Tetrahedral and Octahedral arrangements of resistors: An experimental activity using incandescent-halogen lamps

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Abstract

This article is the third in a trilogy, in which experimental activities involving classic symmetrical resistive circuits are proposed, where we draw attention to the fact that the use of halogen-incandescent lamps as resistors promotes an excellent visualization of symmetries or non-existences, through the comparison of the brightness of the lights, making the experimental activity a more playful and attractive practice for the student. This work aims to contribute to the small number of pedagogical experimental works involving symmetrical resistive electrical circuits, a proposal that approaches the subject in a playful and light way. Our methods use low-cost and easily accessible material. In the present paper, one focuses on the tetrahedral and octahedral cases. Both the theoretical development and the experimental analysis are presented and compared. The main implications are the importance of using arguments of symmetry as a pedagogical tool in solving problems (in the specific case, simplification-analysis of resistive electrical circuits) was evidenced in the analysis of the arrangements.

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1. Introduction

Teaching resistive circuits have been a common topic in Physics Teaching, see for instance (Bradley and Tongtian, 2015), (Brown, 2003), (Garde et al. 2016), (Greenslade, 2022), (Harsha et al, 2015), (Jankovic, 2010), (Morse, 1993), (Sokolowski, 2019), (Vi, 1998), (Wörner, 2019), (Yongzhao and Zhang, 1998). According to Motta and Santos (2022, 2023) , when the topic of symmetrical resistive circuits is addressed in the classroom, students generally report the feeling that they are faced with purely mathematical and algorithmic problems. In this sense, experimental activity is essential to verify, through qualitative measurements or observations, that these are physics problems! Furthermore, the conflict between alternative conception and experimental reality can be an interesting trigger for conceptual changes, providing students with significant learning.

This article is the third in a trilogy, in which experimental activities involving classic symmetrical resistive circuits are proposed; where we draw attention to the fact that the use of halogen-incandescent lamps as resistors promotes an excellent visualization of symmetries or non-existences, through the comparison of the brightness of the lights, making the experimental activity a more playful and attractive practice for the student. The first two articles (Motta and Santos, 2022), (Motta and Santos, 2023) covered the lattice hexagon, the square-based pyramid, and the hexahedron (cube), among others. In this work, we will cover the regular tetrahedron and octahedron, completing Plato's three simplest solids with the hexahedron. As a difference between the articles (Motta and Santos, 2022), (Motta and Santos, 2023), in this article, in addition to measuring potential differences (voltage) performed in the first two (Motta and Santos, 2022), (Motta and Santos, 2023), we will also measure equivalent resistance and electric current intensity, using a multimeter and a clamp meter (the latter being an instrument not often used by high school students).

The objective of this paper is to present a pedagogical sequence in which symmetrical resistive electrical circuits are conceptualized and assembled. It is also illustrated by concrete form (experimental verification) the Theorem of the Midpoint (TPM).As for the organization of this article: in section 2 (Methods) , the low-cost and easily accessible material used was presented; in addition to the methodology employed, both in the theoretical development and the experimental analysis. In section 3 (Results and Discussion), results, the theoretical and

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experimental analyses of the proposed arrangements were performed. Finally, in section 4 (Conclusions), we conclude with the analysis of the results and the final considerations.

2. Method

The material used is easy to access and inexpensive; the dimensions of the circuit (edges) are, on average, 30 cm long in the case of the tetrahedron and 50 cm in the case of the octahedron. The material consists of i) Rigid/flexible copper wires, 1.5 mm2, 750 V; ii) Porcelain sockets; iii) 4.2 mm2 steel rod; iv) Clear bulb incandescent-halogen lamps (105 W-127 V); v) Multimeter and vi) Clamp meter. Illustrations of the experimental apparatus are presented in the next section.

A safety note: if the frame used is made of iron or any other metal conductor, we suggest applying a coat of insulating paint and using insulating adhesive tape on the corners as a precaution against accidents!

For the three cases discussed in this article, one referring to the tetrahedral arrangement and the other two referring to the octahedral arrangement, a theoretical analysis of the distributions of electric current and voltages in each branch, as well as the equivalent electrical resistance of the circuit, was performed. To this end, we used, in addition to series-parallel reductions, a tool for simplifying resistive electrical circuits that are rarely discussed in textbooks, which is the Midpoint Theorem (MPT) (Motta and Santos, 2022), (Motta and Santos, 2023). In this analysis, it was assumed - as occurs in the exercises proposed in the books - that the electrical resistance is constant (ohmic behavior), even knowing that the condition of the same temperature for all resistors used is not obeyed when the circuit used here is in operation (since the filaments are identical, different brightness-luminosities imply, according to quantum theory, different temperatures). The discrepancy between some experimental data, as expected, and those predicted theoretically, opens the possibility for discussion with students in the context of a real case, of the voltage-current curves for incandescent lamps.

A didactic observation: in all the diagrams, the corresponding symmetrical resistors are represented using the same color and the same number. The “two sides” are differentiated by the use of the line symbol on one of them. This notation aims to better visualize the symmetry of the circuit.

Since the focus is on symmetry, we will group the experimental data into groups of terminals corresponding to symmetrical resistors. Furthermore, to facilitate understanding, the data tables use the same colors as those used in the arrangements.

Theoretical voltages and intensities of electric current will be expressed in terms of the total input voltage in the circuit (UAA´) and the electrical resistances of the lamps (R); such resistances will be considered constant and their uncertainties will not be taken into account ($\delta R = 0$).

Since the input voltage (UAA') has to be measured, there is a theoretical uncertainty associated with both the voltages and the theoretical electric current intensities.

With regard to the measuring instruments and the measurement process, there is an uncertainty of 1.2% in the measured values, given by the multimeter manufacturer, in addition to the uncertainty associated with the oscillation of the value indicated at the time of reading (resolution).

