DEPARTMENT OF EDUCATION
SCHOOLS DIVISION OF NEGROS ORIENTAL
REGION VII
Kagawasan Ave., Daro, Dumaguete City, Negros Oriental

DIRECT-CURRENT CIRCUITS

for GENERAL PHYSICS 2/ Grade 12/ Quarter 3/ Week 6

SELF-LEARNING KIT

NegOr_Q3_GenPhysics2_SLKWeek6_v2

FOREWORD

This Self-Learning Kit is designed to cater your needs as STEM students for Modular Distance Learning. It is carefully planned to holistically develop your life-long learning skills. This serves as a guide in understanding concepts about direct-current circuits specifically resistors in series and parallel, Kirchhoff's rules and R-C circuits.

This module focuses on the analysis of simple circuits that contain batteries, resistors and capacitors in various combinations. Kirchhoff's rules simplify the analysis of these circuits as it follows the laws of conservation of energy and conservation of electric charge. Finally, you will learn to evaluate the equivalent resistance, current and voltage in a given network of resistors connected in series and parallel and they can also solve problems involving the calculation of currents and potential difference in circuits consisting of batteries, resistors and capacitors. The knowledge gained will help you understand daily scenarios involving circuits such as but not limited to tripping of circuit breakers when too many devices are plugged in.

OBJECTIVES

At the end of this Self-Learning Kit, you should be able to:

K: evaluate the equivalent resistance, current, and voltage in a given network of resistors connected in series and/or parallel;

S: calculate the current and voltage through and across circuit elements using Kirchhoff's loop and junction rules (at most 2 loops only);

: solve problems involving the calculation of currents and potential difference in circuits consisting of batteries, resistors and capacitors; and

A: recognize the importance of circuits as a major part in making technologies functional.

LEARNING COMPETENCIES

Evaluate the equivalent resistance, current, and voltage in a given network of resistors connected in series and/or parallel **(STEM_GP12EMIIIg-48).**

Calculate the current and voltage through and across circuit elements using Kirchhoff's loop and junction rules (at most 2 loops only) **(STEM_GP12EMIIIg-49).**

Solve problems involving the calculation of currents and potential difference in circuits consisting of batteries, resistors and capacitors **(STEM_GP12EMIIIg-51).**

I. WHAT HAPPENED

If all appliances were operating at one time, a circuit breaker would probably be tripped, preventing a potentially dangerous situation. What causes a circuit breaker to trip when too many electrical devices are plugged into one circuit?

Adapted from https://www.eskom.co.za/news/Pages/Sep28.aspx

Figure 1. A single outlet with multiple appliances connected

PRE-ACTIVITY:

Objective: Compare series and parallel circuits with the use of drinking straws.
Materials: 4 pcs. Drinking straws; scotch tape
Procedure:

1. Tape one pair of drinking straw end to end.
2. Tape a second pair side by side.

Guide Questions:

1. Which pair is easier to blow through?
2. What would happen if you were comparing three straws taped end to end with three taped side by side?
3. Write your answers on your notebook.

PRE-TEST:

MULTIPLE CHOICE: Choose the letter of the correct answer. Write your answer on your notebook.

1. Which statement describes current in a series circuit?
   a. It stays the same throughout.
   b. It splits up across each component.
   c. It increases.
2. Which statement describes voltage in a series circuit?
   a. It stays the same throughout.
   b. It splits up across each component.
   c. It increases.
3. What happens to the voltage in a parallel circuit?
   a. It splits up across each component.
   b. It splits across the branches.
   c. It stays the same throughout.
4. Which of the following quantity remains in parallel circuit?
   a. Current and voltage b. current c. voltage
5. In a parallel circuit, if one of the bulbs blew out, the other bulb would not be able to light up. This statement is ___.
   a. True b. False c. Neither true nor false

II. WHAT I NEED TO KNOW

Adapted from https://www.google.com/amp/s/arstechnica.com/cars/2017/02/have-you-looked-at-your-windshield-wipers-lately/%3famp=1

Figure 2. A car equipped with windshield wipers that can operate during rainfall

Many automobiles are equipped with windshield wipers that can operate intermittently during a light rainfall. How does the operation of such wipers depend on the charging and discharging of a capacitor?

*The wipers are part of an RC circuit whose time constant can be varied by selecting different values of **R** through a multiposition switch. As it increases with time, the voltage across the capacitor reaches a point at which it triggers the wipers and discharges, ready to begin another charging cycle. The time interval between the individual sweeps of the wipers is determined by the value of the time constant.*

DISCUSSION:

Resistors in Series and Parallel

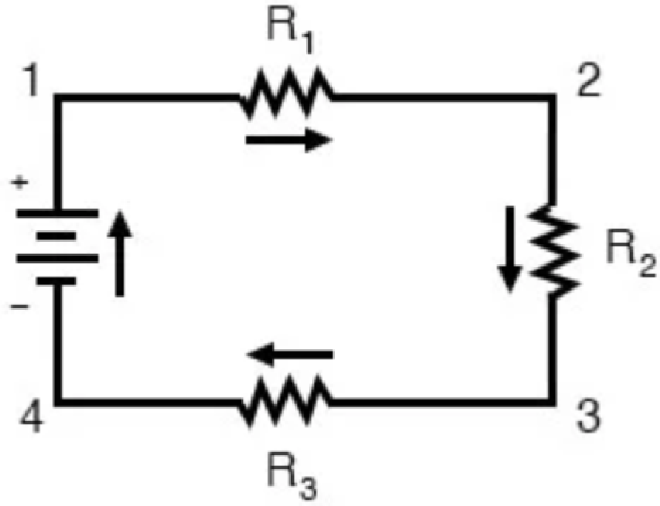
Suppose that you and your friends are at a crowded basketball game in a sports arena and decide to leave early. You have two choices:

1. Your whole group can exit through a single door and walk down a long hallway containing several concessions stands, each surrounded by a large crowd of people waiting to buy food or souvenirs; or
2. Each member of your group can exit through a separate door in the main hall of the arena, where each will have to push his or her way through a single group of people standing by the door.

