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EXPLORATION OF A DC CIRCUIT IN A VIRTUAL LABORATORY[17]

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Abstract: Today, students learn best by watching and practicing, and an interactive simulation can do much more to build their knowledge, regardless of the text and formulas in the textbook. On the other hand, some natural phenomena cannot be directly observed. The virtual laboratory solves this problem - it can be shown, for example, how the current is flowing in the wire and what causes the glow of a light bulb.

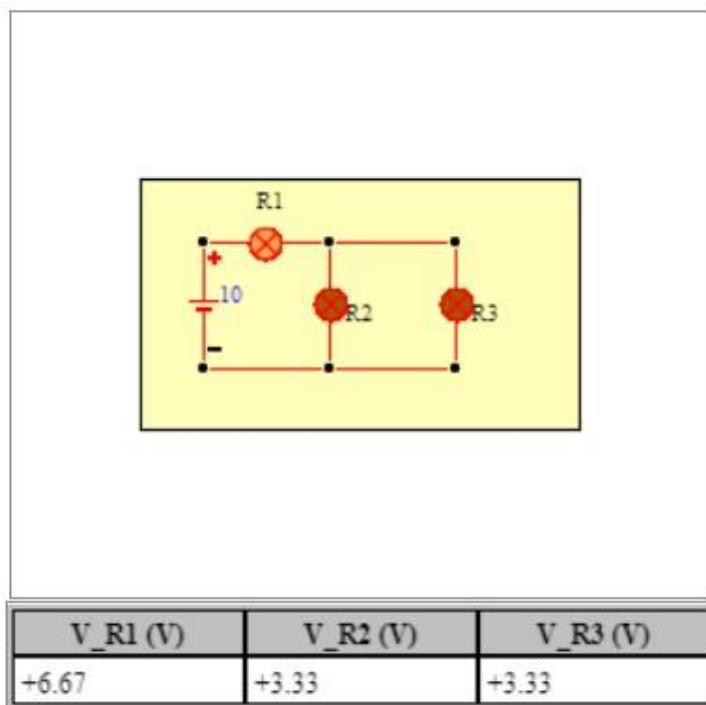*Keywords: Virtual laboratory, DC circuit, current, voltage, resistance*

INTRODUCTION

In today's digital world, in which students have access to information anywhere and at anytime (Goranova, 2014), laboratories from science classrooms also need to be transferred to cyberspace. Interactive simulations can be extremely useful (Goranova, 2019) in presenting abstract concepts and quantities that cannot be directly observed, but become indispensable in the context of virtual learning entirely in an online environment. This is often the only way for students to touch the practical side of science.

EXPOSITION

Physlet® Physics is a virtual physics lab that includes a wide range of physical demonstrations and experiments. Each chapter is divided into four sections: Illustrations, Explorations, Problems, and Supplements. Chapter 30 deals with DC circuits and the features of serial and parallel connection of consumers, which are discussed sequentially in the classes in the subjects Man and Nature in sixth grade and Physics in seventh and ninth grade.

Illustration 30.1 (Pic. 1) is a simple electrical circuit consisting of three consumers. It is possible for consumers to be represented in the circuit as resistors, but for the purposes of the demonstration it is more appropriate to use electric lamps. The table below the diagram shows the voltages on each of the consumers.

V_R1 (V)	V_R2 (V)	V_R3 (V)
+6.67	+3.33	+3.33

Pic. 1 Illustration 30.1

Students can see that although the lamps are identical, their brightness is different and depends on the voltage drop across them.

When one of the lamps burns out, it stops glowing, breaks its branch from the circuit and becomes equivalent to a very large resistance. In the demonstration there is an opportunity to "burn" one or more lamps in different combinations, and it is clear which of the others are lit and which are not, as well as the voltage on each of them.

It is observed that if there is a voltage drop on a working lamp, it lights up. If the lamp marked R1 burns out, none lights up. If only R2 or R3 burns out, the others are lit, but if both burn out, no lamp will be lit again.
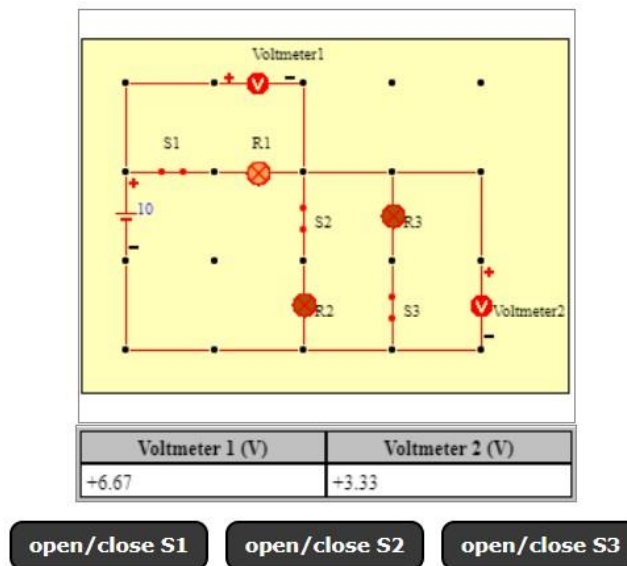
Illustration 30.2 (Pic. 2) represents the same scheme, but allows the flow of electric current to be controlled by means of switches. Two voltmeters are also connected to the circuit, the readings of which are shown in the table below.