3. Results and Discussion

The lamps used have the following nominal specifications (Nominal power: PN = 105 W; Nominal voltage: UN = 127 V), from which we obtain the values of the nominal current intensity (IN) and the nominal electrical resistance (RN).

$PN = UN\ IN \rightarrow (105\ W) = (127\ V).\ IN \rightarrow IN = 0.827\ A;$

$UN = RN.\ IN \rightarrow (127\ V) = RN.\ (0.827\ A) \rightarrow RN = 154\ \Omega.$

3.1. Tetrahedron

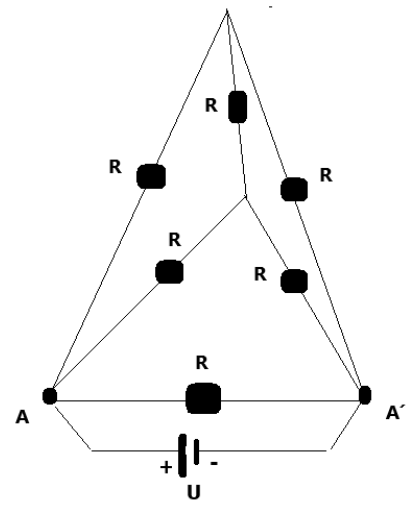

Figure 1. Schematic of the tetrahedral arrangement of resistors

From the electrical circuit schematized in Figure 1, it is possible to obtain another equivalent electrical circuit, such that this equivalent circuit presents a plane of symmetry. To do this, the following trick can be used: consider that some resistors, in a given branch, whose electrical resistances are R, are equivalent to the series association of two resistors with electrical resistances equal to R/2, as shown in Figure 2.

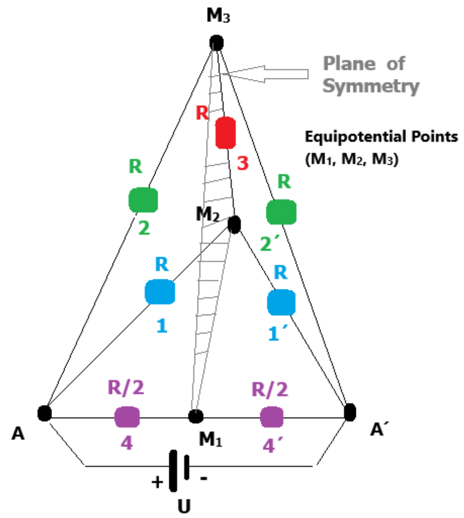

Figure 2. Diagram of the tetrahedral arrangement of resistors, in which the symmetry plane M1M2M3 is indicated

Since the circuit has a plane of symmetry, for ease, we will perform the initial analysis of only "one of the sides".

Using Kirchhoff's 1st Law (law of nodes or the law of junctions), the Midpoint Theorem (MPT), by which $U_{AM1} = U_{AM2} = U_{AM3} = U/2$ and, naming $U_{AA'}/R = I$, where $U_{AA'}$ represents the potential difference between points A and A' (V_A - $V_{A'}$), we have the distribution of electric currents indicated in Figure 3.

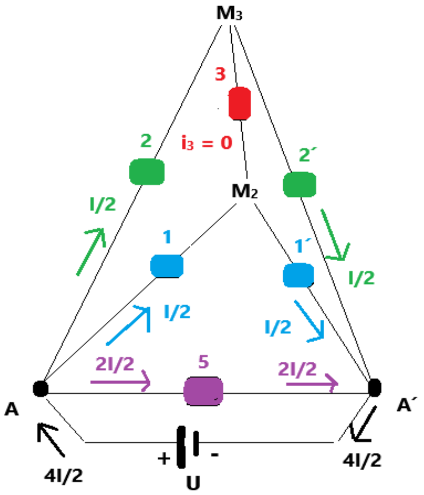

Figure 3. A diagram of the distribution of electric currents for the circuit is shown in Figure 1

Applying Kirchhoff's 1st Law to terminals A or A', we have that the total electric current intensity of the circuit is $\frac{4I}{2} = 2\frac{U_{AA'}}{R}$. From the definition of equivalent resistance (R_{eq}), we have $R_{eq\ AA',\ teórica} = \frac{R}{2}$ ($R = R_N = 154\ \Omega$)), whence $Req_{AA'}$ theoretical = 77.0 Ω.

From the relation $P = R.i^2$ for the electric power consumed in each resistor, we arrive at the following comparison between the theoretical powers: $P_5 > (P_1 = P_{1'}) = (P_2 = P_{2'}) > (P_3 = 0)$; where the proportion between the values of the theoretical powers is: 4: 1 : 0. This theoretical prediction is in agreement with the qualitative observations of the brightness, associated with the effective powers, as indicated in Figure 4.

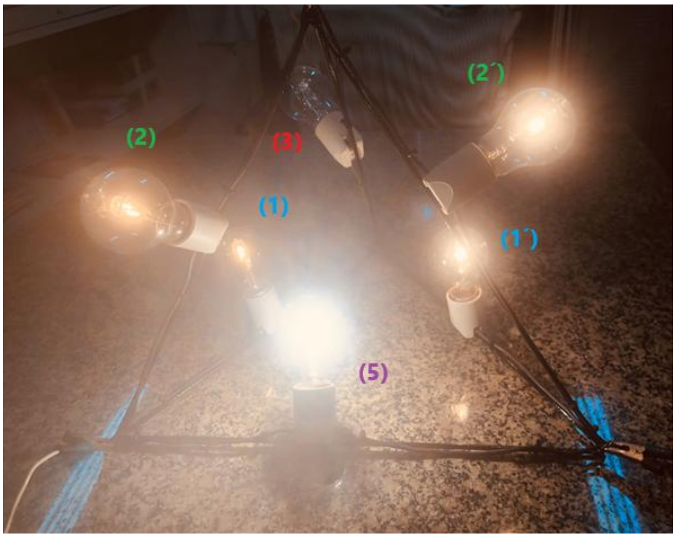

Figure 4. Circuit corresponding to the tetrahedral resistor arrangement in operation (UAA' = 128 V). Source: authors. The numbering of lamps according to the diagram in Figure 3