In which scenario will less time be required for your group to leave the arena?

It should be clear that your group will be able to leave faster though the separate doors than down the hallway where each of you has to push through several groups of people. We could describe the groups of people in the hallway as acting in ***series***, because each of you must push your way all through the group. The groups of people around the doors in the arena can be described as acting in ***parallel***. Each member of your group must push through only one group of people, and each member pushes through a *different* group of people. This simple analogy will help us understand the behavior of currents in electric circuits containing more than one resistor.

The Series Circuit



Adapted from https://www.allaboutcircuits.com/textbook/direct-current/chpt-5/what-are-series-and-parallel-circuits/

Figure 3. A series circuit with three resistors (labelled R_1, R_2, and R_3) connected in a long chain from one terminal of the battery to the other

Figure 3 illustrates a **series circuit** where all components are connected using a single pathway. In other words, a series circuit is characterized by a single loop for current to flow. The current is the same for all the components along this circuit. Thus,

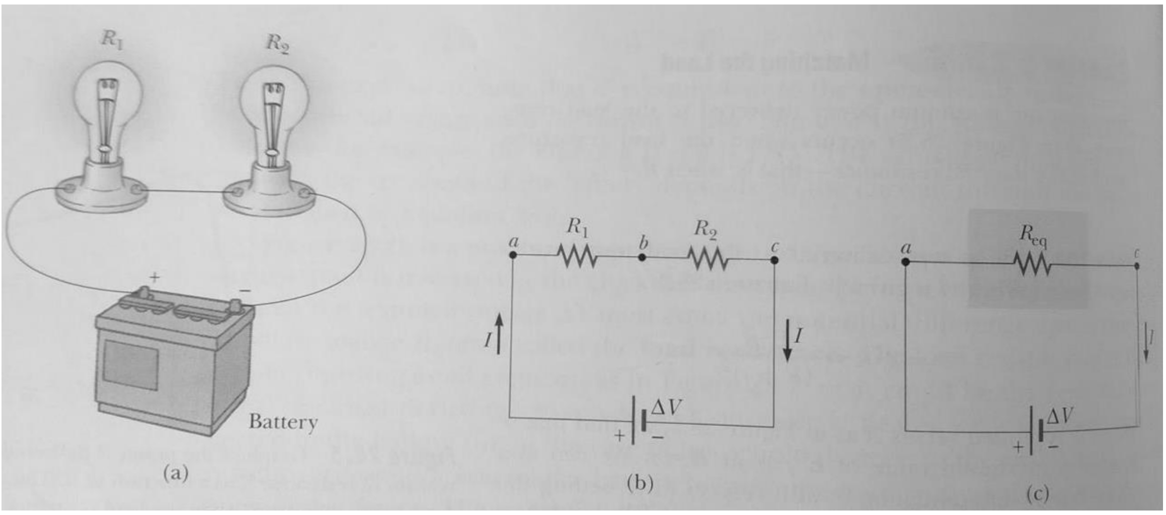
> *for a series combination of resistors, the currents in the two resistors are* ***the same*** *because any charge that passes through R_1 must also pass through R_2.*

$$I_{total} = I_1 = I_2 = I_3 = \ldots = I_n$$

The *total voltage* is the **sum of the individual voltages** across the circuit.

$$V_{total} = V_1 + V_2 + V_3 + \ldots + V_n$$

Now, consider the illustration below.



Adapted from Thomson Learning Inc.

Figure 4. (a) A series connection of two resistors R_1 and R_2. The current in R_1 is the same as that in R_2; (b) Circuit diagram for the two-resistor circuit; (c) The resistors replaced with a single resistor having an equivalent resistance $R_{eq} = R_1 + R_2$

The potential difference applied across the series combination of resistors will divide between the resistors. In the ilustration, since the voltage drop from a to b equals IR_1 and the voltage drop from b to c equals IR_2, the voltage drop from a to c is

$$\Delta V = IR_1 + IR_2 = I\,(R_1 + R_2)$$

Therefore, we can replace the *two resistors in series* with a *single resistor* having an *equivalent resistance* R_{eq}, where:

$$R_{eq} = R_1 + R_2$$

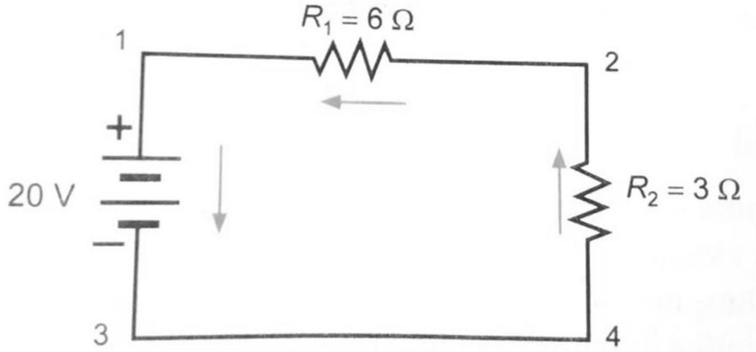
The resistance (R_{eq}) is equivalent to the series combination R_1 and R_2 in the sense that the circuit current is unchanged when R_{eq} replaces $R_1 + R_2$.

