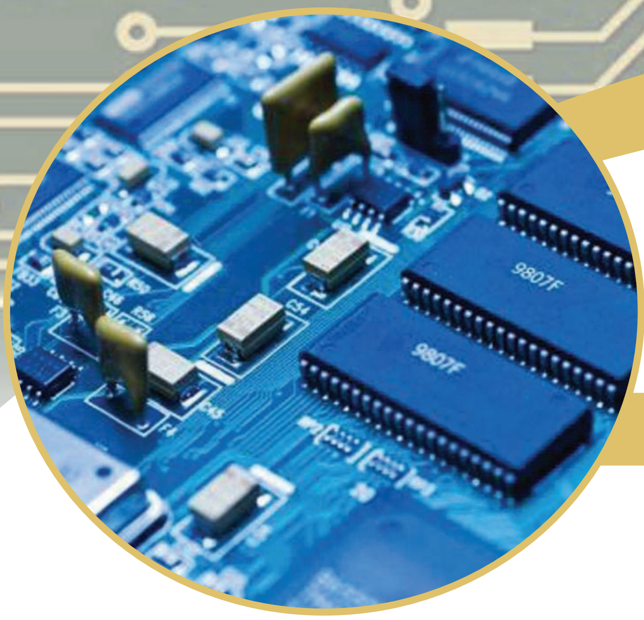


PHYSICAL SCIENCE

ELECTRIC CIRCUITS

GRADE 12

basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

Read to Lead
A Reading Nation is a Leading Nation

2030
NDP

Foreword

In order to improve learning outcomes the Department of Basic Education conducted research to determine the specific areas that learners struggle with in Grade 12 examinations. The research included a trend analysis by subject experts of learner performance over a period of five years as well as learner examination scripts in order to diagnose deficiencies or misconceptions in particular content areas. In addition, expert teachers were interviewed to determine the best practicesto ensure mastery of thetopic by learners and improve outcomes in terms of quality and quantity.

The results of the research formed the foundation and guiding principles for the development of the booklets. In each identified subject, key content areas were identified for the development of material that will significantly improve learner's conceptual understanding whilst leading to improved performance in the subject.

The booklets are developed as part of a series of booklets, with each bookletfocussing onlyon one specific challenging topic. The selected content is explained in detail and include relevant concepts from Grades 10 - 12 to ensure conceptual understanding.

The main purpose of these booklets is to assist learners to master the content starting from a basic conceptual level of understanding to the more advanced level. The content in each booklets is presented in an easy to understand manner including the use of mind maps, summaries and exercises to support understanding and conceptual progression. These booklets should ideally be used as part of a focussed revision or enrichment program by learners after the topics have been taught in class. The booklets encourage learners to take ownership of their own learning and focus on developing and mastery critical content and skills such as reading and higher order thinking skills.

Teachers are also encouraged to infuse the content into existing lesson preparation to ensure in-depth curriculum coverage of a particular topic. Due to the nature of the booklets covering only one topic, teachers are encouraged to ensure learners access to the booklets in either print or digital form if a particular topic is taught.

Table of Contents

2. HOW TO USE THIS BOOKLET

This booklet is aimed at summarising important aspects in the study of electric circuits. It is not aimed at replacing the prescribed textbook and it must be used in conjunction with the textbook and other relevant study materials. The booklet combines the definitions that have been provided since Grade 10, to show how the topic progresses up to Grade 12. It includes the examination guidelines, to provide guidance on how far the learner should go in terms of mastering the content. Additionally, misconceptions are clarified for ease of understanding. The exercises provided in this booklet will not ensure sufficient practise; therefore, the learner should supplement them with additional practise.

3. STUDY AND EXAMINATION TIPS

3.1 TIPS relating to Resistance, Current and Potential Difference

In the section on electric circuits, you need to understand the different components, how they function and how they are connected. The exam questions will, in most cases, have a circuits comprising of a combination of components connected in series and/or parallel. Start by identifying which resistors are connected in parallel and which are connected in series. When calculating the sum of resistors in parallel make sure you do not make the mistake of omitting to take the reciprocal of $\frac{1}{R_T}$ in your final answer:

$$\frac{1}{R_T} = \frac{1}{R_x} + \frac{1}{R_y}$$

If $\frac{1}{R_T} = \frac{1}{0,25}$ then $R_T = 4\Omega$.

Many learners forget to get the reciprocal of R_T.

Some learners use this **wrong formula:**.$R_T = \frac{1}{R_x} + \frac{1}{R_y}$. Make sure that you DO NOT use this incorrect equation.

R must be written correctly as it appears in the data sheet.

It is advisable to read the statement and then study the circuit, before attempting to answer the questions asked. Find out what you can calculate given the information, just like geometry riders in mathematics.

You need to practise the questions that will be asked. For example: “What will happen to the lost volts if the resistance of the circuit is increased? State whether it will increase, decrease or remain the same. Explain. 3 marks”.

Answer: Decreases

Explanation:

- Increasing the external resistance of the circuit will cause the external potential difference (V) to increase, and the current (I) will decrease.
- Therefore, more voltage is required in the external circuit ($IR_{external}$).
- So, **the lost volts (Ir) should decrease** to accommodate the increase in the potential difference in the external circuit because ...
- Emf and r are constant.
- Emf = IR +Ir

When asked to calculate the total resistance of the circuit, start by calculating the resistors in parallel.

Do not do this $\frac{1}{R_T} = \frac{1}{R_x} + \frac{1}{R_y} + R_z$ as this is INCORRECT.

NB: It is important to understand how **current (I), potential difference (V)** and **resistance** behave in a circuit, and how they are related, according to Ohm’s law.

Memorise definitions in the table below with understanding, as they constitute **± 13%** of the paper, which means these should be considered ‘free marks’. Write them as they appear in the Examinations Guideline. Most of the definitions are found in the formula sheet.

Example: $F = \frac{kQ_1kQ_2}{r^2}$ Coulomb’s law.

$F \alpha Q_1Q_2$ means **directly proportional.** When the **product** (multiplication) of the two charges is increased, the electrostatic force increases.

$F \alpha \frac{1}{r^2}$ = means **inversely proportional.** When you increase F, r^2 decreases.

