education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Just-in-Time Training

Workshop Term 2 2017

Facilitators' Manual

Physical Sciences

Grade 10 & 11 Electric Circuits

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what I do matters

Grade 10 Content , concepts and skills extracted from CAPS pp 42-45	
Electric circuits	
Emf, Terminal Potential Difference (terminal pd)	Define potential difference in terms of work done and charge. V = W/Q • Know that the voltage measured across the terminals of a battery when no current is flowing through the battery is called the emf • Know that the voltage measured across the terminals of a battery when current is flowing through the battery is called terminal potential difference(terminal pd). • Know that emf and pd are measured in volts (V) • Do calculations using V = W/Q
Current	Define current, I, as the rate of flow of charge. It is measured in ampere (A), which is the same as coulomb per second • Calculate the current flowing using the equation • Indicate the direction of the current in circuit diagrams (conventional
Measurement of voltage (pd) and current	how to correctly connect an ammeter to measure the current through a given circuit element • Draw a diagram to show how to correctly connect a voltmeter to measure the voltage across a given circuit element
Resistance	• Define resistance • Explain that resistance is the opposition to the flow of electric current • Define the unit of resistance; one ohm (Ω) is one volt per ampere. • Give a microscopic description of resistance in terms of electrons moving through a conductor colliding with the particles of which the conductor (metal) is made and transferring kinetic energy. • State and explain factors that affect the resistance of a substance • Explain why a battery in a circuit goes flat eventually by referring to the energy transformations that take place in the battery and the resistors in a circuit
Resistors in series	Know that current is constant through each resistor in series circuit. • Know that series circuits are called voltage dividers because the total potential difference is equal to the sum of the potential differences across all the individual components. • Calculate the equivalent (total) resistance of resistors connected in series using: $R_s = R_1 + R_2 + \cdots$
Resistors in parallel	• Know that voltage is constant across resistors connected in parallel • Know that a parallel circuit is called a current divider because the total current in the circuit is equal to the sum of the branch currents • Calculate the equivalent (total) resistance of resistors connected in parallel using: $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$ Know that for two resistors connected in parallel, the total resistance can be calculated using: $R_P = \frac{Product}{sum} = \frac{R_1 \times R_2}{R_1 R_2}$

Grade 11 Electric circuits Extracted from CAPS pp 88-89	
Ohm's Law	• Determine the relationship between current, voltage and resistance at constant temperature using a simple circuit • State the difference between Ohmic and non- Ohmic conductors, and give an example of each • Solve problems using the mathematical expression of Ohm's Law, R=V/I, for series and parallel circuits
Power, energy	• Define power as the rate at which electrical energy is converted in an electric circuit and is measured in watts (W) • Know that electrical power dissipated in a device is equal to the product of the potential difference across the device and current flowing through it i.e. P=IV • Know that power can also be given by $P = I^2R \; or \; P = \frac{V^2}{R}$ • Solve circuit problems involving the concept of power • Know that the electrical energy is given by E=Pt and is measured in joules (J) • Solve problems involving the concept of electrical energy • Know that the kilowatt hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour • Calculate the cost of electricity usage given the power specifications of the appliances used as well as the duration if the cost of 1 kWh is given

Contents

1. Introduction

This manual is aimed at assisting teachers to understand the kind of errors learners make when answering electric circuits questions with the aim of addressing those errors when teaching. Apart from knowing the types of errors as such, teachers need to have an understanding of causes of those errors. If a learner gives a strange answer the teacher should be interested in knowing how the learner arrived at that answer.

Errors learners make when answering electric circuits questions are as a result of their lack of the following:

(a) Lack of understanding of concepts information related to concepts.
(b) Lack of knowledge skills to analyse and interpret and defining a given problem
(c) Lack of knowledge of the relationship between concepts and the relationship between what the learner knows and the information in a given problem.
(d) Misconceptions derived from teachers which can be in the form of what they said and how it was interpreted by learners or test and examination questions which are ambiguous.

Each of the source of errors will be discussed and how to deal with them in class

2. Problems associated with lack of understanding of concepts information related to concepts

Learners fail to give correct definitions, when they lack understanding of concepts. Apart from knowing a concepts learners need to have information related to concepts.