Table 1. Potential differences (voltage), electric current intensities (theoretical and experimental), and electrical resistances correspond to the terminals of the circuit in Figure 1. The values are written in color to easily identify the corresponding points in the figure

Points (terminals)	Voltage (V) (experiment)	Voltage (V) (theory)	Electrical Resistance (Ω) (experiment)	Electric Current Intensity (A) (experiment)	Electric Current Intensity (A) (Theory)
AA´	128 ± 2	128 ± 2	8.4 ± 0.2	0.76 ± 0.02	0.83 ± 0.013
AM_3	67,6 ± 0.9	64 ± 1	8.1 ± 0.2	0.53 ± 0.02	0.42 ± 0.007
$A´M_3$	61,2 ± 0.8	64 ± 1	6.7 ± 0.2	0.53 ± 0.02	0.42 ± 0.007
AM_2	67,2 ± 0.9	64 ± 1	7.1 ± 0.2	0.52 ± 0.02	0.42 ± 0.007
$A´M_2$	61,5 ± 0.8	64 ± 1	6.8 ± 0.2	0.52 ± 0.02	0.42 ± 0.007
M_1M_2	0,10 ± 0.01	0	6.2 ± 0.2	0.003 ± 0.001	0

The electrical resistance of a single lamp-holder-conductor wire assembly measured with the multimeter was (10.4 Ω ± 0.2 Ω). From Table I, we have: The total electrical current intensity of the circuit measured was $I_{AA'} + I_{AM1} + I_{AM2}$ = 0.76A + 0.52A + 0.53 A = (1.81 A ± 0.04 A). The total equivalent electrical resistance of the circuit with the circuit in operation is $U_{AA'}/I_{TOTAL}$ = 128 V/1.81 A = (70.7 Ω ± 1.5 Ω). The total experimental equivalent electrical resistances measured with the multimeter, with the circuit turned off, are: $R_{AA'}$ = (6.6 Ω ± 0.2 Ω), RAM2 = (6.8 Ω ± 0.2 Ω), R_{AM3} = (5.4 Ω ± 0.2 Ω), $R_{A'M2}$ = (10.7 Ω ± 0.2 Ω), $R_{A'M3}$ = (6.6 Ω ± 0.2 Ω) and RM2M3 = (7.1 Ω ± 0.2 Ω); average value, (7.2 Ω ± 0.2 Ω).

The discrepancy between the total electrical resistance values of the circuit previously found – which will also occur for the two following arrangements – will be analyzed in section 4, discussion of the results.

3.2. Octahedron

3.2.1. Terminals on the same edge

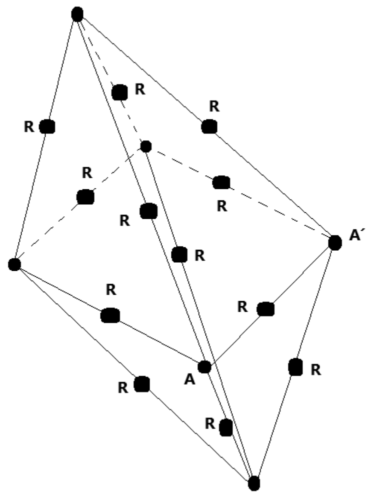

Figure 5. Diagram of the octahedral arrangement of resistors with terminals on the same edge

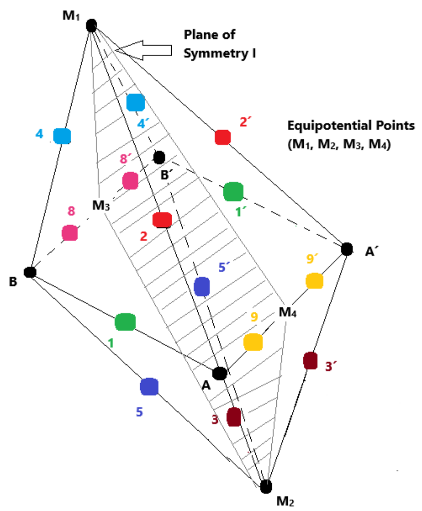

Figure 6. Diagram of the tetrahedral arrangement of resistors, in which one of the symmetry planes M1M2M3M4 (plane I) is indicated

We can see that there is another plane of symmetry, plane AA´B´B (plane II), not indicated in Figure 6.

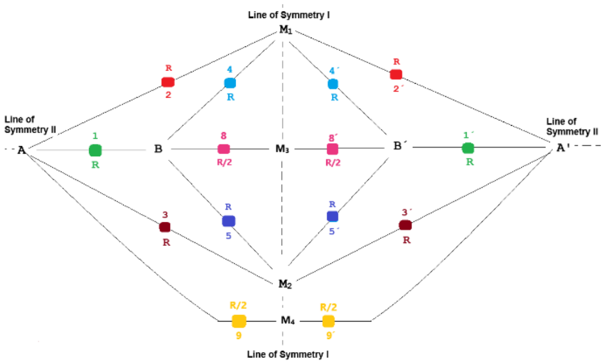

Figure 7. Schematic of the two-dimensional (2D) circuit equivalent to the circuit shown in Figure 6

Simplifying the electrical circuit shown in Figure 7, using the series-parallel reduction method and a method analogous to that used in the previous case of the tetrahedron, we have the following current distribution (see the detailed development in the Appendix).