3.2 Electricity: Definitions

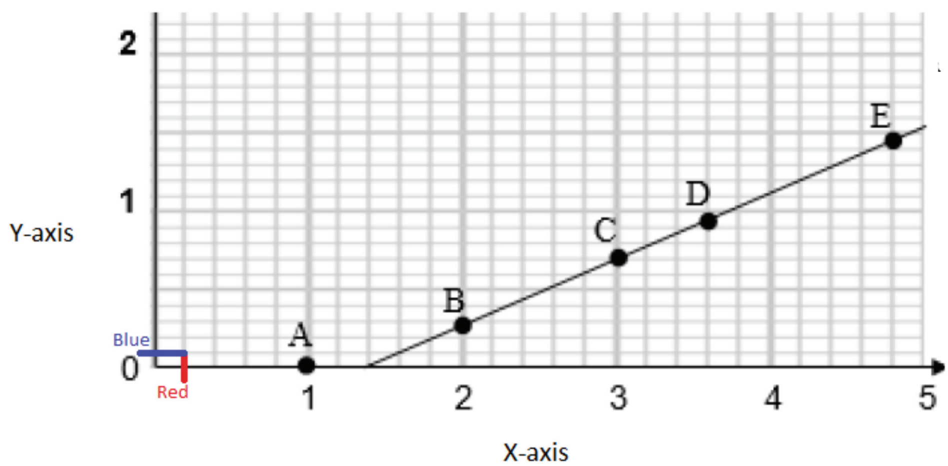
Grade 10	
ampere (A)	The unit of measurement of electric current.
coulomb (C)	The unit of measurement of an electric charge. Definition: The current is one ampere when a charge of one coulomb per second passes a given point in a conductor.
electric current	The rate of flow of the charge, i.e. ($I = \frac{Q}{\Delta t}$)
Emf	The potential difference (voltage) measured across the terminals of a battery when no charge flows through the battery. OR The potential difference (voltage) measured across the terminals of a battery on open circuit.
ohm (Ω)	Unit of measurement of resistance. Definition: One ohm is one volt per ampere.
potential difference	The potential difference between the ends of a conductor is equal to the energy transferred (from electrical to other forms of energy) per unit electric charge flowing through it, i.e. ($V = \frac{Q}{W}$)
resistance	Resistance is the ratio of the potential difference across a resistor to the current in the resistor.
volt (V)	The unit of measurement of potential difference.
voltmeter	An instrument used to measure potential difference. A voltmeter is connected in parallel and has a very high resistance level.
ammeter	The instrument used to measure electric current. An ammeter is connected in series and has a very low resistance level.

Grade 11	
Ohm's Law: $R = \frac{V}{I}$	The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.
Ohmic conductor	It obeys Ohms law.
non-Ohmic conductor	It does not obey Ohms law.
power: $P = \frac{W}{t}$	The rate at which electrical energy is converted in an electric circuit.
kilowatt hour: ***kWh***	The energy that a circuit with a power of 1 kilowatt can transfer in one hour.

Grade 12	
Ohm's Law: $R = \frac{V}{I}$	The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.
power: $P = \frac{W}{t}$	The rate at which work is done.
internal resistance (r)	The resistance between the terminals of a real battery.

3.2 Reading and interpreting from the graph

Study the graph below.



Calculating the value of the small square on the red **x-axis:**

$$\frac{\Delta x}{\text{no. of blocks in between}} = \frac{1 - 0}{5} = 2.2.\therefore$$

The value of the first block is 0.2.

Calculating the value of the small square on the red **y-axis:**

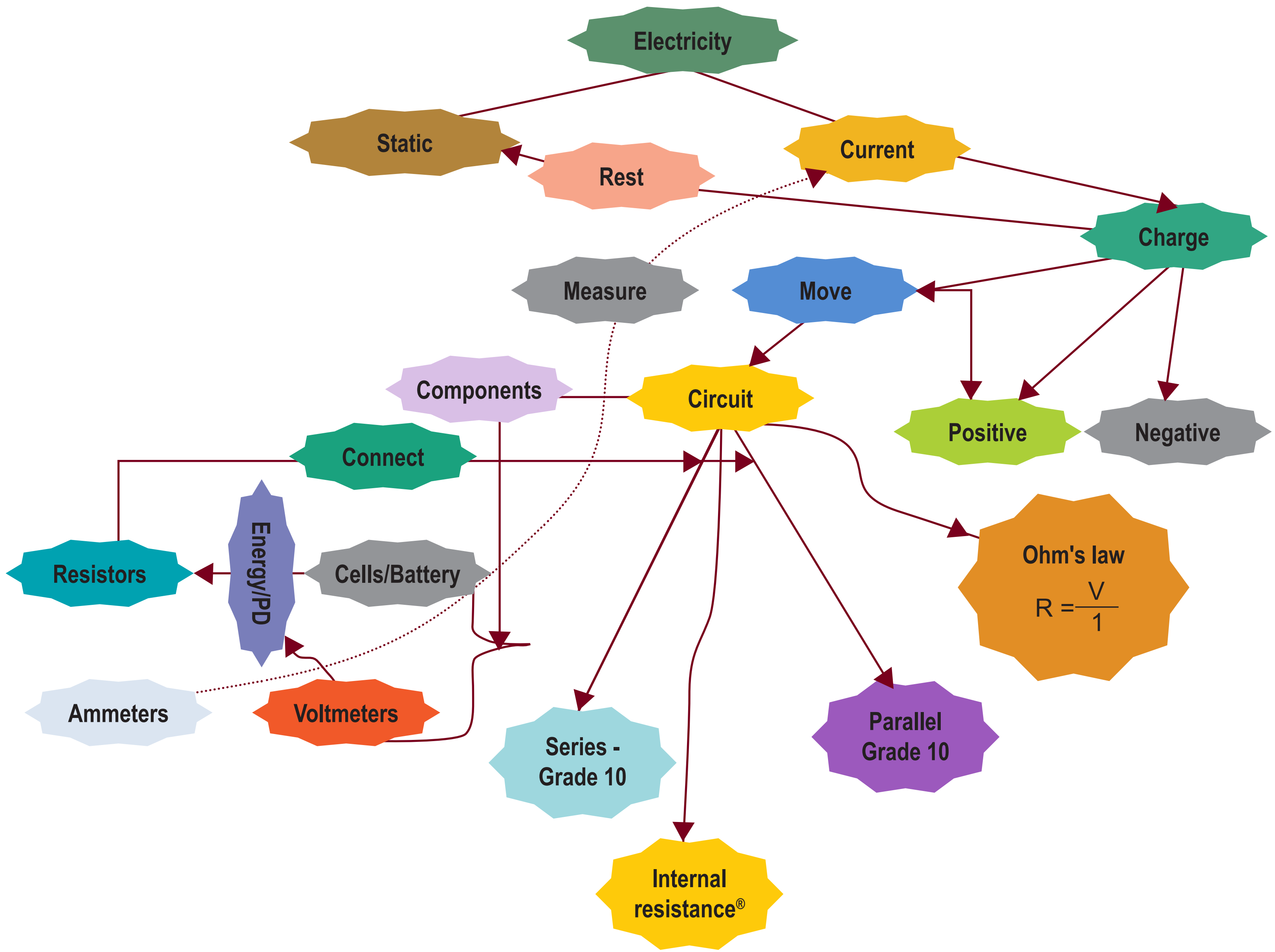
$$\frac{\Delta y}{\text{no. of blocks in between}} = \frac{1 - 0}{10} = 0.1.\therefore$$

