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ARTICLE

The Science of Magnets and Temperature

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Magnets work due to an electrical current caused by their electrons. The electrons of a magnet's atom spin like a top, as they circle around the nucleus, or core of an atom. The movement that they make generates electric currents which causes each electron to act like a magnet (Stanley 2021). Magnets can either attract or repel from each other (opposite poles can attract, while same poles repel) (Stanley 2021). In order to become magnetized, a strong magnetic substance has to either enter the magnetic field of the existing magnet. When magnets are exposed to heat, they reduce their magnetic strength and when a magnet is exposed a cold environment, the magnetic strength is enhanced. This applies to majority of the magnets, except ceramic (ferrite) magnets (HIS Sensing Team 2021). They can get demagnetized at low temperatures easier than in hot temperatures (Encyclopaedia Britannica 2021). Continue reading more about this for the full explanation and results!

PURPOSE

The purpose of this experiment is to find out the effect of temperature on magnetic strength.

HYPOTHESIS

The colder the magnet is, the stronger it will be. Therefore, the magnet exposed to dry ice will be the strongest, whereas the one subjected to boiling water will be the weakest.

MATERIALS AND METHODS

The experiment was tested on one magnet, which was exposed to different temperatures for a period of time.

The materials used to carry out my experiment were the following:

1. Two pieces of tape, 30 cm apart from
2. Metal balls (20 were aligned behind the magnet)
3. Gloves for the dry ice
4. One magnet (used multiple times)
5. Dry ice
6. Thermometer
7. Pot of boiling water (100°C)
8. Tongs for the dry ice

The control variables are the following:

• Thermometer brand and size
• Magnet brand and size
• Metal ball type and size
• The time the magnet would be put in the temperature (1 h each)
• The length the magnet will be dragged (30 cm each)

The independent variable:

• Temperature

The dependent variable:

• Magnet's strength

PROCEDURE

For my experiment, I decided to put one magnet into each of the following temperature settings: A pot of boiling water (exposed into 100°C), room temperature (20°C), freezer (-16°C), dry ice (-78°C) and outside (-20°C). Once the magnets were placed into their respective settings for an hour, they were placed horizontally with twenty metal balls at one end. The magnets were dragged for 30 cm. The number of metal balls still magnetized to the magnet were recorded on a chart (the higher the number of metal balls, the stronger the magnet would be). Then, the magnet was placed into its respective temperature for the second time and was then dragged horizontally again. The independent, dependent and control variables remained the same. This second attempt was made to ensure the accuracy of the outcome; but if the number of metal balls in the first and second experiment for a specific temperature was different, an average was taken of the two.

RESULTS AND DISCUSSION

My experimental results have proven that my hypothesis was partially correct: Temperature did have an effect on magnetic strength. What I was wrong about was that the magnet exposed to dry ice was not the strongest. This was because the extreme cold caused the particles to start to fall apart out of alignment, and slowly lose their magnetic attraction (HIS Sensing Team 2021). Upon further research, I learnt that this was called the Curie temperature point, where super frigid temperatures could weaken the magnetic attraction (Encyclopaedia Britannica 2021). From this, I learnt that different magnetic materials have different temperature tolerance; the type of magnet I own can only tolerate up to 20°C. Curie point, or Curie Temperature is the temperature at which certain magnetic substances experience changes in their magnetic properties (Encyclopaedia Britannica 2021). This temperature was named after the French physicist, Pierre Curie, who discovered the laws associated to the change in temperature of certain magnetic properties. When a magnet is cooled below its Curie point, its magnetism will increase (Encyclopaedia Britannica

2021). The magnetic particles move slower, as their kinetic energy is reduced (usmagnetix 2021), and so there is less vibration between the particles itself. Thus, this allows the magnetic field to enhance the magnet's magnetic behaviour (HSI Sensing Team 2021). Raising the temperature to the Curie point for a magnet will create more vibration and disrupt the arrangement of particles, weakening the magnetic behaviour.

Despite the particular result on the dry ice, the results still showed that the magnetic attraction is stronger when magnets are exposed to low temperatures and weaker when subjected in heat experiences.

I ended up creating two designs because I found a fatal flaw in my original set up. The original design was set up to hang the magnet vertically down with metal balls hanging underneath. I decided not to continue with this design because it introduced two extra variables that could affect my results: The gravitational pull, which could pull the magnet down, giving it extra weight; and the magnetic field strength, through which the metal balls could pass. Since I do not have the lab equipment to control these two variables, I decided to eliminate the gravitational pull of the metal balls' weight. Therefore, I came up with my second design, called the "drag force," where the magnet would be dragged for a fixed length with twenty metal balls behind. That way, there would be no gravity to add extra weight.

WHAT COULD BE DONE DIFFERENTLY

For future reference to make this experiment more interesting, I would have observed more on how temperature affects a magnet by experimenting with more extreme temperatures, such as with substances in near absolute zero. I would also have liked to preform the experiment in an anti-gravity environment, to see if gravity has an affect on a material's magnetic ability. Furthermore, I would also have tested with different types of magnets, such as ceramic or ferrite magnets (HSI Sensing Team 2021).