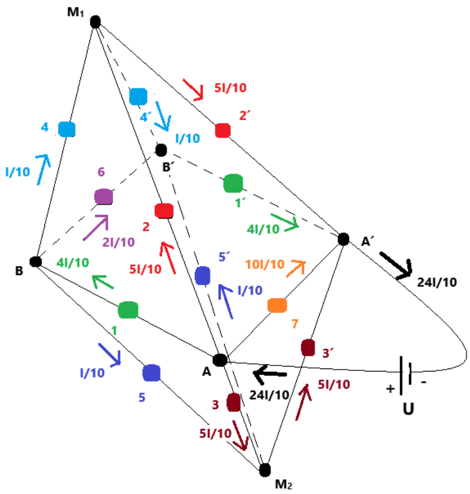

Figure 8. A diagram of the distribution of electric currents for the circuit is shown in Figure 5

Since the total electric current intensity of the circuit is $\frac{24\,I}{10} = \frac{12}{5}\frac{U_{AA'}}{R}$, from the definition of equivalent resistance, we have: $R_{eq\ AA',\,theoretical} = \frac{5\,R}{12}$;; whence $R_{eq\ AA',\,theoretical} = 64.2\ \Omega$.

We have the following comparison between the theoretical powers: $P_7 > [(P_2 = P_{2'}) = (P_3 = P3')] > (P_1 = P_{1'}) > P_6 > [(P_4 = P_{4'}) = (P_5 = P_{5'})]$; where the proportion between the values of the theoretical powers is: 100 : 25: 16 : 4: 1. This theoretical prediction is in agreement with the qualitative observations of the brightness, associated with the effective powers, as indicated in Figs. 9 and 10. Note: since the lamps have a nominal voltage of 127 V and the assembly was done with 222 V, lamp number 7 could not be placed, as it would burn out. Its absence, as we know, does not influence the behavior of the other elements of the circuit. For this situation, the total electric current intensity of the circuit predicted theoretically is $14I/10 = 7U_{AA'}/5R$; therefore, the equivalent resistance of the circuit is given by $R_{eq\ AA',\,theoretical} = 5R/7 = 110\ \Omega$.

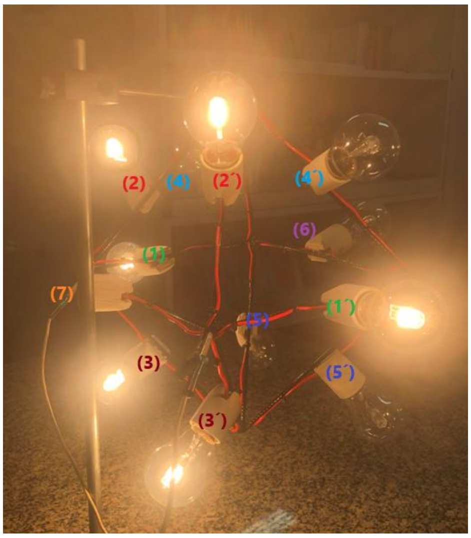

Figure 9. Circuit corresponding to the octahedral arrangement of Figure 5 and Figure 8 (terminals on the same edge) in operation ($U_{AA'}$ = 222 V). Numbering of the lamps according to the diagram in Figure 8 ("front" view)

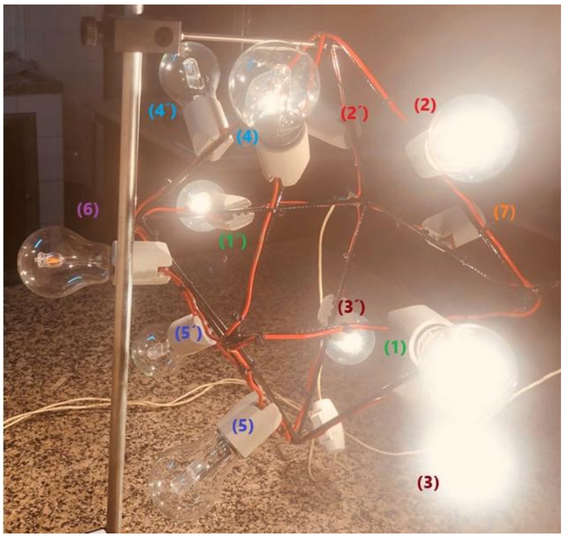

Figure 10. Same as Figure 9 ("front" view)

Table 2. Potential differences (voltage), electric current intensities (theoretical and experimental), and electrical resistances correspond to the terminals of the circuit in Figure 5. The values are written in color to easily identify the corresponding points in the figure

Points (terminals)	Voltage (V) (experiment)	Voltage (V) (theory)	Electrical Resistance (Ω) (experiment)	Electric Current Intensity (A) (experiment)	Electric Current Intensity (A) (Theory)
AA´	222 ± 3	222	5.9 ± 0.1	***	
AB	103 ± 2	89	5.3 ± 0.1	0.70 ± 0.02	0.577
A´B´	103 ± 2	89	5.7 ± 0.1	0.62 ± 0.02	0.577
AM_1	111 ± 2	111	5.1 ± 0.1	0.72 ± 0.02	0.721
$A'M_1$	112 ± 2	111	4.8 ± 0.1	0.72 ± 0.02	0.721
AM_2	112 ± 2	111	5.1 ± 0.1	0.66 ± 0.02	0.721
$A'M_2$	111 ± 2	111	4.8 ± 0.1	0.68 ± 0.02	0.721
BM_1	11.0 ± 0,2	22.2	3.8 ± 0.1	0.19 ± 0.02	0.144
$B'M_1$	8.4 ± 0,2	22.2	6.2 ± 0.1	0.18 ± 0.02	0.144
BM_2	8.7 ± 0,2	22.2	5.0 ± 0.1	0.22 ± 0.02	0.144
$B'M_2$	9.2 ± 0,2	22.2	4.7 ± 0.1	0.16 ± 0.02	0.144
BB´	29.8 ± 0,4	44.4	5.4 ± 0.1	0.26 ± 0.02	0.288
M_1M_2	1.15 ± 0,01	0			

From Table 2 above, we have: The total electrical current intensity of the circuit measured, in the absence of the lamp in branch AA', is $I_{AB} + I_{AM1} + I_{AM2}$ = 0.70 A + 0.72 A + 0.66 A = (2.08 A ± 0.03 A). The equivalent electrical resistance of the circuit in operation is then UAA'/ITOTAL = 222 V/2.08 A = (107 Ω ± 2 Ω). The total experimental equivalent electrical resistances, with the presence of the lamp in branch AA´, measured with the multimeter, with the circuit turned off, are $R_{AA'}$ = (5.5 Ω ± 0.2 Ω), R_{AB} = (5.4 Ω ± 0.2 Ω), $R_{BB'}$ = (5.5 Ω ± 0.2 Ω) and $R_{B'A'}$ = (4.6 Ω ± 0.2 Ω); average value = (5.5 Ω ± 0.2 Ω).