The equivalent resistance of three or more resistors connected in series is:

$$R_{eq} = R_1 + R_2 + R_3 + \ldots$$

*This relationship indicates that the equivalent resistance of a series connection of resistors is always **greater than** any individual resistance.*

Example 1: Compute the equivalent resistance, total voltage and the individual values and total values of the voltage in the series circuit below.



Adapted from DIWA Learning Systems Inc.

Figure 5. A series circuit

Solution*:* The total resistance in the circuit is computed as follows:

$$
\begin{aligned}
R_{eq} &= R_1 + R_2 \\
&= 6\ \Omega + 3\ \Omega \\
&= \boldsymbol{9\ \Omega}
\end{aligned}
$$

Because the total voltage is $20V$, you can compute the total current as follows:

$$I_{total} = \frac{V_{total}}{R_{total}}$$

$$= \frac{20V}{9V} = \mathbf{2.22\ A}$$

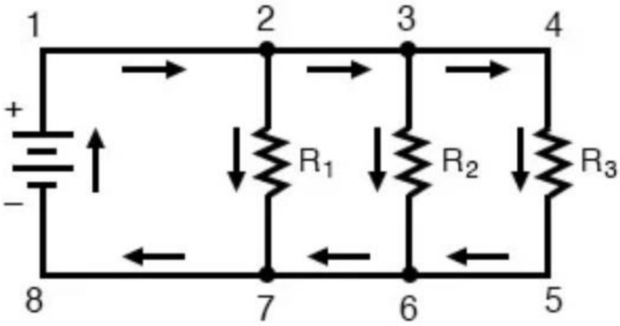
Because the type of connection is a *series circuit*, I_1 is 2.22 A and I_2 is also 2.22 A. From these values, you have:

$$
\begin{aligned}
\Delta V &= IR \\
V_1 &= I_1 R_1 \\
&= (2.22\ A)(6\ \Omega) \\
&= \boldsymbol{13.32\ V}
\end{aligned}
$$

$$
\begin{aligned}
V_2 &= I_2 R_2 \\
&= (2.22\ A)(3\ \Omega) \\
&= \boldsymbol{6.66\ V}
\end{aligned}
$$

The Parallel Circuit

Parallel circuits use branches to allow current to pass through more than one path, unlike in the series circuit.



Adapted from https://www.allaboutcircuits.com/textbook/direct-current/chpt-5/what-are-series-and-parallel-circuits/

Figure 6. A parallel circuit with three resistors with but more than one continuous path for current to flow

The voltage between two points in the circuit does not depend on the path taken; thus, the individual voltages in a parallel circuit are the same as the total voltage..

$$V_{total} = V_1 = V_2 = V_3 = \ldots = V_n$$

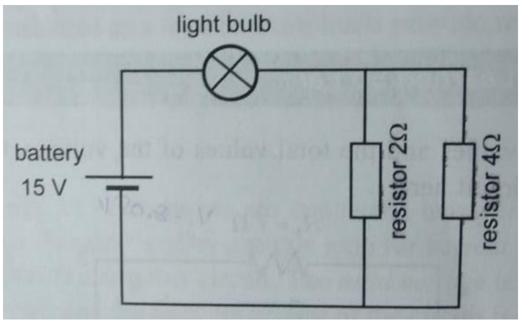
However, unlike in the series circuit, the *current* in each load is **not the same** as the total current in the circuit. The *total current* is the **sum of the individual currents** across the resistors.

$$I_{total} = I_1 + I_2 + I_3 + \ldots + I_n$$

The reciprocal of the equivalent resistance in this type of circuit is equal to the sum of the reciprocals of the individual resistances. Always remember that the equivalent resistance is always less than the individual resistances.

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

Example 2: Compute the equivalent resistance, current and voltage of the parallel circuit below.



Adapted from DIWA Learning Systems, Inc.

Solution: The equivalent resistance of the circuit is computed as V_1 follows:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$
$$= \frac{1}{2\Omega} + \frac{1}{4\Omega} = \frac{\mathbf{3}}{\mathbf{4}\Omega}$$
$$\frac{1}{R_{eq}} = \frac{4}{3\Omega} = \boldsymbol{1.33\Omega}$$

Because the total voltage is $15V$ and the resistors are connected in parallel, then is $15V$ and V_2 is also $15V$. Then, we have:

$$I_1 = \frac{V_1}{R_1} = \frac{15V}{2\Omega} = \boldsymbol{7.5\,A}$$

$$I_2 = \frac{V_2}{R_2} = \frac{15V}{4\Omega} = \boldsymbol{3.75\,A}$$

Finally, you can compute the total current as follows:

$$I_{total} = \frac{V_{total}}{R_{eq}}$$
$$= \frac{15V}{1.33\Omega} = \boldsymbol{11.28\,A}$$