The value of the first block is 0.1.

Find the value of:

- the **y** value of B. It will be 0.3.
- the **x** value of **D**. It will be 3,6.

4. OVERVIEW OF TOPIC



5. ELECTRIC CIRCUITS

5.1 Prior Knowledge

The topic starts as early as Grade 8. In Grade 10 it progresses to calculating a combination of series and parallel resistors, but excluding internal resistance.

Grade 11 deals with Ohm's law and this progresses in Grade 12.

The **atom** is the smallest possible particle of an element.

Charge (Q) – unit Coulomb (C).There are two types of charge, namely positive and negative charge.

Principle of conservation of charges: Charges cannot be created or destroyed, but can be transferred from one object to the other.

The function of the charge is to **transfer energy** to the resistor/ load.

Short circuit: If there is no resistor, the circuit will short circuit and cause sparks, because energy was not transferred.

This topic links with Electrostatics from Grade 6 and FET Grade 10 and 11. The charges are present in all the material, including air. Some materials can be charged easily through the transfer of electrons when the material is rubbed; others can only be charged through induction. There are good and bad conductors (insulators) of charges (current).

5.2 Types of energy

Four different types of energy that we will study are potential energy, electrical energy, light energy and chemical energy.

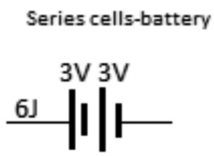
Energy transfer in the circuit:
Chemical energy (battery-galvanic cell) → Electrical potential energy → light energy (bulbs, TV); kinetic energy (motor, fans); heat energy (heaters); sound energy (siren).

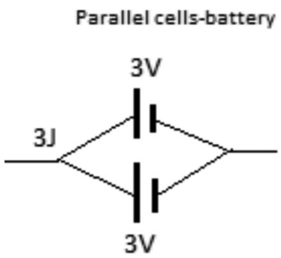
5.3 Components of the circuit

5.3.1 CONNECTING WIRES

Conducting wires are composed of charges and other particles (which we will not study here) and therefore they can conduct electricity. Good conductors must be made up of low resistance material. Gold and silver have very low resistance even less than that of copper wire which is most often used in electric circuits. But because gold and silver are expensive they cannot be used often. Eskom also has a challenge with copper wire being stolen too frequently.

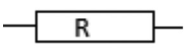
5.3.2 CELL/ BATTERY



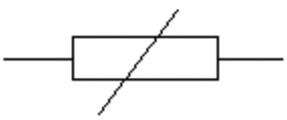


The cell/ battery is the source of energy. It transfers energy to every coulomb of charge that passes through it. When a cell is marked 3V, it means that it can **transfer 3J of energy** to every coulomb of charge passing through it.

5.3.2 RESISTORS



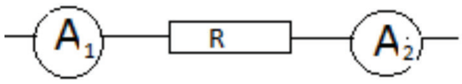
The resistor offers resistance to the flow of charges, e.g. bulbs, motor, radio, TV, fan, projector, etc.



A **rheostat** is a variable resistor – this means that it can provide different values of resistance within a specified range - (the resistance can either be increased or decreased).

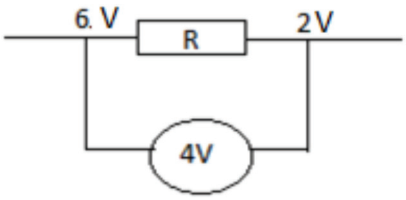
5.3.3 AMMETER (A)

It measures the current (I) (the flow of charges) that pass through it. It is connected in series to the circuit. The wires inside the ammeter must be of negligible resistance. The current measured by A_1 and A_2 is the same. The more charges that pass through the ammeter per second, the higher the current: $I = \frac{Q}{t}$



5.3.4 VOLTMETER (V)

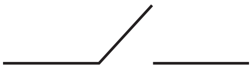
NB! A voltmeter is constructed in such a way that it has a very high resistance, so that no current (or negligible current) can flow through it.



It measures the potential difference (energy delivered) across the resistor. Therefore it is connected in parallel across the resistor. It measures the voltage before and after the charges pass through the resistor and then calculates the difference, i.e.
6V-2V= 4V.

5.3.5 SWITCH (S)

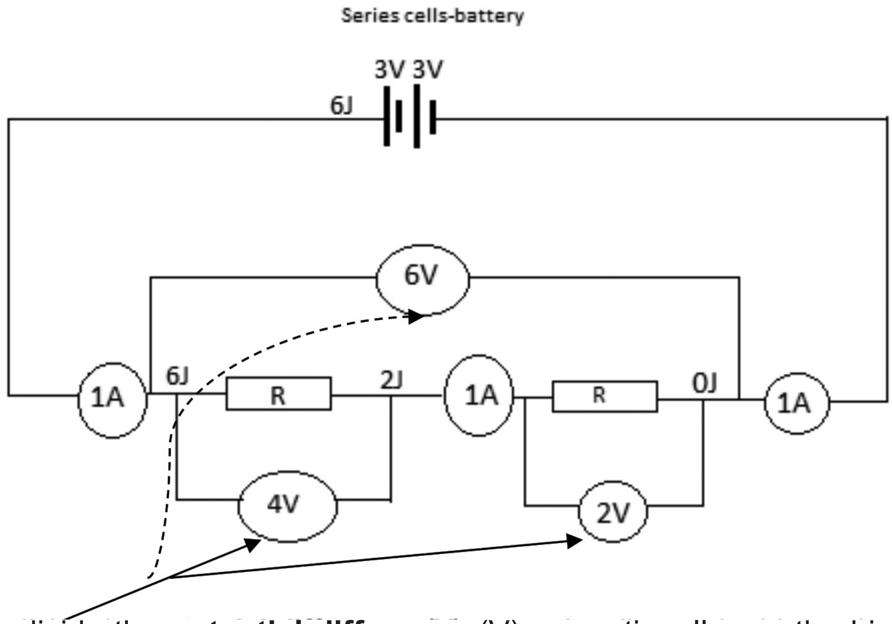
Open switch: current does not flow.