By opening and closing the keys, the lamps can be turned on and off and students can think about what it is like to burn the lamps in the previous demonstration.
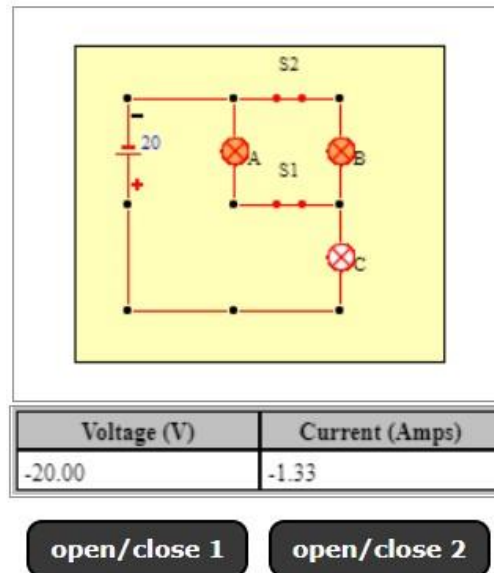
It can be seen that if switch S1 is opened, the connection between the source and the rest of the circuit is broken and none of the lamps are lit. It can also be noted that the voltage on the lamps R2 and R3 is equal to zero, while on the switch S1 it is equal to the voltage of the source.

On the other hand, when only switch S2 is open (lamp R2 is switched off), the circuit closes through the other two lamps and they light up. Since the two consumers have the same resistance and are connected in series, the voltage on each of them is the same and is equal to half the voltage of the source. The same happens when opening the key S3 only.

When considering the different situations, it can be concluded that the sum of the voltages in the different parts of the circuit is always equal to the voltage of the source.

Voltmeter 1 (V)	Voltmeter 2 (V)
+6.67	+3.33

open/close S1 open/close S2 open/close S3

Pic. 2 Illustration 30.2

Voltage (V)	Current (Amps)
-20.00	-1.33

open/close 1 open/close 2

Pic. 3 Exploration 30.1.

Exploration 30.1 again presents an electrical circuit with two consumers connected in parallel and a third connected in series to them. Switches have also been added to the two parallel branches of the chain with wich they can be switched on and off. The table below the diagram shows the voltage of the source and the current through it (the total current in the whole circuit).

The aim of the research is to open and close the switches and take into account the change of the current in the circuit, to analyze it and to draw conclusions about the values of the resistance of the three consumers.

When both switches are closed, it can be seen that lamp C is brighter than lamps A and B, which is explained by the fact that the current through C is the sum of the currents through A and B. If the switch S1 is opened (it is switched off A) lamp C remains connected in series to B and students can trace the circuit. It can be seen that the current through the circuit decreases, but lamp B is brighter than before. The reason is that the current passes completely through the left lit lamp.

When the two switches are closed, the lamps connected in parallel apparently have the same brightness, which would mean that they have the same resistance. When S1 is open and S2 is closed, the current through the circuit is 1 A. The value is also read when S1 is closed and S2 is

open, which is also 1 A. It is concluded that the resistances of consumers A and B are the same ($R_A = R_B$).

When only one of the switches is closed, using a law of Ohm, it turns out that the equivalent resistance of the circuit is

$$R_A + R_C = \frac{U}{I} = \frac{20\,V}{1\,A} = 20\Omega$$

On the other hand, when both switches are closed the equivalent resistance of the circuit is

$$\frac{1}{2}R_A + R_C = \frac{U}{I} = \frac{20\,V}{1,33\,A} \approx 15\Omega$$

Solving the two equations, it is found that all consumers in the circuit are the same and the resistance of each of them is 10 Ω.

CONCLUSIONS

The simulations shown illustrate the concepts of open and closed circuit, and that current flows between two points only if there is a voltage drop between them. The ability to interact with the simulations allows them to be better explored and by illustration - better understood by students.

REFERENCES

Goranova, E. D. (2014). Model for Information Technologies Training in Multimedia Environment. Ruse: Publishing center of the University of Ruse (***Оригинално заглавие***: *Горанова, Е., 2014. Модел за обучение по информационни технологии в мултимедийна среда. Русе: Издателски център на Русенски университет.*)

Goranova, E. (2019). Creation of Electronic Learning Objects for the High Cognitive Levels of Bloom's Digital Taxonomy. *Knowledge international Journal*, 31(2), 585-590.

Illistration 30.1, 2021. URL: https://www.compadre.org/Physlets/circuits/illustration30_1.cfm (Accessed on 6.5.2021).

Illustration 30.2, 2021. URL: https://www.compadre.org/Physlets/circuits/illustration30_2.cfm
    Accessed on 6.5.2021).

Exploration 30.1, 2021. URL: https://www.compadre.org/Physlets/circuits/ex30_2.cfm
    Accessed on 6.5.2021).