KIRCHHOFF'S RULES

A general way to analyze a circuit is by using Kirchhoff's rules. These rules are used by electrical engineers as they compute the amount of current that goes through a circuit regardless of its configuration. These statements were first discovered by Gustav Kirchhoff, a German physicist, in 1845. Kirchhoff's rules contain the following two statements:

1. ***Kirchhoff's Point/Junction Rule***: The sum of all the currents entering a point or junction of the circuit is equal to the sum of all the currents leaving that point or junction.

$$\sum I_{in} = \sum I_{out}$$

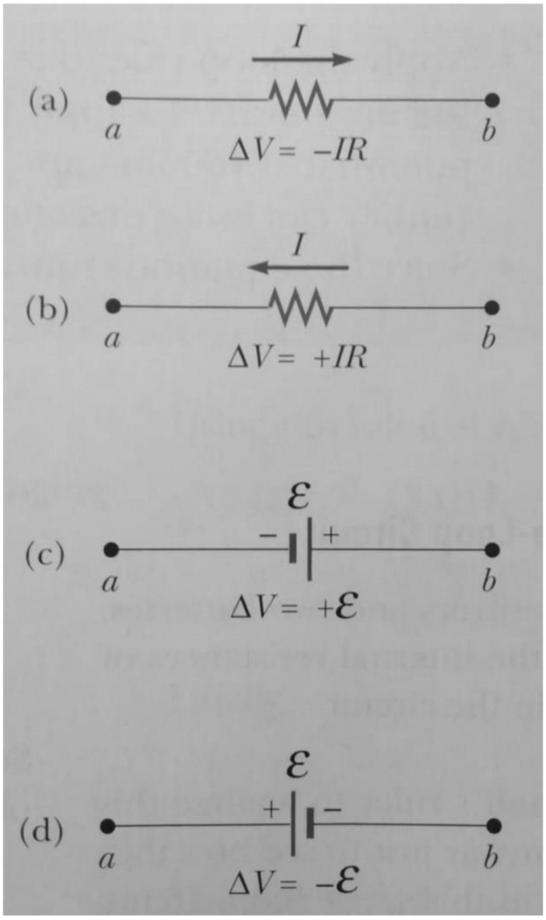
2. ***Kirchhoff's Loop/Circuit Rule***: The sum of the potential differences across all elements around any closed ciruit loop muct be zero.

$$\sum_{\substack{\text{Closed} \\ \text{loop}}} V = 0$$

The loop rule is based on the conservation of electric charge. No charge can accumulate at the junction. *The total charge entering and leaving the junction at a particular amount of time should always be the same.*

In justifying our claim that Kirchhoff's second rule is a statement of conservation of energy, we imagined carrying a charge around a loop. When applying this rule, we imagine *travelling* around the loop and consider changes in electric potential, rather than the changes in potential energy. You should also note the following sign conventions when using the second rule:

- Because charges move from the high-potential end os a resistor to the low-potential end, is a resistor is traversed in the direction of the current, the change in potential ΔV across the resistor is ***– IR***. (Fig. 6.a)
- If a resistor is traversed in the direction *opposite* the current, the change in potential ΔV across the resistor is ***+IR.*** (Fig. 6.b)
- If a source of emf (assumed to have zero internal resistance) is traversed in the direction of the emf (from – to +), the change in potential ΔV is + ε (Fig. 6.c). The emf of the battery increases the electric potential as we move through it in its direction.
- If a source of emf (assumed to have zero internal resistance) is traversed in the direction oppocite the emf (from + to -), the change in potential ΔV is – ε (Fig. 6.d). In this case, The emf of the battery reduces the electric potential as we move through it.



Adapted from Thomson Learning Inc.

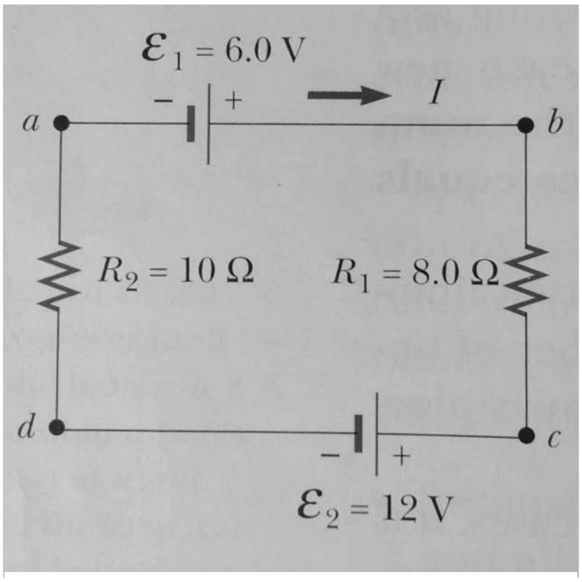
Figure 7. Rules for determining the potential changes across a resistor and a battery

Problem-Solving Hints:

- *Draw a circuit diagram, and label all the known and unknown quantities. You must assign a **direction** to the current in each branch of the circuit. Do not be alarmed if you guess the direction of a current incorrectly; your result will be negative, but **its magnitude will be correct**. Although the assignment of current directions is arbitrary, you must adhere rigorously to the assigned directions when applying Kirchhoff's rules.*
- *Apply the junction rule to any junctions in the circuit that provide new relationships among the various currents.*
- *Apply the loop rule as to many loops in the circuit as are needed to solve for the unknowns. To apply this rule, you must correctly identify the change in potential as you imagine crossing each element in traversing the closed loop (either clockwise or counterclockwise). Watch out for errors in sign!*
- *Solve the equations simultaneously for the unknown quantities.*

Example 3: *A Single-Loop Circuit*

A single-loop circuit contains two resistors and two batteries. (Neglect the internal resistances of the batteries), find the current in the circuit.