3.2.2. Terminals that are at opposite vertices

From Figs. 11 and 12, we can see that there are other symmetry planes, that were not indicated in the figures, they are: AM1A´M3 and AM2A´M4.

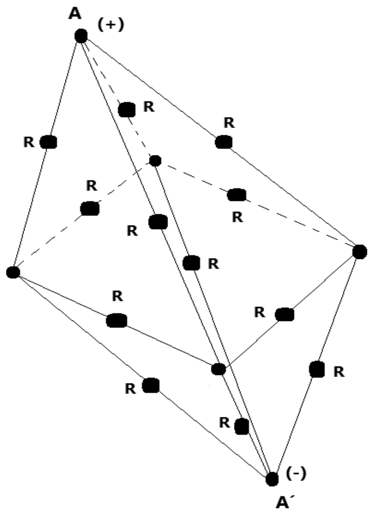

Figure 11. Diagram of the octahedral arrangement of resistors with terminals that are not on the same edge

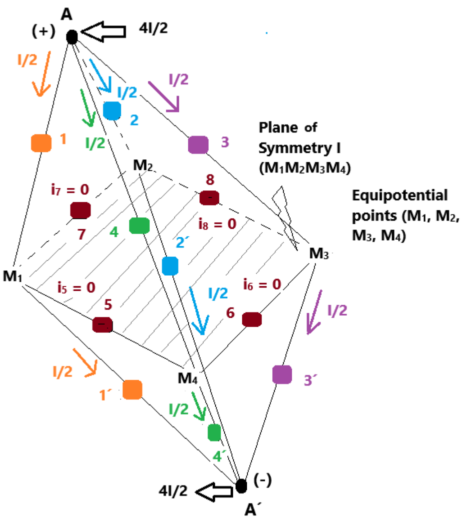

Figure 12. A diagram of the distribution of electric currents for the circuit is shown in Figure 11

Since the total electric current intensity of the circuit is $\frac{4\,I}{2} = 2\,\frac{U_{AA'}}{R}$, from the definition of equivalent resistance, we have: $R_{eq\ AA',\ theoretical} = R/2 = 77\ \Omega$.

We have the following comparison between the theoretical powers: $(P_1 = P_{1'}) = (P_2 = P_{2'}) = (P_3 = P_{3'}) = [(P_4 = P_{4'})$; where the ratio between the values of the theoretical powers is: 1: 1. This theoretical prediction is in agreement with the qualitative observations of the brightness, associated with the effective powers, as indicated in Fig. 13.

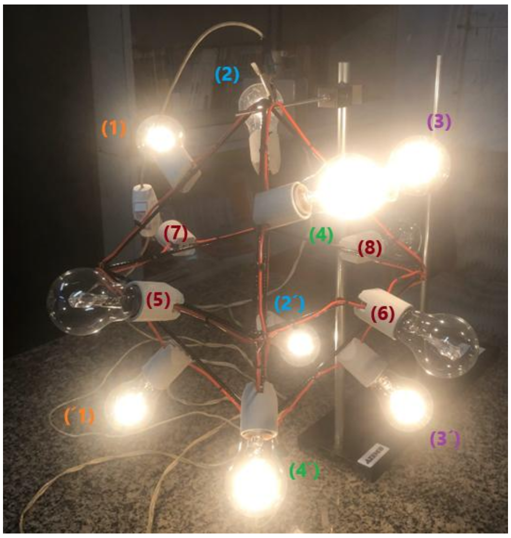

Figure 13. Circuit corresponding to the octahedral arrangement of figures 11 and 12 (terminals that are at opposite vertices) in operation ($U_{AA'}$ = 129 V). Numbering of the lamps according to the diagram in Figure 8

Table 3. Potential differences (voltage), electric current intensities (theoretical and experimental), and electrical resistances, correspond to the terminals of the circuit in Figure 11

Points (terminals)	Voltage (V) (experiment)	Voltage (V) (theory)	Electric Current Intensity (A) (experiment)	Electric Current Intensity (A) (Theory)
AA´	129 ±2	129	***	***
AM_1	63.5 ± 0.7	64.5	0.552 ± 0.006	0.419
$A´M_1$	64.9 ± 0.7	64.5	0.542 ± 0.006	0.419
AM_2	63.8 ± 0.7	64.5	0.523 ± 0.006	0.419
$A´M_2$	64.5 ± 0.7	64.5	0.486 ± 0.006	0.419
AM_3	63.7 ± 0.7	64.5	0.526 ± 0.006	0.419
$A´M_3$	64.8 ± 0.7	64.5	0.537 ± 0.006	0.419
AM_4	63.2 ± 0.7	64.5	0.516 ± 0.006	0.419
$A´M_4$	65.1 ± 0.7	64.5	0.521 ± 0.006	0.419
M_1M_2	0.28 ± 0.01	0	0.006 ± 0.001	0
M_1M_4	0.27 ± 0.01	0	0.017 ± 0.001	0
M_2M_3	0.23 ± 0.01	0	0.025 ± 0.001	0
M_3M_4	0.31 ± 0.01	0	0.007 ± 0.001	0

From Table 3, we have: The total electrical current intensity measured was $I_{AM1} + I_{AM2} + I_{AM3} + I_{AM4}$ = 0.552 A + 0.523 A + 0.526 A + 0.516 A = (2.117 A ± 0.012 A). The equivalent electrical resistance of the circuit in operation is $U_{AA´}/I_{TOTAL}$ = 129 V/2.117 A = (60.9 Ω ± 2.7 Ω). The total experimental equivalent electrical resistances, measured with the multimeter, with the circuit, turned off, are $R_{eq, AA´}$ = (5.4 Ω ± 0.2 Ω), Req, M1M3 = (5.5 Ω ± 0.2 Ω) and $R_{eq, M2M4}$ = (5.4 Ω ± 0.2 Ω); average value (5.5 Ω ± 0.2 Ω).