Closed switch: current flows in the circuit.

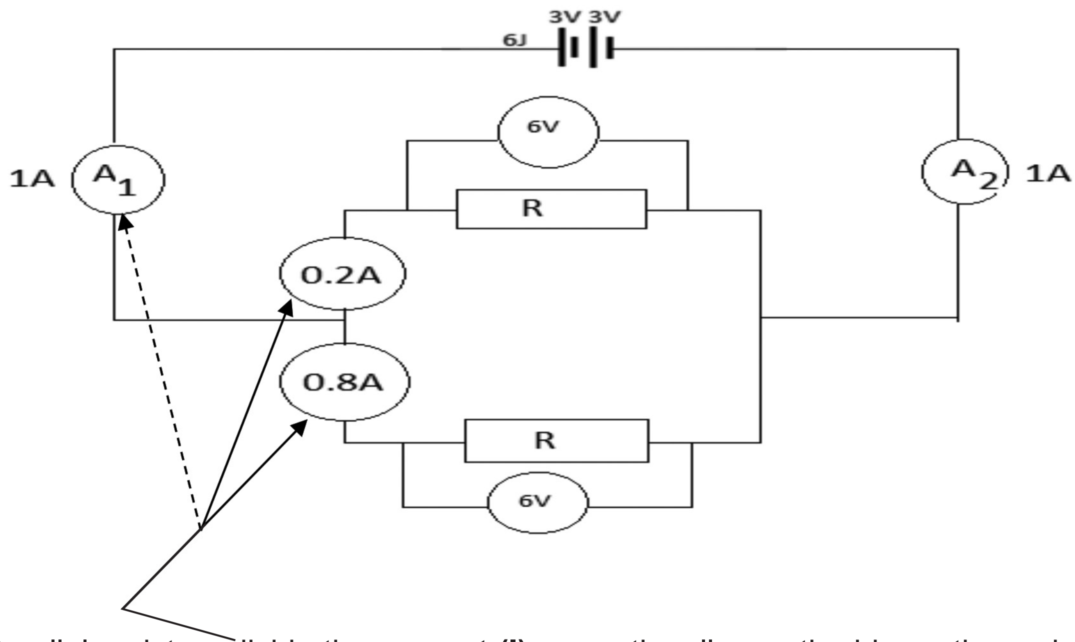
5.4 Series and parallel resistors

Series circuit resistors



- Series resistors <u>divide</u> the **potential difference** (V) proportionally, so: the bigger the resistor, the higher the potential difference; the smaller the resistor, the lower the potential difference, i.e. $V_T = 4V + 2V = 6V$.
- **Current (I)** is the same at all points in the circuit, even inside the resistors.
- **Total resistance** is the sum of all the resistors, i.e. $R_T = R_{4V} + R_{2V}$
- **The advantage of connecting resistors in a series is:**
  - ✓ Series circuits save the **energy** (potential difference), because the energy is shared among the connected resistors.
- **The disadvantage of connecting resistors in parallel:**
  - ✓ If one resistor breaks, the whole circuit is affected.
  - ✓ Total resistance increases as more resistors are added and the current decreases.

Parallel resistors



- Parallel resistors <u>divide</u> the **current (I)** proportionally, so: the bigger the resistor, the **lower the current** flow; the smaller the resistor, the bigger the current flow,

  i.e. $I_T = I_{0.2} + I_{0.8} = 1A$.
- The **potential difference** is the same across all the resistors, irrespective of their size.
- The **total resistance** is $\frac{1}{R_T} = \frac{1}{R_{0.2A}} + \frac{1}{R_{0.8A}}$,

NB:

$R = \frac{1}{R_{0.2A}} + \frac{1}{R_{0.8A}}$

This is wrong.

The final answer should be: $\frac{1}{R_T} = \frac{1}{R_{0.2A}} + \frac{1}{R_{0.8A}}$ and not $\frac{1}{R_T} = \frac{1}{R_{0.2A}} + \frac{1}{R_{0.8A}}$

$R_T = 2\Omega$ $\frac{1}{R_T} = 2\Omega$

- **Advantages:**
  - ✓ Every resistor can be controlled individually, so, when one breaks, the circuit still functions.
  - ✓ Adding more resistors decreases total resistance and the current increases.
  - ✓ More Power compared to Series connection: $P = \frac{W}{\Delta t}$

A multi-plug in our home will trip if too many appliances are connected.

Example of parallel resistors: connections between rooms in a home; connections between different houses in townships and villages.

- **Disadvantage:**
  - ✓ They use more **energy** (potential difference), because each resistor uses the maximum amount of energy.

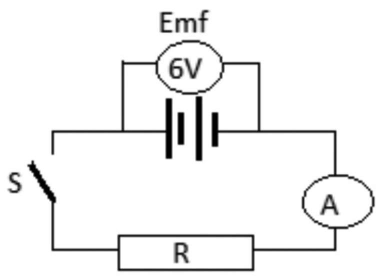
5.5 Skill required to identify parallel circuit resistors

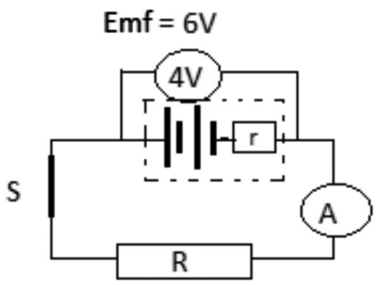
- Follow the path of the current.
- When you see the junction/ wires split, check whether there is a resistor in the wire that has split.
- If there is a resistor, the current divides.
- Use a different colour pen to show the split.