Adapted from Thomson Learning Inc.

***Solution*:**

We do not need Kirchhoff's rules to analyze this simple circuit, but let us use them anyway just to see how they are applied. There are no junctions in this single-loop circuit; thus, the current is the same in all elements. Let us assume that the current is clockwise. Traversing the circuit in a clockwise direction, starting at a, we see that a to b represents a potential change of + ε_1, b to c represnts a potential change of $- IR_1$, c to d represents a potential change of $- \varepsilon_2$, and d to a represnts a potential change of $-IR_2$. Applying Kirchhoffs's loop rule gives:

$$\boldsymbol{\sum V = 0}$$

$$\mathcal{E}_1 - IR_1 - \mathcal{E}_2 - IR_2 = 0$$

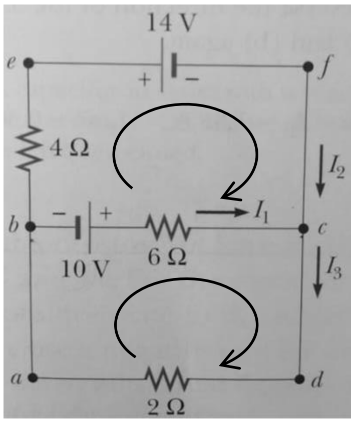
Solving for I and using the values given in the figure, we obtain:

$$I = \frac{\varepsilon_1 - \varepsilon_2}{R_1 - R_2} = \frac{6.0V - 12V}{8.0\Omega + 10\Omega} = \boldsymbol{-\ 0.33\,A}$$

The negative sign for I indicates that the direction of the current is opposite the assumed direction.

Example 4: Applying Kirchhoff's Rules

Find the current I_1, I_2, I_3 in the circuit shown in the figure on the right.



Adapted from Thomson Learning Inc.

Solution:

Notice that we cannot reduce this circuit to a simpler form by means of the rules of adding resistances in series and in parallel. We must use Kirchhoff's rules to analyze this circuit. We arbitrarily choose the directions of the currents as labeled in the figure. Applying Kirchhoff's junction rule to junction c gives:

$$(1) \quad I_1 + I_2 = I_3$$

We now have one equation with three unknowns - I_1, I_2, and I_3. There are three loops in the circuit – *abcda, befcb, and aefda.* We therefore need only two loop equations to determine the unknown currents. (The third loop equatio would give no new information). Applying Kirchhoff's loop rule to loops *abcda* and *befcb* and traversing these loops clockwise, we obtain the expressions:

$$(2) \quad abcda \;\; 10V – (6\Omega)\, I_1 - (2\Omega)\, I_3 = 0$$

$$(3) \quad befcb \;\; -14V + (6\Omega)\, I_1 – 10V - (4\Omega)\, I_2 = 0$$

Note that the loop *befcb* we obtain a positive value when traversing the 6-Ω resistor because our direction of travel is opposite the assumed direction of I_1.

Expression (1), (2), and (3) represent three independent equations with three unknowns. Substituting equation (1) into Equation (2) gives:

$$10 \; – (6\Omega)\, I_1 – (2\Omega)\, (I_1 + I_2) = 0$$

$$(4) \quad 10\ V = (8\Omega)\, I_1 + (2\Omega)\, I_2$$

Dividing each term in Equation (3) by 2 and rearranging gives:

$$(5) \quad -12V = - (3\Omega)\, I_1 + (2\Omega)\, I_2$$

Subtracting Equation (5) from Equation (4) eliminates I_2 giving:

$$22V = (11\Omega)\, I_1$$

$$\boldsymbol{I_1 = 2A}$$

Using this value of I_1 in Equation (5) gives a value for I_2:

$$(2\Omega)\, I_2 = (3\ \Omega)\, I_1 – 12\ V = (3\Omega)\ (2A) – 12V = -6V$$

$$\boldsymbol{I_2 = -3A}$$

Finally,

$$I_3 = I_1 + I_2$$
$$= \boldsymbol{-1A}$$

The fact that I_2 and I_3 are both negative indicates only that the currents are opposite the direction we chose for them. However, the numerical values are correct.