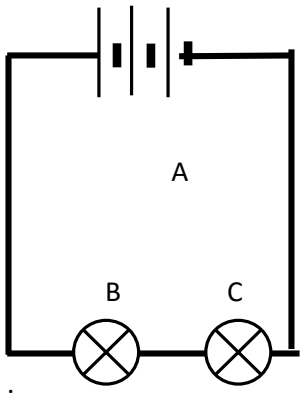
Example 1

What is resistance?

Wrong Answer: Resistance is opposition to the flow of an electric current.

Question 2

Three 1,5V cells are connected in series with two identical light bulbs, each with a resistance of 2Ω, are connected as shown in the diagram below



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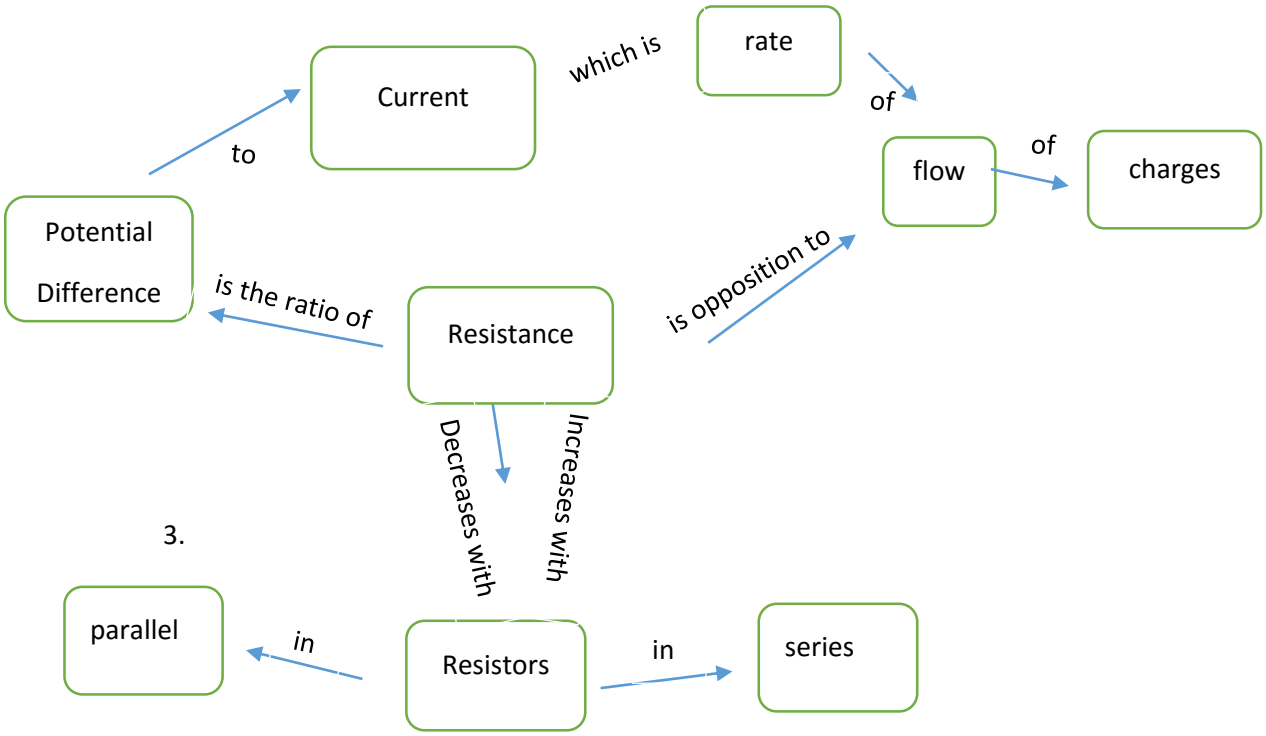
What will happen to the total resistance if a third light bulb is connected in parallel with the other two light bulbs?

Wrong Answer: The total resistance will increase.

Answers to both questions above shows that the learner does not understand resistance and how resistance changes as resistors are added in series or parallel.

