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# ANALYSIS OF THE ORIENTATION OF THE MAGNETIC FIELD WITH COMPASSES ON AN ELECTRICALLY CHARGED WIRE

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**Abstract –** In this article, it's showed an experiment about the influence of the magnetic field produced around an electrically charged conductive wire with direct current on magnetically susceptible objects. There were used three compasses previously inspected to verify the alteration of their orientations, favorable to the magnetic field generated around the conductive wire, which passes over the compasses, and connected to a resistor, such as the experiment performed by Oersted in 1820, which proved that a direct current directed electric field generates a magnetic field, where until then, electricity was dissociated from electromagnetism; thus found that a conducting wire is capable of changing the direction of a needle previously positioned to true north.

**Keyword:** Oersted's experiment, Electromagnetic theory, direct current, Maxwell Equations.

## INTRODUCTION

Hans Christian Oersted was a physicist and chemist 19th century Danish, who gained access to works postulated by philosophers, researchers and scientists of that time, who defended the idea that electricity and magnetism behaved as well as a fluid in his acting environment, and with the north and south poles unable to be separated. There were also observations that pointed to the influence of atmospheric discharges on electronic equipment, notably predominant over those who had their shares performed by electric fields, but also by magnetic fields, such as compasses. Oersted concluded, after contemplating some of these phenomena, that naturally occurred the existence of a ruling force in the space of these same phenomena. At some point during everyday life from his experiments, he noticed that the needle of his compass moved when it moved approached an energized loop and noticed a circular motion behavior around the loop, having as a parameter the linear direction of conduction promoted by the electric current that circulated in the coil. Through this causality, he decided to compose a simple experiment that brought to light the idea that electricity and magnetism were phenomena interconnected or dependent on each other. As explained in [1], Oersted observed that when using a copper conductor wire carrying a current continues and positioning it over a compass was you can change the direction of the compass needle. That article shows the recreation of this experiment with notes on the development of the test and employing calculations with Maxwell's equations, as seen in [2], in order to prove, both experimentally and theoretically, the intrinsic relationship between magnetism and electric current.

## DEVELOPMENT

The experiment carried out in the laboratory needed the following items: a copper wire (bare at the ends), three compasses previously inspected (so as not to get an inaccurate result), a voltage regulator source, and a ground for conductive wire, which an end is the negative of the source and the other the positive of the source shorted to ground, already present at the power source. voltage. That said, the first part of the experiment was configured with the conductive wire fixed on top of the compasses, and in the second part, only one compass. As shown in figure [1] there is a pattern in the magnetic field lines, however, in order to prove the existence of these field lines present in the theory, experiment, as shown in figure [2], aim to obtain the result of the interaction of magnetic field lines around compasses, even considering that, as a result, the rehearsal environment has many variables to be considered, which results in less accurate data, However, it is still possible to achieve the objective of contemplate the interaction of field lines in the movement of compasses.

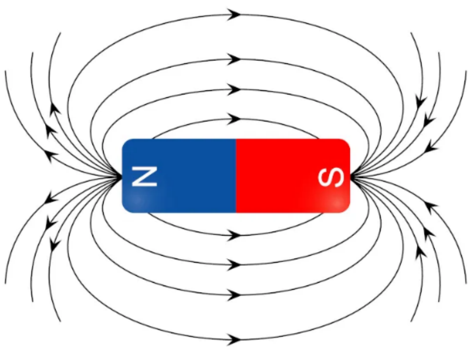


Figure 1 – Magnetic field.

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Figure 2 – Three compasses with the regulator source turned off.

Figures [3] and [4] show the second part of the experiment, the figure [3] shows the compass and the conductor wire fixed with the regulating source turned off and the figure [4] shows the same, but with the source connected regulator. In this way, when using only a compass, it was possible to make a more accurate measure of the data obtained. That said, we have checked the: current (A, Amps), Voltage (V, Volts), Power (W, Watts), distance (m, meters), with the purpose of applying numerical methods with Maxwell's equations to determine the intensity of the magnetic field (T, Tesla).

Figure 3 – A compass with the regulator power turned off.

Figure 4 – A compass with the regulator source on.

Tables 1, 2 and 3 present the data regarding to the values used in the voltage regulator source, considering the electric current (A) applied and the power (W), resulting from the product of the current supply and voltage, to find and reason that exists between the electric current and the field resulting magnetic field (T) in relation to the distance (m) of the driver, considering that the data were only recorded at the time the needle remained constant.

TABLE 1 – Data taken from the regulator source, changing electric current and voltage, with wire leaning against the compass.

| **Voltage (V)** | **Current (A)** | **Potencies (S)** | **Magnetic field (T)** |
|---|---|---|---|
| 5 | 0,5 | 2,5 | 3.1831E-05 |
| 10 | 1 | 10 | 6.3662E-05 |
| 15 | 1,5 | 22,5 | 9.5493E-05 |
| 20 | 2 | 40 | 0,000127324 |
| 25 | 2,5 | 62,5 | 0,000159155 |
| 30 | 3 | 90 | 0,000190986 |
| 32 | 3,2 | 102,4 | 0,000203718 |

Note: Comparing the data obtained from 5 V to 5 V and from 0.5 A to 0.5 A, up to 32 V and 3.2 A, with a distance of 1 mm.

