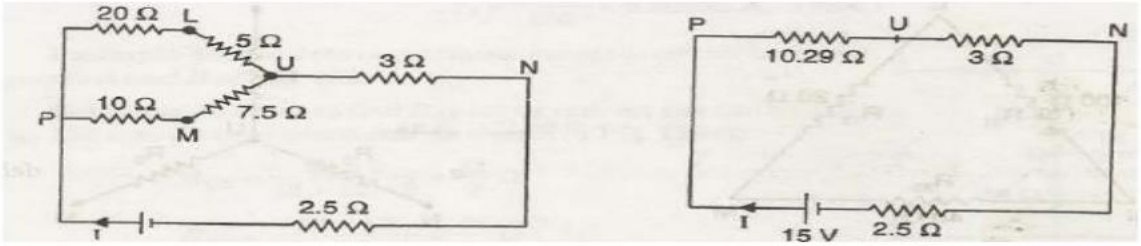
$R_1 = R_{12} R_{31} / R_{12} + R_{23} + R_{31} = 10 \times 25 / 10 + 15 + 25 = 5$ ohms

$R_2 = R_{23} R_{12} / R_{12} + R_{23} + R_{31} = 15 \times 10 / 10 + 15 + 25 = 3$ ohms

$R_3 = R_{31} R_{23} / R_{12} + R_{23} + R_{31} = 25 \times 15 / 10 + 15 + 25 = 7.5$ ohms



The given circuit thus reduces to the circuit shown in below fig.



The equivalent resistance of

(20 + 5) ohms || (10 + 7.5) ohms = 25 x 17.5 / 25 + 17.5 = 10.29 ohms

Total resistance = 10.29 + 3 + 2.5 = 15.79 ohms

Hence the total current through the battery,

I = 15 / 15.79 = 0.95 A **(/10marks)**

2. The node voltages and the directions of the branch currents are assigned as shown in given figure. Applying KCL to node 1, we get: 5 = I10+ I3

5= (V1-0)/10 +(V1-V2)/3

V1(13/30) -V2(1/3) = 5 .....(1)

Applying KCL to node 2, we get: **I3= I5 + I1**

(V1-V2)/3 = (V2 -0)/5 + (V2-10) /1

V1(1/3)-V2(23/15) = -10.....(2)

Solving the these two equations for V1 and V2 we get :

V1 = 19.85 V and V2 = 10.9 V and the currents are :
I10= V1/10 = 1.985A
I3 = (V1-V2)/3 = (19.85-10.9)/3 = 2.98A
I5 = V2/5 = 10.9/5 =2.18A
I1 = (V2-10) = (10.9-10)/1 = 0.9A

(/10marks)