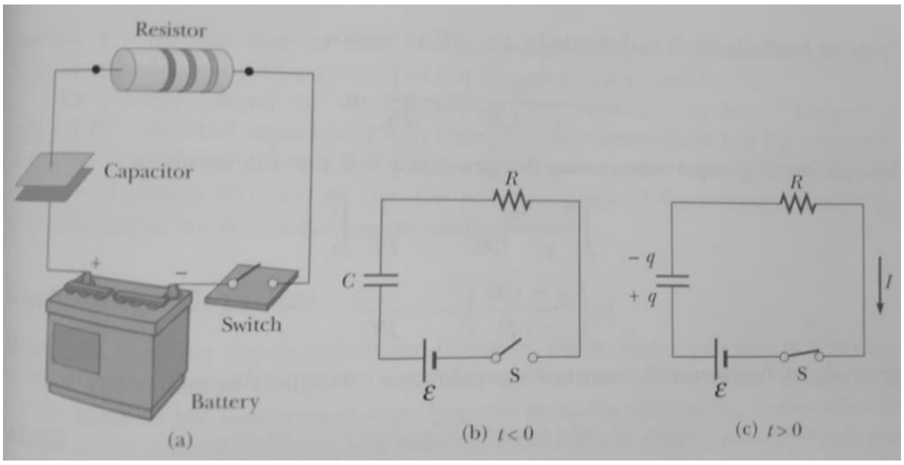
Capacitors

A capacitor is an electric component that temporarily stores charges within a circuit. Inside it are two conducting plates facing each other and separated by an insulator referred to as dielectric. This material impedes the continuous passage of electric current through the capacitor and stores it until it is discharged at a later time.

Capacitors are constructed by inserting an insulator to form a gap along the path of a conductor. The size of this insulator affects the amount of charges stored in the capacitor. The junction between the conductor and the dielectric in a capacitor can be adjusted so the amount of charges that can be stored by the capacitor may vary. This junction is in the form of a plate to accommodate and hold the dielectric in place. Aside from the distance between the conductor and the insulator, changing the diameter of the conducting plates also changes the amount of charges that the capacitor can store.

Charging a Capacitor

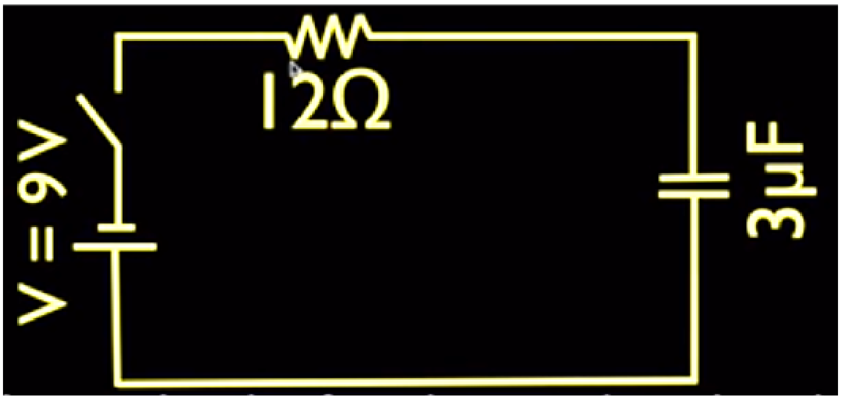
Let us assume that the capacitor in the figure below is initially uncharged. There is no current while switch S is open. If the switch is closed at $t = 0$, however, charge begins to flow, setting up a current in the circuit, and the capacitor begins to charge. Note that during charging, charges do not jump across the capacitor plates because the gap between the plates represents an open circuit. Instead, charge is transferred between each plate and its connecting wire due to the electric field established in the wires by the battery, until the capacitor is fully charged. As the plates become charged, the potential difference between the capacitors increase. The value of the maximum charge depends on the voltage of the battery. Once the maximum charged is reached, the current in the circuit is zero because the potential difference across the capacitor matches that supplied by the battery.



Adapted from Thomson Learning Inc.

Figure 8. (a) A capacitor in series with a resistor, switch, and battery; (b) circuit diagram representing this system at time $t < 0$, before the switch is closed; (c) circuit diagram at time $t > 0$, after the switch has been closed

Example 5:



Adapted from www.m.youtube.com/watch?v=OIpHPsnLINU

Immediately after the switch is closed *($t = 0$)*, what is:

1. Charge on capacitor;
2. Potential difference across capacitor;
3. Current through the circuit; and
4. Potential difference across resistor?

Solution:

1. $Q_c = 0C$
2. $V_c = 0V$
3. $V = IR$ $\quad\quad I = \frac{V}{R} = \frac{19V}{12\Omega} = 0.75\ A$
4. *Potential difference:* $V_R = IR$
$= 0.75A \times 12\Omega = 9V$

Charging Summary:

at t = 0	***as t = ∞***
$V_c = 0V$	$V_C = V_b$
$Q_c = 0C$	$Q_c = C{\cdot}V_b$
$I = \frac{V_b}{R}$	$I = 0A$
$V_R = V_b$	$V_R = 0V$

Discharging a Capacitor

Discharging a capacitor through a resistor proceeds in a similar fashion. Initially, the current is $I_0 = V_0/R$, driven by the initial voltage V_0 on the capacitor. As the voltage decreases, the current and hence the rate of discharge decreases, implying another exponential formula for V. Using calculus, the voltage V on a capacitor C being discharged through a resistor is found to be:

$$V(t) = V_0 e^{-t/RC}$$

Discharging Summary:

$$Q_c \longrightarrow 0C$$
$$V_C = V_b \longrightarrow 0V$$
$$I \longrightarrow 0A$$

PERFORMANCE TASK:

Directions: Read the given facts below. After which, answer the questions that follow. Be guided with the given rubric. Write your answers in your notebook.