5.6 Internal resistance (r) and lost volts

Open switch

The Emf is 6V





Closed switch

Emf = 6V

Terminal Potential difference = 4V

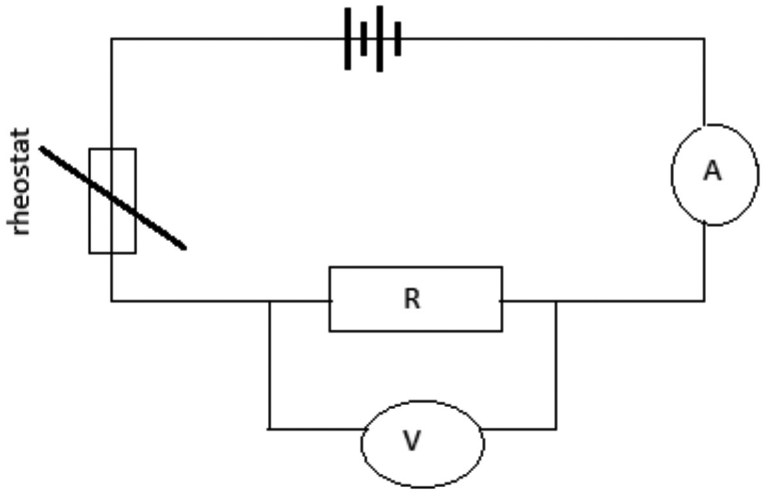
Lost volts due to internal resistance =

What happens to the lost volts when the external resistance is increased?

Answer and Explanation:

- Increasing the external resistance of the circuit will cause the potential difference to increase, and the current will decrease.
- Therefore more voltage is required in the external circuit ($IR_{external}$).
- So the **lost volts (Ir) should decrease** to accommodate the increase in the potential difference in the external circuit because...
- Emf and r are constant.

5.7 Ohm's law explained



The rheostat is used to vary the current by increasing or decreasing the resistance, i.e.changing the current of the circuit.

Independent variable: Current

Dependent variable: Potential difference across the resistor.

Constant variable: Temperature (Emf).

Observation 1: When increasing the resistance of the circuit by adjusting the rheostat: the current (**A**) decreases; and the potential difference (**V**) across the resistor (**R**) also decreases.

Explanation:

- When we increase the resistance of the rheostat, more voltage (energy) is needed.
- The EMF is constant.
- Therefore, the rheostat will proportionally share the potential difference with resistor R,

Observation 2: After decreasing the resistance of the circuit by adjusting the rheostat: the current (**A**) increases; and the potential difference (**V**) across the resistor (**R**) increases.
Explanation:

- When we decrease the resistance of the rheostat, the rheostat will need less voltage (energy).
- The EMF is constant.
- Therefore, it will proportionally share with the resistor (R), so the resistor (R) will have to increase its potential difference.

5.8 Factors affecting the resistance of the conductor

1. **Type of material**

Gold is a very good conductor and better than copper. Copper is generally used because it is cheaper. Nichrome wire has a higher resistance than copper.

2. **Length** of the conductor

The longer the conductor, the higher the resistance.

3. **Thickness** of the conductor

The thicker the conductor, the lower the resistance.

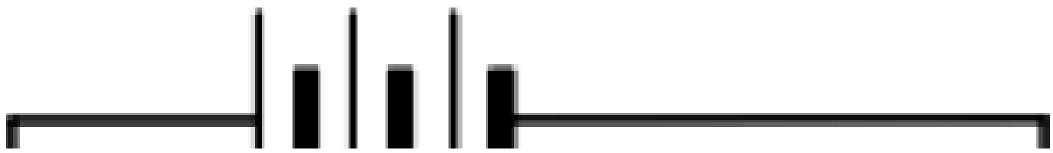
4. **Temperature** of the conductor

The higher the temperature of the conductor, the higher the resistance.

5.9 Practice questions

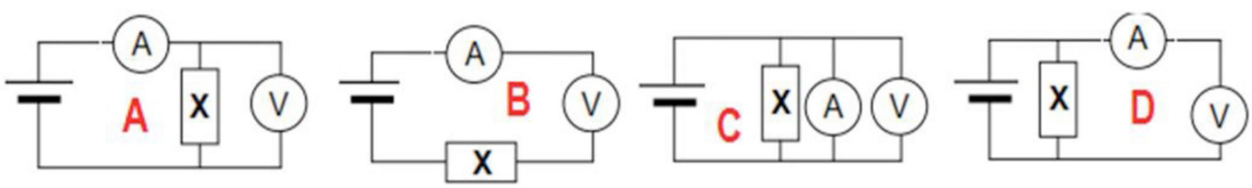
QUESTION 1: MULTIPLE CHOICE QUESTIONS

1.1 Consider the circuit diagram below. Which ONE of the following correctly describes the change in total resistance and total current when switch S is closed?

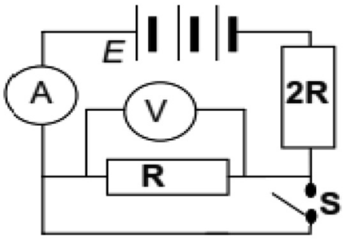


	TOTAL RESISTANCE	TOTAL CURRENT
A	decreases	decreases
B	increases	increases
C	decreases	increases
D	increases	decreases

1.2 Which ONE of the circuits below can be used to measure the current in conductor X and the potential difference across its ends?



1.3 In the circuit diagram below, the internal resistance of the battery and the resistance of the conducting wires are negligible. The emf of the battery is E.



When switch S is closed, the reading on the voltmeter V (in volts) is …

A.0 B. $\frac{1}{3}$E C. $\frac{2}{3}$E D. E

1.4 Ampere second could be the unit of …

A. power B. energy C. conductance D. charge

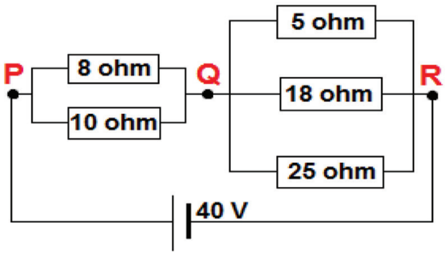
1.5 A circuit contains two unequal resistances in parallel; therefore:

A. The current is the same in both.
B. A larger current flows in the larger resistor.
C. The potential difference across each resistor is the same.
D. The smaller resistance has a smaller current flowing through it.