In table 2, the supplied voltage value was disregarded, keeping constant at 5 volts, because its value does not influence the calculation for the magnetic field, changing the value of the current supplied by the regulating source and also the distance driver's compass, which enables an analysis of the relationship that electric current and distance have with the resultant magnetic field (T).

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TABLE 2 – Data taken from the regulator source, changing the electric current and the distance between the conductor and the compass.

| Distance (m) | Current (A) | Potencies (S) | Magnetic field (T) |
|---|---|---|---|
| 0,01 | 0,5 | 2,5 | 3.1831E-06 |
| 0,02 | 1 | 5 | 3.1831E-06 |
| 0,03 | 1,5 | 7,5 | 3.1831E-06 |
| 0,04 | 2 | 10 | 3.1831E-06 |
| 0,05 | 2,5 | 12,5 | 3.1831E-06 |
| 0,06 | 3 | 15 | 3.1831E-06 |
| 0,07 | 3,2 | 16 | 2.91026E-06 |

Note: Comparing the data obtained from 0.5 A to 0.5 A and from 1, 2, 3, 4, 5, 6 and 7 cm, with 5 V, up to 3.2 A.

In table 3, the current is fixed at 3.2 Amperes (A), which in turn causes the value of supplied power was also disregarded, considering that it depends only on the amount of electric current and the distance, with the fixed value at 16 Watts (W), as well as the its value does not influence the calculation for the field magnetic (T). In this way, only the distance to investigate the association of the field magnetic with the same.

TABLE 3 – Data taken from the regulator source, only the distance between the driver and the compass.

| Distance (m) | Magnetic field (T) |
|---|---|
| 0,01 | 2.037E-05 |
| 0,02 | 1.019E-05 |
| 0,03 | 6.791E-06 |
| 0,04 | 5.093E-06 |
| 0,05 | 4.074E-06 |
| 0,06 | 3.395E-06 |
| 0,07 | 2.910E-06 |
| 0,08 | 2.546E-06 |
| 0,09 | 2.263E-06 |
| 0,1 | 2.037E-06 |

Note: Comparing the data obtained from 0.5 A to 0.5 A and from 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 cm, with 5 V and 3.2 A.

To obtain the value of the generated magnetic field, it is necessary to know the current flowing through the conductor, the punctual distance of it in relation to the object with magnetic susceptibility, in this case, the compasses. For this, the following formula is used:

$$B = \frac{\mu_0 . i}{2\pi . l}$$

Which "B" is the magnetic field intensity, "$\mu_0$" is the magnetic permeability, in this experiment is the air permeability, "i" is the current and "l" is the distance between the charged conductive wire and the compass.

## RESULTS AND DISCUSSION

It was possible to determine from Table 1 that the magnetic field generated by the wire was very low. This is due to the current used, where the current maximum allowed by the equipment is 3.2 A. However, even with the magnetic field generated low amount of magnetic field, it was enough for caused the interaction of the magnetic field, making with the compass pointing in the direction of the field electric, that is, from negative to positive. As current increase, it is possible to notice that, when the conductive wire is positioned close to the compass, the change that occurs in the orientation of the field magnetic field increases significantly with each current step, from 0.5 to 0.5 Amperes. in the table 2, with increasing distance and current variation electricity, the magnetic field is practically not affected. It is possible to observe with the data arranged in the table that the distance is inversely proportional the electric current that generates the magnetic field, in this way, if the current varies from 0.5 to 0.5 Amperes and the distance varies every 1 centimeter, the field resulting magnetic field is extremely similar, that is, the compass needle remained almost in the same position. Table 3 shows the data referring to the modification of the distance in relation to current fixed at 3.2 Amperes. As the distance grew, the resulting magnetic field that acts on the compass, has decreased exponentially, to a certain extent point that is almost zero. Finally, figure [5] shows the exponential graph of the magnetic field function (T) over distance and with constant electric current, that is, as the distance increases, the field magnetic tends to decrease. This is because as the distance is inversely proportional to the field magnetic, when the distance increases, less lines of magnetic force tend to affect the compass, as the magnetic field will always have a zone of influence larger, the closer you are to the object magnetically susceptible; the compass.

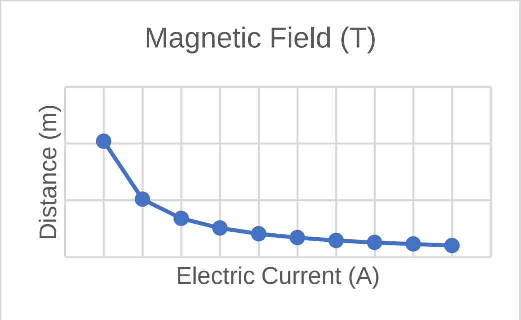


Figure 5 – Graph of the magnetic field with distance from 1 cm to 10 cm and fixed electric current at 3.2 A.

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