Adapted from https://nl.ifixit.com/News/34355/why-keeping-your-old-christmas-lights-is-better-than-upgrading-to-led

Strings of lights are used for many ornamental purposes, such as decorating Christmas trees. Over the years, both parallel and series connections have been used for multilight strings powered by *120 V*. Series-wired bulbs are safer than parallel-wired bulbs for indoor Christmas-tree use because series-wired bulbs operate with less light per bulb and at a lower temperature.

In a parallel-wired string, each bulb operates at *120 V*. By design, the bulbs are brighter and hotter than those of a series-wired string.

1. What happens if the filament of a single bulb fails (or if the bulb is removed from its socket)? Why?
2. Why are parallel-wired strings more dangerous than series-wired strings?
3. What will happen if one bulb in a parallel-wired string fails or removed? Why?

Rubric:

	FOCUS The single-controlling part made with an awareness of task about a specific topic.	**CONTENT** The presence of ideas developed through facts, examples, anecdotes, details, opinions, statistics, reasons and/or explanations	**ORGANIZATION** The order developed and sustained within and across paragraphs using transitional devices and including introduction and conclusion	**STYLE** The choice, use and arrangement of words and sentence structures that create tone and voice.	**CONVENTIONS** Grammar, mechanics, spelling, usage and sentence formation.
4	Sharp, distinct controlling point made about a single topic with evident awareness of task	Substantial, specific, and/or illustrative, confident, demonstrating strong development and sophisticated ideas.	Sophisticated arrangement of content with evident and/or subtle transitions.	Precise, illustrative use of a variety of words and sentence structures to create consistent writer's voce and tone appropriate to audience.	Evident control of grammar, mechanics, spelling, usage and sentence formation.
3	Apparent point made about a single topic with sufficient awareness of task.	Sufficiently developed content with adequate elaboration or explanation.	Functional arrangement of content that sustains a logical order with some evidence of transitions.	Generic use of a variety of words and sentence structures that may or may not create writer's voice and tone appropriate to audience.	Sufficient control of grammar, mechanics, spelling, usage and sentence formation.
2	No apparent point but evidence of a specific topic.	Limited content with inadequate elaboration or explanation.	Confused or inconsistent arrangement of concept with or without attempts at transition.	Limited word choice and control of sentence structures that exhibit voice and tone.	Limited control of grammar, mechanics, spelling, usage and sentence formation.
1	Minimal evidence of a topic.	Superficial and/or minimal content.	Minimal control of content arrangement.	Minimal variety in word choice and minimal control of sentence structures.	Minimal control of grammar, mechanics, spelling, usage and sentence formation.

Adapted from https://pt.slideshare.net/mobile/jennytuazon01630/rubrics-in-essay

III. WHAT I HAVE LEARNED EVALUATION/POST-TEST:

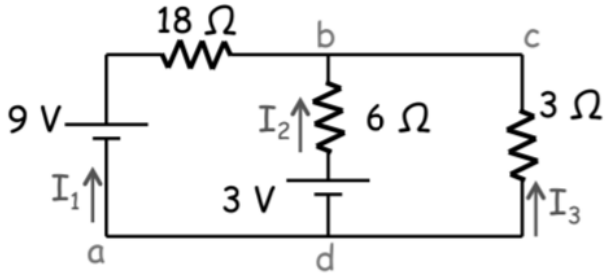
I. MULTIPLE CHOICE: Choose the letter of the correct answer. Write your answer on your notebook.

1. Which of the following quantity remains in parallel circuit?
   a. Current and voltage b. current c. voltage
2. Which statement describes current in a series circuit?
   a. It stays the same throughout.
   b. It splits up across each component.
   c. It increases.
3. What happens to the voltage in a parallel circuit?
   a. It splits up across each component.
   b. It splits across the branches.
   c. It stays the same throughout.
4. In a parallel circuit, if one of the bulbs blew out, the other bulb would not be able to light up. This statement is ___.
   a. True b. False c. Neither true nor false
5. Which statement describes voltage in a series circuit?
   a. It stays the same throughout.
   b. It splits up across each component.
   c. It increases.
6. For a series combination of resistors, the currents in the two resistors are ____________.
   a. The same b. increases c. decreases
7. The equivalent resistance of a series connection of resistors is always _____________ any individual resistance.
   a. Less than b. greater than c. equal
8. According to Kirchhoff's Point/Junction Rule, the sum of all the currents entering a point or junction of the circuit is _____ to the sum of all the currents leaving that point or junction.
   a. Less than b. greater than c. equal
9. Street lights are connected in which of the following configuration?
   a. Series b. parallel c. neither a nor b
10. In a series circuit, if one of the bulbs blew out, the other bulb would not be able to light up. This statement is ______.
    a. True b. false c. neither true nor false

II. Problem Solving: Solve the given problems below. If computations are needed, show the solution in your notebook.

1. A circuit has a resistor with a resistance of 3Ω followed by three parallel branches each holding a resistor with a resistance of 5Ω. What is the equivalent resistance of the circuit?

2. Find the current through each battery.



Adapted from https://www.bbc.co.uk/bitesize/guides/z437hyc/test

REFERENCES

David,Oliver M. *General Physics 2*.
Makati City, Philippines: DIWA Learning Systems Inc., 2017.

DC Circuits Containing Resistors and Capacitors | Physics.
Retrieved from https://courses.lumenlearning.com/physics/chapter/21-6-dc-crcuits-contaning-resistors-and-capacitors. Retrieved on January 18, 2021.