Learners need to be involved in the drawing of flow diagrams and concept maps to facilitate their understanding of concepts. These diagrams foster understanding of concepts and relationship among concepts

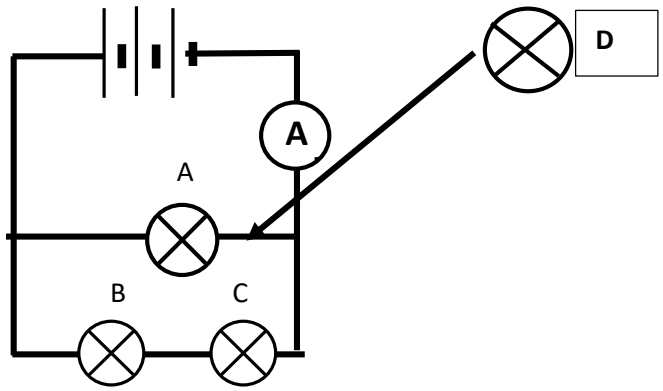


4. Lack of knowledge of the relationship between concepts.

This covers the relationship between what the learner knows and the information in a given problem.

Activity 1

Aim	To allow participants practice on analysing changes total current in the circuit as additional bulbs are added at different points of the circuit.
Duration	10 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook and this manual.



Question 3

a) What will happen to the ammeter reading in the above circuit if a fourth bulb is connected at position D next to bulb A as shown in the diagram above? Is it going to increase, decrease or stay the same? Explain.

Answer.
It will decrease, because adding a second resistor to the top branch of the circuit will increase the total resistance of the above branch which will lead to the decrease of the current in the top branch. The resistance of the bottom branch has not changed hence no change in the bottom branch current. The total current will decrease because of the decrease in the top branch current.

b) Explain what will happen to the ammeter reading if bulb D is connected in series between the negative terminal of the battery and the ammeter?

Answer.

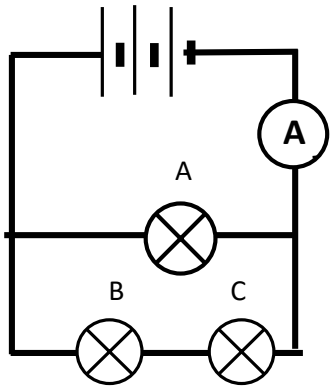
Adding the second bulb in series between the negative terminal of the battery and the ammeter will cause the total resistance of the circuit to increase, because increasing resistors n series increases the total resistance. The total current in the circuit through the ammeter will decreases as there is an inverse relationship between current and resistance.

5. Misconceptions derived from teachers.

This results from how the question has been phrased in the test or examination.

Activity 2

Aim	To allow participants to notice the effect on learner answers if the question is not properly phrased.
Duration	5 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook and this manual.



Question 4

a) **Discuss** what will happen to the ammeter reading if bulb C is removed from the circuit?

This question can be interpreted in two ways. Bulb C is removed and there is no flow of charge through the bottom branch of the circuit. No current in bottom branch. No change in resistance of top branch. No change in ammeter reading.

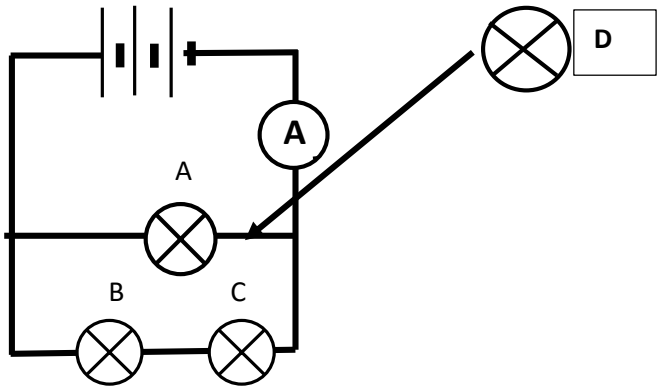
Or

Bulb C is removed and there is replaced by a wire on negligible resistance. The resistance of the bottom branch decreases which leads to more current in the bottom branch of the circuit. No change in resistance of top branch, no change in current in the top branch. Increase total current.