To have a more general view of the results regarding the electrical resistance magnitude corresponding to the three arrangements, Table 4 was prepared in which the following naming convention was adopted:

R_1 = Theoretical equivalent resistance of the circuit, taking the resistances of the lamps as ohmic (constant) and of nominal values (154 Ω);

R_2 = Experimental equivalent resistance of the circuit, obtained from the relationship ($U_{AA´}$ / I_T);

R_3 = Experimental equivalent resistance of the circuit, measured by the multimeter, with the circuit turned off.

Table 4. Experimental equivalent resistances of the circuit

	R_1 (Ω)	R_2 (Ω)	R_3 (Ω)
Tetrahedron	77	70.7 ± 1.5	7.2 ± 0.2
Octahedron: terminals on the same edge, without the AA branch lamp	110	107 ± 2	***
Octahedron: terminals on the same edge, considering the lamp on branch AA´	64	***	5,3 ± 0.2
Octahedron: terminals at opposite vertices	77	60.9 ± 2.7	5.5 ± 0.2

4. Conclusion

Qualitatively, we once again have a clear perception of the existing symmetries, evidenced by observing the brightness of the lamps. "This aspect mentioned here makes the activity quite playful, bringing to the real world a subject considered by students to be very abstract and mathematical" [2]. From a quantitative point of view, analyzing Table 1, Table 2, Table 3, we observe very similar values, in general, of voltages and intensities of electric current in the symmetrical resistors; with relatively small values in the resistors located in the planes of symmetry. This last experimental result illustrates the Midpoint Theorem (MPT). We note a deviation in the values of potential differences, current intensities, and electrical resistances about those theoretically predicted under the hypothesis of ohmic behavior and nominal values. This is largely because electrical resistances are not effectively constant (non-ohmic behavior of incandescent lamps; tungsten filaments). The differences in potential and effective operating currents of each resistor, as they are generally below the nominal values, imply that the effective electrical resistances are also below the nominal values (the lamps are operating at lower temperatures than they would be in the nominal situation (In the case of tungsten, the resistivity decreases with the decrease in temperature), resulting in current intensities in each branch, in general, above those predicted in the hypothesis of ohmic behavior. For the same reason, the equivalent resistance measurements of the circuits in operation are below the theoretically predicted values. It can be said, in a way, that the electrical resistance values measured with the multimeter are obtained with the "cold, low temperature" circuit, while the values of the circuit in operation are measured with the "hot, high temperature" circuit, and the theoretical values in the ohmic hypothesis and nominal values would correspond to the operation of the "very hot, very high temperature" circuit. It is worth noting that the discrepancies in the values of the equivalent resistances taking different vertices show us that the resistances of the lamp-holder-conductor sets corresponding to each branch are different, which in itself would justify, at least in part, some discrepancies in potential differences and currents previously mentioned.

Author Contributions

All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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References

Allen, B., & Liu, T. (2015). Platonic relationships among resistors. *The Physics Teacher*, 53(2), 75-78.

Brown, R. (2003). Series and parallel resistors and capacitors. *The Physics Teacher*, 41(8), 483-485.

Garde, E. A., Escobar, I., Franco, T., Suarez, C., Felix, S. V., Benitez, Y., ... & Belendez, A. (2016). A conceptual map about alternating current circuits. Dalam *INTED2016 Proceedings* (hlm. 5591-5597). IATED.

Greenslade, T. B. (2002). A nomograph for resistors in parallel. *The Physics Teacher*, 40(8), 458-459.

Harsha, N. S., Sreedevi, A., & Prakash, A. (2015). An unsolved electric circuit: A common misconception. *Physics Education*, 50(5), 568.

Jankovic, S. (2010). Tracking connections: An exercise about series and parallel resistances. *The Physics Teacher*, 48(6), 391-393.

Motta, L., & Santos, A. C. F. (2021). Symmetric resistive circuits: An experimental approach. *Revista Brasileira de Ensino de Física*, 43, e20210012.

Motta, L., & dos Santos, A. C. F. (2023). Symmetrical cubic arrangements of resistors: An experimental approach. *The Physics Teacher*, 61(6), 461-466.

Morse, R. A. (1993). "Feeling" series and parallel resistances. *The Physics Teacher*, 31(6), 347.

Sokolowski, A. (2019). Applying structural mathematics in physics: Case of parallel connection. *The Physics Teacher*, 57(9), 627-629.

Vi, R. (1998). Equivalent resistors of polyhedral resistive structures. *American Journal of Physics*, 66, 90.

Wörner, C. H. (2019). Simple symmetrical circuits and a comment on the importance of topology. *Physics Education*, 54(6), 065019.

Yongzhao, Z., & Shuyan, Z. (1998). Calculating resistance networks using circuit symmetry. *Physics Education*, 33(1), 32.

Appendix

Series-parallel reductions and determination of electric current intensities related to the octahedron arrangement with terminals on the same edge.