1.6 Three equal resistors connected in a series across a source of emf together dissipate 10 watts of power. What would be the power dissipated in the same resistors if they are connected in parallel across the same source of emf?

A.10 watts B. 30 watts C. 90 watts D. 270 watts.

1.7 Five resistances are connected as shown below, and the combination is connected to a 40 V supply. What is the voltage between P and Q?



A. 40 V B. 20 V C. 22,5 V D. 17,5 V

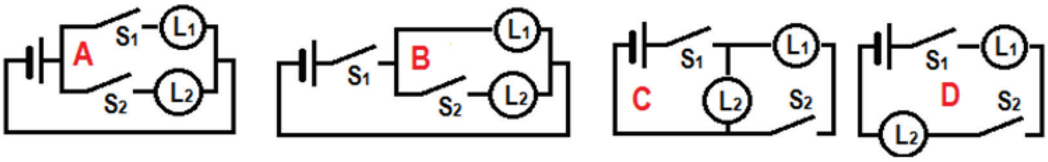
1.8 The current intensity in the circuit is 0,8 A and the voltage on the resistor is 20 V. What is the electrical power of this circuit?

A. 0.04 W B. 16 kW C. 16 W D. 25 Kw

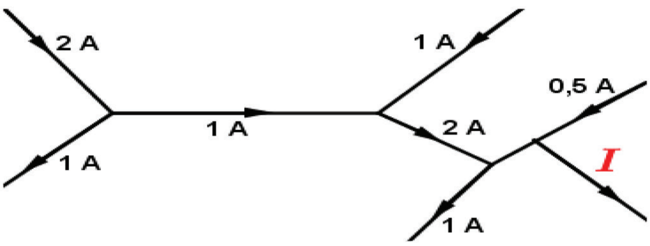
1.9 Which of the following statements is true?

A. Internal resistance mainly affects low-current loads.
B. Internal resistance mainly affects low-resistance loads.
C. Internal resistance mainly affects high-resistance loads.

1.10 Which of the diagrams below represents a circuit in which the following 2 situations are possible?
When Switch S_1 is on and Switch S_2 is off, only light L_1 will be on.
When Switch S_1 is off and Switch S_2 is on, neither light will be on.

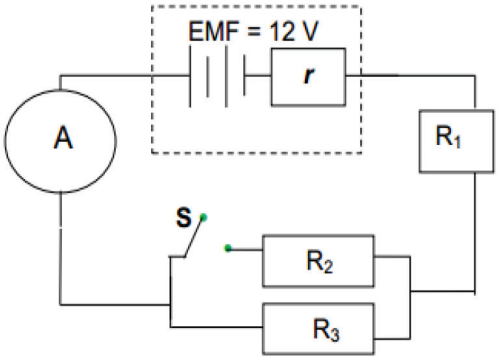


1.11 The current I in the figure is …



A. 1,5 A B. 0,5 A C. 3,5 A D. 2,5 A

1.12 The circuit diagram contains a combination of resistors R_1, R_2 and R_3. The battery has an emf of 12 V and an unknown resistor (R).



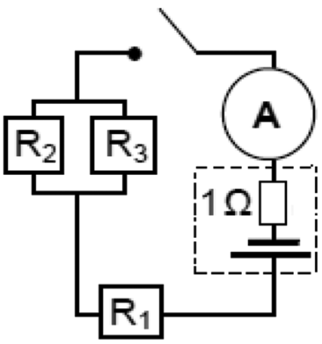
When switch S is closed:

	$R_{external}$	Reading on ammeter A
A	decreases	increases
B	decreases	remains constant
C	decreases	decreases
D	increases	increases

5.10 Open/ structured questions

QUESTION 2

2.1 In the electrical circuit, the battery has an Emf of 6 V and an internal resistance of 1 Ω. The total external resistance of the circuit is 9 Ω.



2.1.1 Calculate the current in R_1 when the switch is closed.

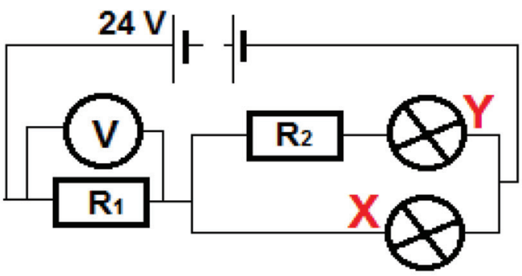
The power dissipated in resistor R_1 is 1,8 W. The resistance of resistor R_3 is 4 times that of resistor R_2 ($R_3 = 4 R_2$).

2.1.2 Calculate the resistance of resistor R_2.

2.2 A hair-dryer operates at a potential difference of 240 V and a current of 9,5 A. It takes a learner 12 minutes to completely dry her hair. Eskom charges energy usage at R1,47 per unit.

Calculate the cost of operating the hairdryer for the 12 minutes. (1 unit = 1 kW·h)

2.3 Two lamps (**X** and **Y**) are connected in the circuit shown below. Lamp **X** is rated at 12 V, 36 W, and lamp **Y** at 4,5 V, 2,0 W. The battery has an emf of 24 V and negligible internal resistance. The resistors, $\mathbf{R_1}$ and $\mathbf{R_2}$ are chosen so that the lamps are operating at their correct working voltage.



2.3.1 Show that the current in each lamp (**X** and **Y**) when it is operated at its correct working voltage in the circuit, is 3 A and 0,44 A respectively.

2.3.2 Calculate the potential difference across R_1.

2.3.3 What is the total current that flows through the circuit?

2.3.4 Calculate the resistance of R_1.

2.3.5 Calculate the resistance of R_2.

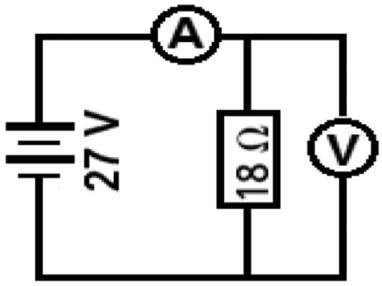
2.3.6 The filament in lamp **X** breaks and the lamp no longer conducts. It is observed that the voltmeter reading decreases and lamp **Y** glows more brightly. Explain, without calculation, why the voltmeter reading decreases.

2.3.7 Explain, without calculation, why lamp **Y** glows more brightly.

2.4 Two light bulbs work on a 120 V circuit. One is 50 W and the other is 100 W. Which bulb has a higher resistance? Explain.