6. Lack of knowledge skills to analyse and interpret and defining a given problem

Activity 3

Aim	To allow participants to notice: • the need for learners to know the relationship between concepts • the need to analyse and interpret questions
Duration	5 minutes
Method	Individual work
Resources	CAPS document, any relevant textbook and this manual.



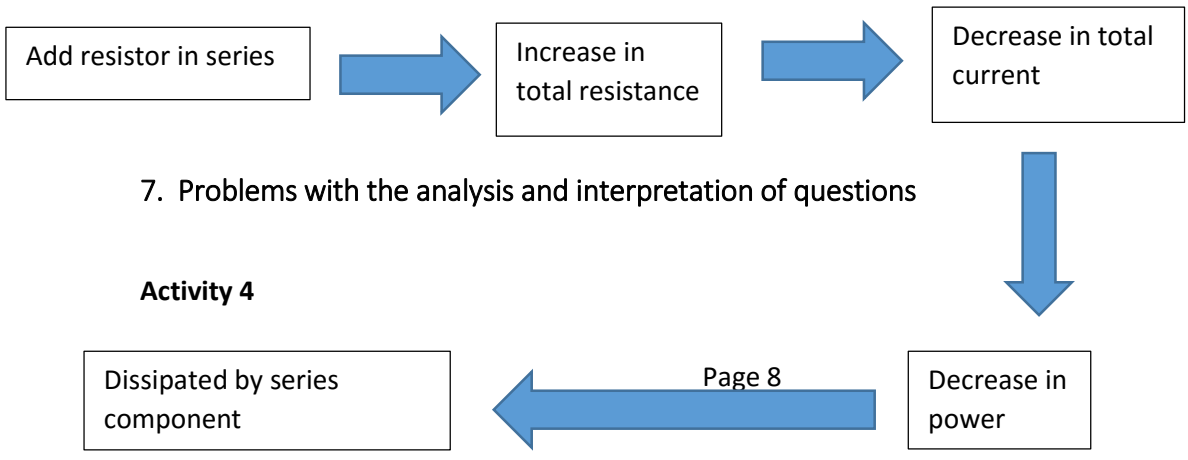
Question 5

What will happen to the power the power dissipated in bulb A as a result of the addition of bulb D at position shown in the diagram above.

Answer.

The power dissipated in bulb A depends on the current in top branch of the circuit. Adding bulb D increases the resistance of the branch which leads to decrease in current in the branch. Power is directly proportional to the square of the current in the part of a circuit. The decrease in current will lead to a decrease in power dissipated through bulb A.

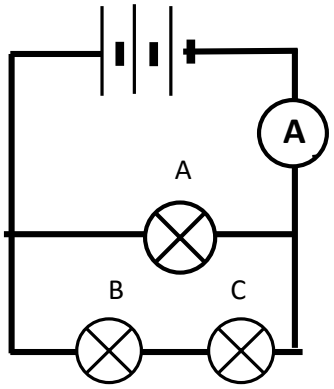
Flow diagrams can be used to relate concepts to each other as follows:



7. Problems with the analysis and interpretation of questions

Activity 4

Aim	To allow participants to deal with questions which demand analysis and interpretation of the question.
Duration	15 minutes
Method	Group l work
Resources	CAPS document, any relevant textbook, calculators and this manual.



Question 6

Bulb A has a resistance of 2Ω , that of bulb B is 3Ω and that of bub C is 4Ω. If the positions of bulbs were to be interchanged without changing the circuit, which bulb arrangement will give the smallest amount of ammeter reading?

Answer.

Present arrangement leads to 2Ω is in parallel with7Ω. Using:

$$\frac{1}{\mathrm{R}_P} = \frac{1}{\mathrm{R}_1} + \frac{1}{\mathrm{R}_2}$$

$$= \frac{1}{2} + \frac{1}{7}$$

$$\frac{1}{R_P} = \frac{9}{14}$$

R_P=1, 56 Ω.

