3055 BA SANGAM COLLEGE

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WORKSHEET 16

SCHOOL: BA SANGAM COLLEGE **YEAR: 13**
SUBJECT: PHYSICS **NAMEOF STUDENT: ______________________**

STRAND	**5 - DIRECT CURRENT**
SUB-STRAND	**5.2 – Kirchoff's Laws**
LEARNING OUTCOME	To study about more complex circuits using **Kirchoff's Laws**

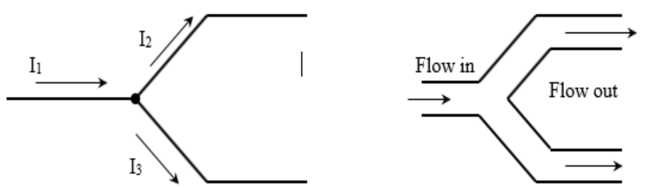
Simple circuits are analysed using Ohm's law. More complex circuits containing several sources of ***emf*** and

Kirchoff's Rule 1- The junction rule

"The sum of currents entering any junction must be equal to the sum of the currents leaving that junction."

$I_{entering} = I_{leaving}$

This junction rule is based on the ***conservation of charge***.



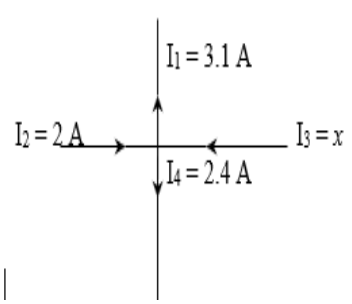
(a) Schematic diagram (b) A mechanical analogue

If we apply the junction rule to the above schematic diagram, we get

$I_{entering} = I_{leaving}$ → $I_1 = I_2 + I_3$.

Example.

Calculate the unknown current in the circuit given.



Using the junction rule, we ge

$I_2 + I_3 = I_1 + I_4$

$x = I_1 + I_4 - I_2$

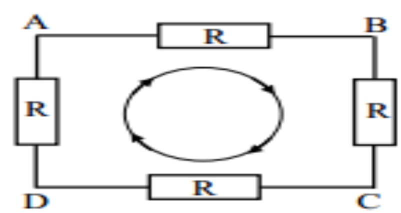
$x = (3.1 + 2.4 - 2)\ A$

$x = 3.5\ A$

Kirchoff's rule 2. The loop rule - *"The sum of the potential differences across all elements around any closed-circuit loop must be zero."*

- The loop rule is based on the principle of ***conservation of energy***.

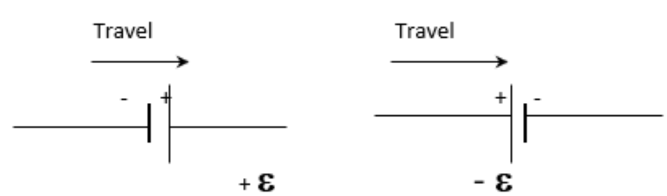
-Any charge moving around any closed loop in a circuit must gain as much energy as it loses.



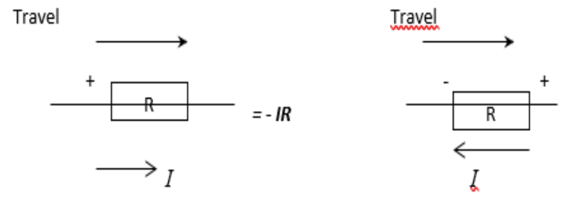
$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

Problem solving strategy.

1. Choose a junction and use the first rule to relate all the currents.
2. Choose any closed loop in the network and designate a direction (clockwise or counter clockwise).
3. For emf's(voltage) use the following the rules:



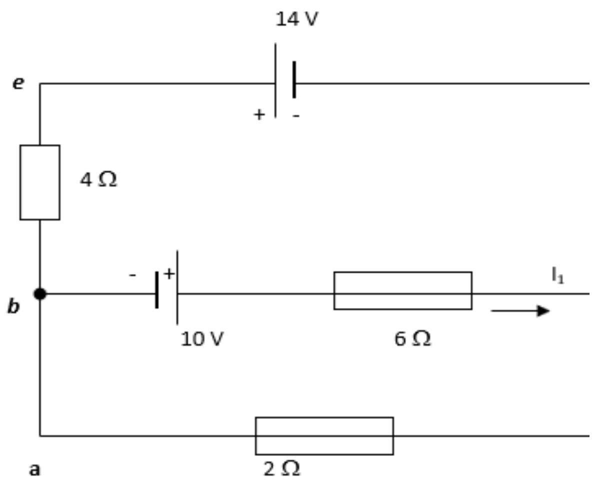
resistances are analysed using Kirchoff's laws.



4. Solve the equations simultaneously for the unknown quantities.

Example

Find the currents I_1, I_2 and I_3 in the multi-loop circuit given.



SOLUTION

Step 1. Choosing junction *c* and applying the Kirchoff's first rule we get $I_1 + I_2 = I_3$. eq (1)

Step 2. The circuit has three loops but only two is needed, so let's take loops *abcda* and *befcb* and traverse in a clockwise direction

Loop abcda: $10\ V - 6\ I_1 - 2\ I_3 = 0$

Loop befcb: $-14\ V + 6\ I_1 - 10\ V - 4\ I_2 = 0$

Loop befcb simplifies to $-24\ V + 6\ I_1 - 4\ I_2 = 0$

Step 3-We now have to use the equations 1, 2 and 3 and solve them simultaneously. Take equation 1 and substitute in equation 2.

$$10 - 6\ I_1 - 2\ (I_1 + I_2) = 0$$

Step 4. **We have to use the equations (3) and (4) and eliminate one of the variables.**

Take equation (3) and divide throughout by 2.

$12 - 3\ I_1 + 2\ I_2 = 0$ eq- (5)

Step 5. **Add equation (5) to (4) to eliminate I_2, gives**

$$\begin{array}{ll} & 12 - 3\ I_1 + 2\ I_2 = 0 \\ (+) & 10 - 8\ I_1 - 2\ I_2 = 0 \\ \hline & 22 - (11)\ I_1 = 0 \end{array} \quad (11)\ \ I_1 = 22 \quad I_1 = 2\ A$$

Step 6. Substituting I_1 in (5) results in a value for I_2

$12 - 3\ (2) + 2\ I_2 = 0$, I_2 = **- 3 A**

Step vii. Finally use equation (1) to calculate I_3

$I_3 = I_1 + I_2$, $I_3 = -1\ A$

The values for the currents are:

I_1 = 2 **A** I_2 = **- 3 A** I_3 **= - 1 A**

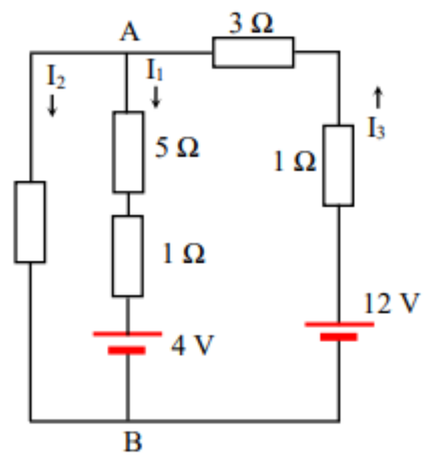
-The **negative** values of I_2 and I_3 indicate that the directions of the currents are **opposite** to that designated initially.

EXERCISE

Use the circuit in Figure 5.17 to answer the questions that follow.

i. Calculate the values of I_1, I_2 and I_3.

ii. Find the potential difference between Points A and B.



6 Marks