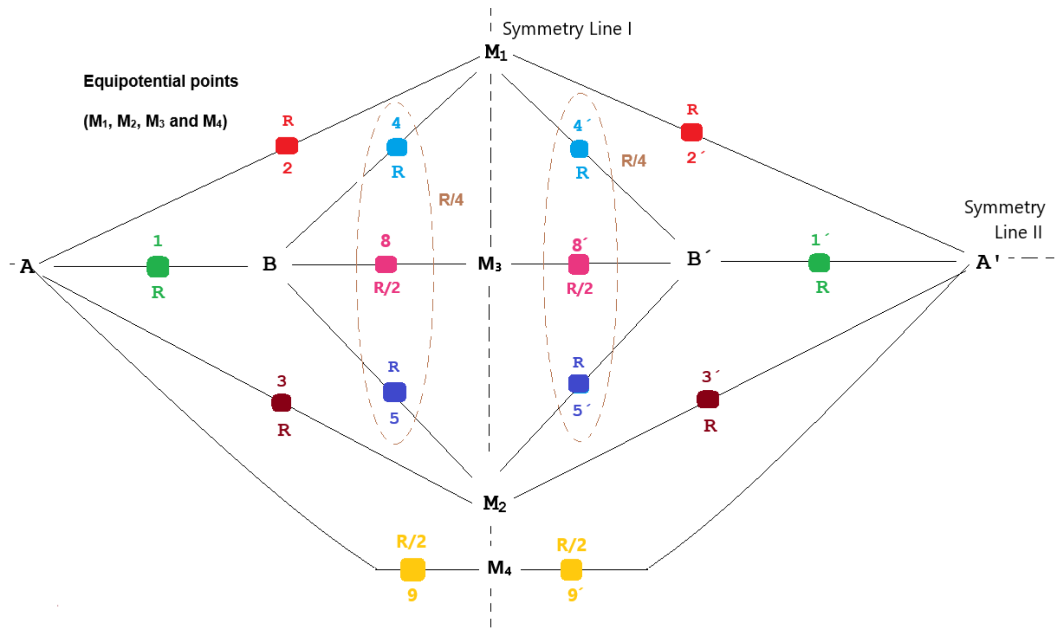

Figure A1: Determination of equivalent resistances for sections BM and B´M

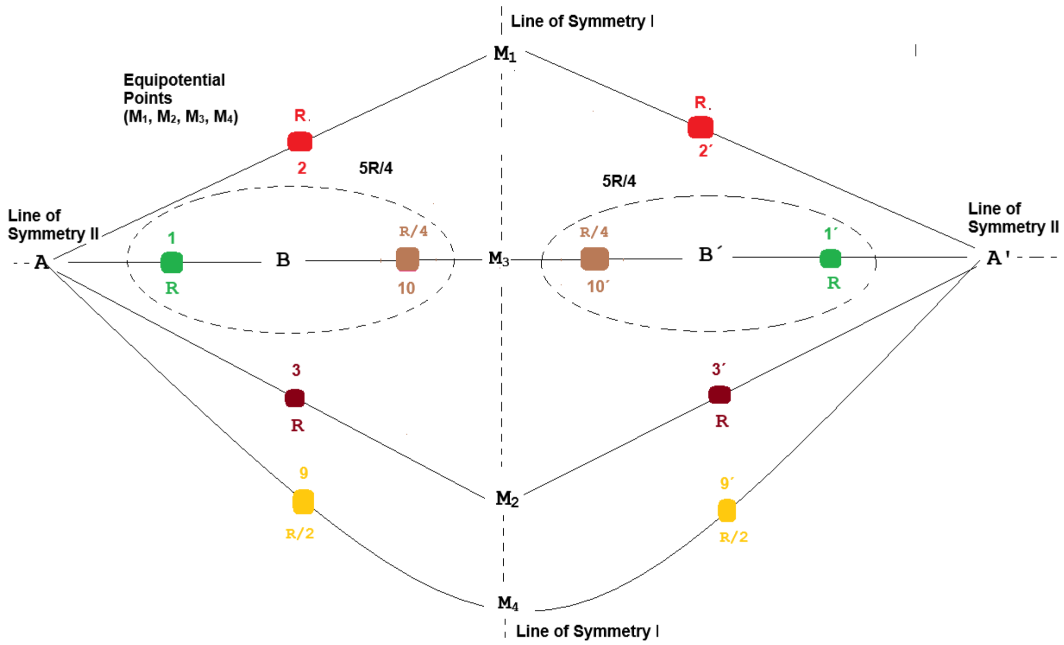

Figure A2: Determination of equivalent resistances for sections ABM and A´B´M.

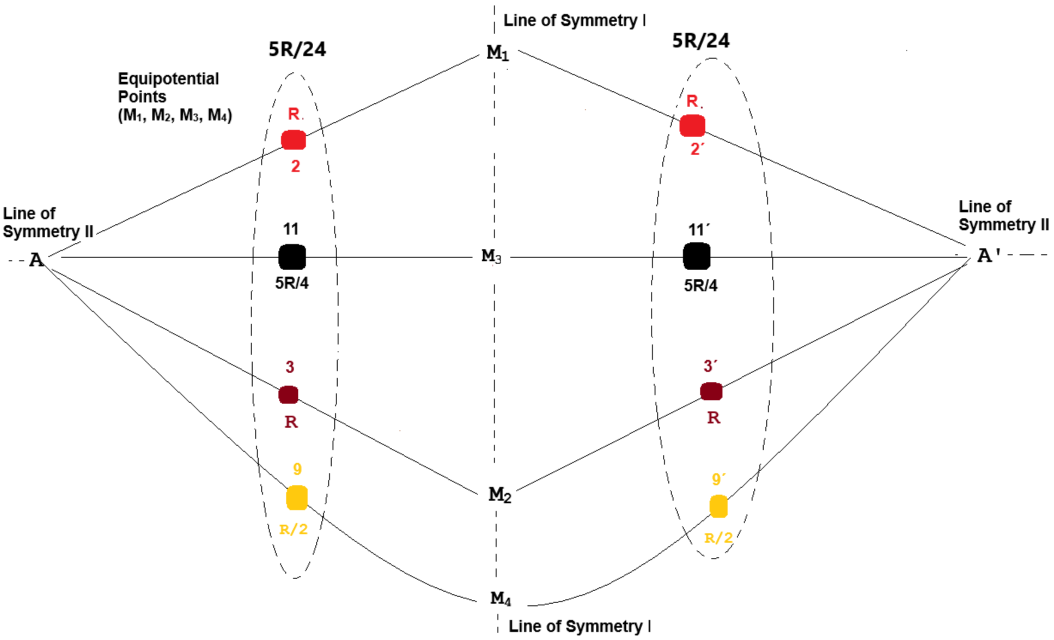

Figure A3: Determination of equivalent resistances for sections AM and A´M.