2.5 What electric quantities must be kept small to transmit electric energy economically over long distances?

2.6 Use the figure below as a reference to answer the questions that follow:



2.6.1 What should the ammeter reading be?

2.6.2 What should the voltmeter reading be?

2.6.3 How much power is delivered to the resistor?

2.6.4 How much energy is delivered to the resistor per hour?

2.7 A lamp draws a 66 mA current when connected to a 6,0 V battery. When a 9,0 V battery is used, the lamp draws 75 mA.

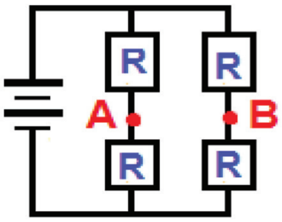
2.7.1 Does the lamp obey Ohm's law?

2.7.2 How much power does the lamp dissipate when it is connected to the 6,0 V battery?

2.7.3 How much power does it dissipate at 9,0 V?

2.8 A student makes a voltage divider from a 45 V battery, a 475 kΩ resistor, and a 235kΩ resistor. The output is measured across the smaller resistor. What is the voltage?

2.9 The circuit has four identical resistors. Suppose that a wire is added to connect points A and B.



Answer the following questions, and explain your reasoning.

2.9.1 What is the current through the wire?

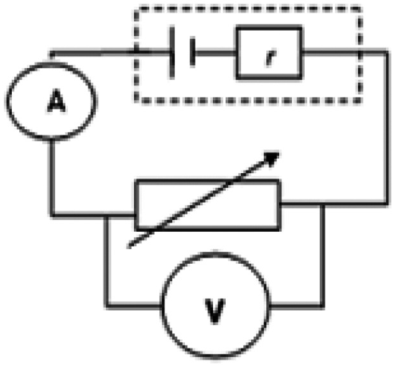
2.9.2 What happens to the current through each resistor?

2.9.3 What happens to the current drawn from the battery?

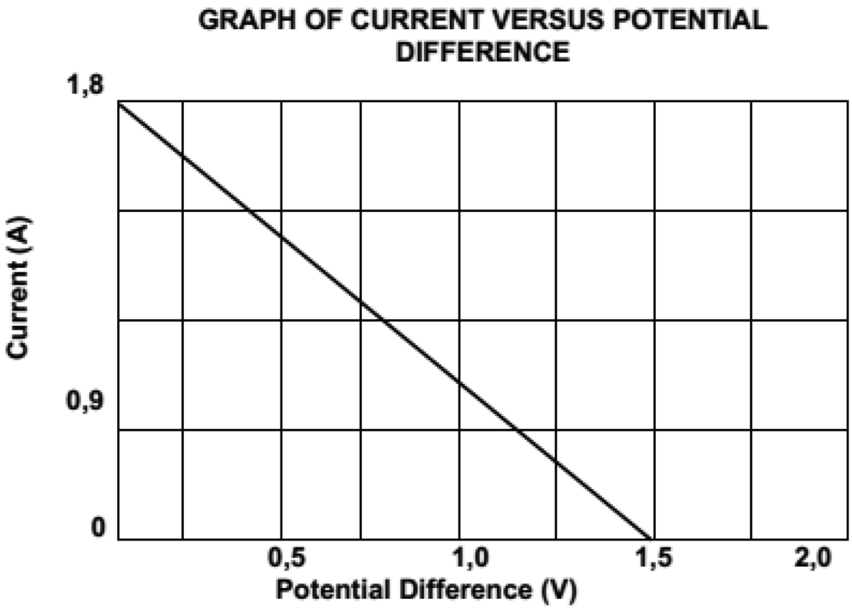
2.9.4 What happens to the potential difference across each resistor?

2.10 Why is there a difference in equivalent resistance between three 60 Ω resistors connected in series and three 60 Ω resistors connected in parallel?

2.11 Learners conduct an experiment as shown in the diagram below.



The results obtained are shown in the graph below.



Use the graph to determine the following:

2.11.1 The emf of the battery.

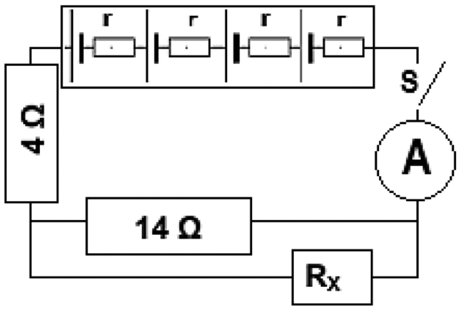
2.11.2 The internal resistance of the battery - without using the equation emf = I(R+r).

The resistance of the rheostat is now increased.

2.11.3 How will this change the voltmeter reading? Write down one of the following options: INCREASES, DECREASES or REMAINS THE SAME.

2.11.4 Explain your answer.

2.12 Four identical cells, EACH with an Emf of 1,5 V and an internal resistance of 0,25 Ω, are connected in series with each other and to the resistors, as shown below.



2.12.1 Write down the potential difference across the cells when the switch is open.

2.12.2 When switch S is closed, the potential difference across the 4 Ω resistor is …?
2 V. Calculate the current in the circuit and the value of R_x.

6. CHECK YOUR ANSWERS

Question 1

1.1 C – The total resistance decreases with the addition of a resistor in parallel; therefore, the total current increases.

1.2 A – The voltmeter must be attached across the resistor (i.e. in parallel). The ammeter must measure all the current going through X.

1.3 A – When the switch is closed, the resistor (R) will be bypassed, i.e. no current will flow through it. The voltmeter will measure the potential difference across a length of the conducting lead: theoretically, that is zero.

1.4 D – Charge. The formula for charge is Q = It (ampere second).

1.5 C – Resistors in parallel are current dividers, so they have the same potential difference across them. The larger resistor will carry less current than the smaller resistor.

1.6 C – 90 watts; V_2 = PR = 10(3R) (for the series circuit) and P(R/3) (for the parallel circuit). Therefore P (for the parallel circuit) = 30R/(R/3) = 90R/R = 90 W.

1.7 C – The voltage between P and Q is 22,5 V. RPQ = 4,4 Ω, and RQR = 3,4 Ω. The voltage is split in the same ratio, i.e. the voltage PQ = 4,4/(4,4+3,4) × 40 = 22,5 V.