Have You Looked at Your Windshield Wipers Lately?
Retrieved from https://www.google.com/amp/s/arstechnica.com/cars/2017/02/have-you-looked-at-your-windshield-wipers-lately/%3famp=1. Retrieved on January 17, 2021.

Kirchhoff's Laws – Electric Circuits Questions and Answers –
Sanfoundry. Retrieved from https://www.sanfoundry.com/electric-circuits-questions-answers-kirchhoffs-laws. Retrieved on January 27, 2021.

Overloading Plugs is Highly Dangerous. Retrieved from
https://www.eskom.co.za/news/Pages/Sep28.aspx. Retrieved on January 18, 2021.

Series and Parallel Circuits Test Questions – National 4 Physics
Revision – BBC Bitesize. Retrieved from https://www.bbc.co.uk/bitesize/guides/z437hyc/test. Retrieved on January 27, 2021.

Serway, Raymond A. and Beichner, Robert J. *Physics for Scientists and Engineers with Modern Physics, Fifth Edition.* United States of America: Thomson Learning Inc., 2000.

RC Circuit Analysis (1 of 8) Voltage and Current. Retrieved
from www.m.youtube.com/watch?v=OlpHPsnLlNU. Retrieved on January 22, 2021.

RC Circuits | Boundless Physics. Retrieved from
https://courses.umenlearning.com/boundless-physics/chapter/rc-circuits/. Retrieved on January 17, 2021.

Rubrics in Essay. Retrieved from
https://pt.slideshare.net/mobile/jennytuazon01630/rubrics-in-essay.
Retrieved on September 7, 2020.

Simple Parallel Circuits | Series and Parallel Circuits | Electronic Textbook. Retrieved from https://www.allaboutcircuits.com/textbook/direct-current/chpt-5/simple-parallel-circuits/. Retrieved on January 17, 2021.

Why Keeping Your Old Christmas Lights is Better Than Upgrading to LED. Retrieved from https://nl.ifixit.com/News/34355/why-keeping-your-old-christmas-lights-is-better-than-upgrading-to-led. Retrieved on January 18, 2021.

DEPARTMENT OF EDUCATION
SCHOOLS DIVISION OF NEGROS ORIENTAL

SENEN PRISCILLO P. PAULIN, CESO V
Schools Division Superintendent

JOELYZA M. ARCILLA EdD
OIC - Assistant Schools Division Superintendent

MARCELO K. PALISPIS EdD JD
OIC - Assistant Schools Division Superintendent

NILITA L. RAGAY EdD
OIC - Assistant Schools Division Superintendent/CID Chief

ROSELA R. ABIERA
Education Program Supervisor – (LRMDS)

ARNOLD R. JUNGCO
PSDS - Division Science Coordinator

MARICEL S. RASID
Librarian II (LRMDS)

ELMAR L. CABRERA
PDO II (LRMDS)

ROWENA R. DINOKOT
Writer

STEPHEN C. BALDADO
Lay-out Artist

ALPHA QA TEAM
JOSE MARI B. ACABAL
MA. MICHELROSE G. BALDADO
GENEVA FAYE L. MENDOZA

BETA QA TEAM
ZENAIDA A. ACADEMIA
ALLAN Z. ALBERTO
EUFRATES G. ANSOK JR.
ROWENA R. DINOKOT
LESTER C. PABALINAS

SYNOPSIS AND ABOUT THE AUTHOR

This Self-Learning Kit focuses on resistors in series and parallel circuits, Kirchhoff's rules and RC Circuits. In a series circuit, all components are connected using a single pathway while parallel circuits use branches to allow current to pass through more than one path.

A general way to analyse a circuit is by suing Kirchhoff's rules. Kirchhoff's Point/Junction rule states that the sum of all the currents entering a point or junction of the circuit is equal to the sum of all the currents leaving that point or junction. On the other hand, Kirchhoff's Loop/Circuit rule states that the algebraic sum of the potential changes around any complete loop in the network is zero.

RC Circuit is a circuit containing a series combination of a resistor and a capacitor. If a capacitor is charged with a battery through a resistor of resistance, the charge on the capacitor and the current in the circuit vary in time. However, if a charged capacitor is discharged through a resistor of resistance, the charge and current decrease exponentially.

ANSWER KEY

Pre–Activity:

Note: Answers of students may vary depending on their observations.

Pre–Test:

1. a
2. b
3. c
4. c
5. b

What Happened:

If the rating of circuit breaker protecting the circuit is too small, the breaker will be tripped when the last appliance is turned on, preventing all the remaining appliances from operating.

Evaluation/Post–Test:

I. Multiple Choice:

1. c	6. a
2. a	7. b
3. c	8. c
4. b	9. a
5. b	10. a

II. Problem Solving:

1. $\frac{14}{3}\Omega$
2. $I_1 = 400\ mA$
   $I_2 = 200\ mA$

Rowena R. Dinokot graduated Bachelor of Secondary Education – Major in Biology at Jose Rizal Memorial State College, Katipunan Campus, Katipunan, Zamboanga del Norte last 2008. She also finished the degree Master of Arts in Education major in Administration and Supervision at Foundation University, Dumaguete City last 2018. Presently, she is teaching at Demetrio L. Alviola National High School (SHS) as Class Adviser of XII-STEM where she handled Sciences and Research.