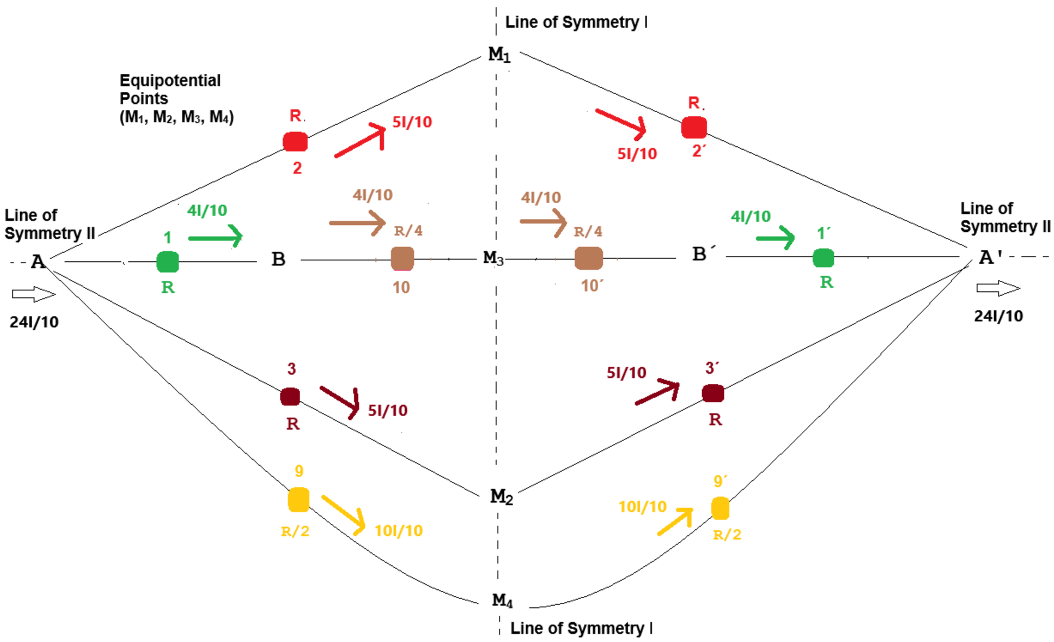

Figure A4: Diagram of the distribution of electric current intensities for sections AM1, AM2, AM3, AM4 and A´M1, A´M2, A´M3, A´M4

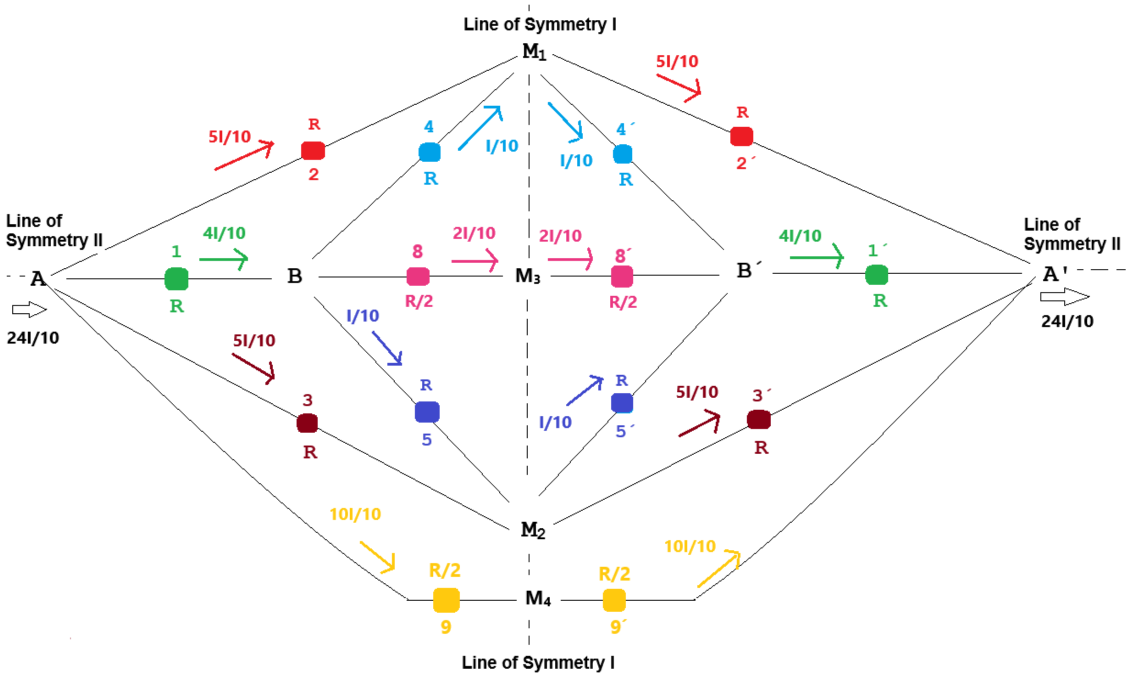

Figure A5: Detailed diagram of the distribution of electric current intensities for sections BM and B´M