1.8 C – P = VI = 20 × 0,8 = 16 W.

1.9 B – The internal resistance of a battery or cell is an important factor when the external circuit has a very low resistance (or a resistance of relative size to the internal resistance). When the external resistance is very high, the internal resistance of the battery is much less significant. Low current loads generally imply a high external resistance.

1.10 B.

1.11 A – 1,5 A. The 2A current (moving right down) is split into two: the 1A current shown, and 1A flowing from the junction toward the next junction. That this latter junction, the 1 A current and the 0,5 A current combine, thus I = 1,5 A.

1.12 A.

Question 2

2.1 1) emf=I (R +r)

6 =I(9 +1)

I= 0,6A

2.1.2 First calculate the resistance of R_1, based on the power dissipated.

$P = I^2R$

$1{,}8 = (0{,}6)^2R$

$R = 5\ \Omega$ –

Then calculate R_2, given that the total external resistance = 9Ω and $R_3 = 4R_2$.

Rp = 9 - 5 = 4Ω

$$\frac{1}{R_p} = \frac{1}{R_3} + \frac{1}{R_2}$$

$$\frac{1}{4} = \frac{1}{4R_2} + \frac{1}{R_2}$$

$R_2 = 5\ \Omega$

2.2 $W = VI\Delta t =$ (240)(9,5)(12x60) = 1, 642x10^6J

Kilowatt-hour (kWh) is a unit of energy equivalent to one kilowatt (1 kW) of power expended for one hour. One watt is equal to 1 J/s. One **kilowatt-hour** is 3,6 megajoules.

kWh = (3600s)[kW] = 3600[s][kJ/s] = 3600kJ = 3,6 MJ.

Thus, energy used = 1,642 x 10^6/3,6x10^6 kWh.

This is multiplied by the cost per kWh (R1,47) = R0,67.

2.3.1

For X: P = VI ∴ I = P/V =36/12 = 3A.

For Y: P = VI ∴ I = P/V =2,0/4,5 = 0,44A.

2.3.2

The voltage across lamp X is 12V; therefore, the voltage across the R_1 resistor must be: 24 – 12 = 12V.

(Resistors, lamps, etc., in a series are voltage dividers.)

2.3.3

The total current through the circuit = current through the two parallel branches = 3 + 0,44 = 3,44A (Parallel branches are current dividers.)

2.3.4

R_1 = V/I = 12/3,44 = 3,488Ω

2.3.5

The potential difference across the R_2 resistor = 12 V (the potential difference across the whole parallel combination) – 4,5 V (the voltage across Y) = 7,5 V. R = V/I = 7,5/0,44 = 17,05Ω.

2.3.6

When lamp X stops conducting electricity, the total resistance of the circuit increases; therefore, the current through the circuit will decrease. Since R_1 remains constant, and V= IR if the current decreases, then the voltage also decreases.

2.3.7

When the lamp stops working, the resistance of the parallel combo (now just R_2 + Y) increases. With greater resistance comes a greater portion of the 24 V potential difference. And since $P = V^2/R$, greater voltage must lead to greater power and greater brightness for lamp Y.

This is illustrated by calculation as follows:

Lamp Y: $P = V^2/R$, therefore $R = V^2/P = (4,5)^2/2$ = 10,125Ω.

Initial voltage division between R_1 and (R_2 + Y/X) was 12:12.

With R_1 = 3,488, R_2 + Y = 17,05 + 10,125 = 27,175 Ω – the 24 volts divided in the ratio 2,73:21,27.

2.4

The 50 W bulb: $P = V^2/R$, therefore $R = V^2/P$. The lower P is, the higher R must be.

2.5

The resistance of the wire and the current passing through the wire should be as low as possible.

2.6.1

$I = V/R = 27/18 = 1,5$ A

2.6.2 27 V

2.6.3

$P = VI = 27 \times 1,5 = 40,5$ W

2.6.4

$E = P.t = 40,5 \times 3600 = 1,46 \times 10^5$ J

2.7.1

No. The voltage is increased by a factor of 9/6 = 1,5, but the current is increased by a factor of 75/66 = 1,1. Therefore, the lamp does not obey Ohm's law.

2.7.2

$P = VI = 66 \times 10^{-3} \times 6 = 0,40$ W

2.7.3

$P = VI = 75 \times 10^{-3} \times 9 = 0,68$ W

2.8

The voltage is divided in the same ratio as the ratio of the resistors.

Thus, voltage across the 235 kΩ resistor = 235/(235+475)x45= 14,894 or 15 V.

2.9.1

0A – A and B are at the same potential; therefore, no current flows through the wire connecting A and B.

2.9.2

Nothing. The current through each of the four resistors will remain the same.

2.9.3

Nothing. It remains the same.

2.9.4

Nothing. It remains the same.

2.10

In a series circuit, the current is opposed by each resistor in turn. The total resistance is the sum of the resistors. In a parallel circuit, each resistor provides an alternative path for current to flow along. The result is a decrease in total resistance.

2.11.1

1,5 V (Emf is measured when there is no current flowing through the external circuit.)

Gradient of the line = $\Delta I/\Delta V$ = (0 -1,8)/(1,5 – 0) = -1,20.

2.11.2

$r = \Delta V/\Delta I = 1/1{,}2 = 0{,}83\Omega$

2.11.3 Increases.

2.11.4

Emf = I(R+r) = IR + Ir = V + Ir. When the resistance of the rheostat is increased, and the emf of the battery remains the same (as it should), the total current flowing is reduced; therefore, IR = V (across the rheostat is reduced) increases.

2.12.1

4 x 1,5 = 5V

2.12.2

(i) V = IR

∴ I = V/R = 2/4 = 0,5 A

(ii) Emf = I(R+r) = 0,5 [(Rp+ 4) + 4(0,25)] = 6V

∴ Rp = 7Ω

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

$$\therefore \frac{1}{7} = \frac{1}{14} + \frac{1}{R_x}$$

∴ Rx = 14Ω

6. MESSAGE TO GRADE 12 LEARNERS FROM THE WRITERS

To be successful in life, you need to go the extra mile, so make sure you study and work hard. I would like to encourage you by quoting Dr John M Tibane, from his book entitled Turbo Think:
“Always do more than is required of you.”
“The number one reason why most people are not wealthy is that they have not decided to be wealthy”.

To be successful you need to decide to be successful and do more than is required of you in order to expedite your success.

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PHYSICAL SCIENCE
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GRADE 12

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