If the 3Ω resistor is at the top and the other resistors at the bottom, then the 3 Ω is in series with 6 Ω. Then:

$$\frac{1}{\mathrm{R}_P} = \frac{1}{\mathrm{R}_1} + \frac{1}{\mathrm{R}_2}$$

$$= \frac{1}{3} + \frac{1}{6}$$

$$\frac{1}{R_P} = \frac{8}{18}$$

R_P=2, 25 Ω.

If the 4Ω resistor is at the top and the other resistors at the bottom, then the 4 Ω is in series with 5 Ω. Then:

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{4} + \frac{1}{5}$$

$$\frac{1}{R_P} = \frac{9}{20}$$

R_P=2, 22 Ω.

The combination which will result in the smallest ammeter reading is to connect bulb A alone and bulb B in series with bulb C as per the present arrangement.

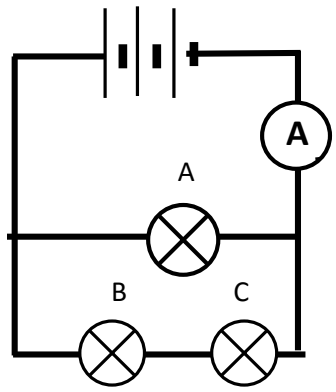
8. Analysis of learners' responses to a summative question

Activity 5

Aim	To allow participants to : a) Identify the error(s) the learner has made if any. b) To provide feedback to the learner by allocating marks and a comment.
Duration	15 minutes
Method	Group l work
Resources	CAPS document, any relevant textbook, calculators and this manual.

Question 7

Three 1,5V cells are connected in series. Three identical light bulbs, each with a resistance of 3Ω, are connected as shown in the diagram below. The reading on the ammeter is 2,25A.



Calculate the equivalent resistance of the light bulbs in this circuit. (4)

Learner A:

$R_T = R_1 + R_2 + R_3$

$= 3 + 3 + 3$

$= 9\ \Omega$

Learner B:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$$

$= 1\ \Omega$

Learner C

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$= \frac{1}{6} + \frac{1}{3}$$

$$= \frac{3}{6} = 0{,}5\Omega$$

Learner D

$$R = \frac{V}{I}$$

$$= \frac{3 \text{ x } 1{,}5}{2{,}25}$$

$= 2\ \Omega$1. For each of the answers provided:

a. identify the error(s) the learner has made if any.

b. provide feedback to the learner by allocating marks and a comment.

Suggested Answers for discussion

Learner A:

$R_T = R_1 + R_2 + R_3$ X No marks Bulbs are not in series. There are two parallel branches.

$= 3 + 3 + 3$

$= 9\ \Omega$ x

Error: Learner has not understood the difference between series and parallel

Learner B:

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ X No marks. There are two branches in parallel not three!

$= \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$

= 1 Ω x When using this formula you must invert and write $\therefore R_{eq} =$ ….. as the last line even if the answer is 1

Error: Learner has not understood that bulbs connected in series in a parallel branch must be added together before calculating the equivalent resistance of the two parallel branches.

Learner has not found R_{eq}. Must invert to show the final answer.

Learner C

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$ √

$= \frac{1}{6}\sqrt{} + \frac{1}{3}\sqrt{}$

$= \frac{3}{6} = 0{,}5\Omega$ x When using this formula you must always invert and write

$\therefore R_{eq} = \frac{6}{3} = 2\ \Omega$ ….. as the last line.

Learner D

$R = \frac{V}{I}\sqrt{}$

$= \frac{3 \text{ x } 1{,}5}{2{,}25}\sqrt{}\sqrt{}$

= 2 Ω √

Answer and method are correct

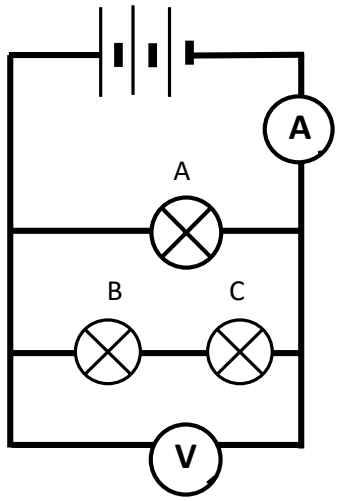
9. Analysis of a poorly set question

Activity 6

Aim	Participants to look at the question in which the learner performance was not good, and to critically examine the validity of the question as a tool to measure learners' understanding and skills. This question has numerous errors and is NOT a good tool for assessment. While it is true that some weaker learners may actually get the same answer as the memo, more able learners will struggle with this question and may not get the answer on the memo and will be confused by it.
Duration	25 minutes
Method	Group l work
Resources	CAPS document, any relevant textbook, calculators and this manual.