THINGS TO IMPROVE

In the future, I would avoid dragging the magnet by hand and would use equipment to ensure that the dragging speed would be fixed. In this experiment, I assumed that the dragging speed was consistent; but if I had dragged the magnet too fast, then it would underestimate the magnetic strength, while too slow would do the opposite. I would also have avoided to use the same magnet over and over, as its magnetic strength could have been enhanced or weakened, depending on the temperature it was set before.

SOURCES OF ERROR

A few possible errors that could have been made during the experiment could be that the drag force was not consistent, which could affect the magnet's ability to hold a certain number of metal balls (as said above); the speed at which the magnet was pulled at could be different every time as it was done manually; and the temperature outside could not have been the same, which would affect the magnet's strength. In addition, since the temperature of the magnet itself could not have been measured without any proper equipment, it is assumed that the temperature it is exposed to is equal to its actual temperature.

Table 1:

	Number of metal balls		
Temperature/ settings	**First experiment**	**Second experiment**	**Average**
Boiling water (100 °C)	9	8	8.5
Room temperature (23 °C)	12	12	12
Freezer (-18 °C)	16	14	15
Outside (-20 °C)	16	15	15.5
Dry ice (-75.5 °C)	14	14	14

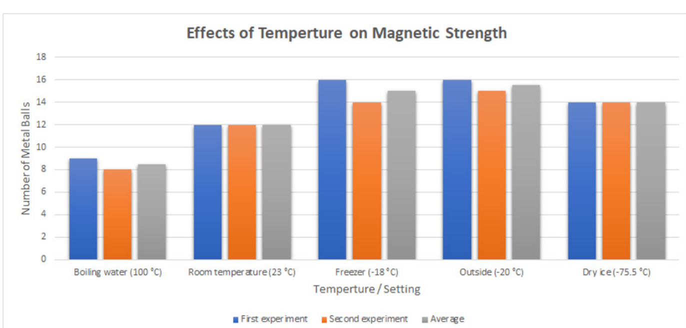

Fig 1: The results on a bar graph.

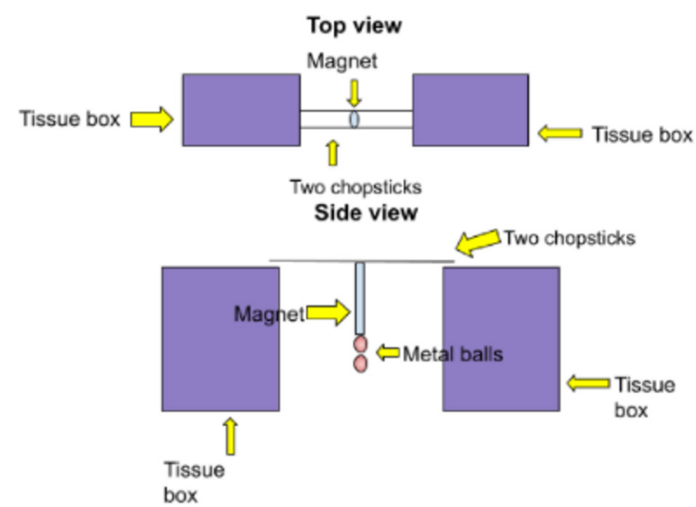

Fig 2: The original set-up

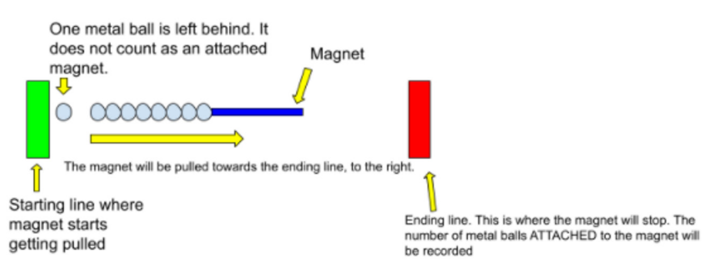

Fig 3: The new set-up

CONCLUSION

For most of the part, the colder my magnet was, the stronger the force. However, when tested dry ice, my magnet reached its peak and its force started diminishing. This diminished magnetic force is called Curie temperature, where certain magnetic materials face a sharp change in their magnetic property. This was a new discovery for me- something I did not expect, as I only thought a magnet would gain more strength in more cold temperatures, and loose magnetic strength in warm temperatures due to the alignment of particles, the movement- or vibration- of particles and its concentrated magnetic field. Nevertheless, I am still very happy that I got the chance to work with magnets and discover more about them in this experiment.

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ABOUT THE AUTHOR - EMMA KAO

"My passion for science started back when I was mixing baking soda and vinegar in first grade. Then it really peaked during COVID when I started to experiment with different types of bake goods. Turns out I really like mixing different ingredients and seeing how they turned out. Outside of school, I enjoy traveling, swimming, fencing, and playing the piano. My passion is to pursue the furthest expanses of the world with my family to see and experience different cultures. I started fencing when I was 8 years old and have won various medals at my local fencing clubs. My most proud achievement was being selected to perform on stage at NAC with the world-renowned pianist Lang-Lang in 2015."