Question 8

Three 1,5V cells are connected in series to three identical light bulbs each with a resistance of 3Ω as shown in the diagram below. The reading on the ammeter is 2,25A and the voltmeter reading across light bulb B is 0,75V.



Calculate the current flowing through light bulb A. (4)

Memo

Cognitive Level 3: Application / Routine problem solving

$V_A = V_{B+C} = 2 \times V_B = 2 \times 0,75 = 1,5V$ √

$I = V \div R$ √

$= 1,5 \div 3$ √

$= 0,5\ A$ √

Questions for reflection and discussion

a. Identify any problems with the language of the question.
b. Identify three different conflicting pieces of information. How could you correct these?
c. Identify any inaccuracies on the memo. Suggest how you would correct these.
d. Do you think the mark allocation and rating of the cognitive level is fair?

Suggested answers

a) The first sentence is problematic:

Three 1,5V cells are connected in series to three identical light bulbs each with a resistance of 3Ω as shown in the diagram below.

The phrase connected in series can be read to refer to the cells or the light bulbs or both.

The sentence is too long. It would be better to re-write as two shorter sentences.

Current does not flow! Current is the flow of charge. Incorrect description.

b). The information given in the text does not correspond with the information in the diagram in two places:

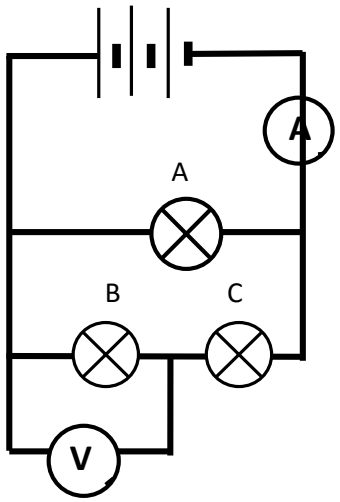
I) light bulbs are not connected in series

ii) the voltmeter is shown to be drawn across light bulbs B and C but the text indicates a value for the voltmeter reading across light bulb B only.

The value of the voltmeter reading is not consistent with the other values in the text.

Corrected question: Question 8

Three 1,5V cells are connected in series. Three identical light bulbs, each with a resistance of 3Ω, are connected as shown in the diagram below. The reading on the ammeter is 2,25A and the voltmeter reading across light bulb B is 2,25V.



Calculate the current passing through light bulb A. (4)

c). Apart from the incorrect values used in the memo, there are three other inaccuracies in this memo.

- The level of cognitive demand is correct but the mark allocation of 4 marks should be increased to 5 or 6 marks
- The formula used for which one mark is allocated is not the formula given on the data sheet. Learners must use the formula given and show how they substitute into the formula. Learners should not change the subject of the formula and then sub
- No alternative method of finding the solution is shown.

Corrected Memo

Cognitive Level 3: Application / Routine problem solving

$V_{B+C} = 2 \times V_B = 2 \times 2,25 = 4,5V$ √

$V_A = V_{B+C} = 4,5V$ √

R = V÷ I √

3√ = 4,5√ ÷ I

I = 1,5 A √

Alternative method 1:

VA = V battery = 3 x 1,5 √ = 4,5V √

R = V÷ I √

3√ = 4,5√ ÷ I

I = 1,5 A √

Alternative method 2:

VA = V battery = 3 x 1,5 √ = 4,5V√

I Total = 2,25A

Current divides in parallel branch in ratio of 2 : 1 (inverse of resistance)

More current passes through the branch with smaller resistance i.e through light bulb A

2,25A divided by 3 is 0,75 A

IA = 2 x 0,75 = 2,25A