ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

IARJSET

International Advanced Research Journal in Science, Engineering and Technology

2nd International Conference on Advances in Mechanical Engineering (ICAME-2016)

Amrutvahini College of Engineering, Sangamner

Vol. 3, Special Issue 1, March 2016

Behaviour of Ferromagnetic Materials In a Magnetic Field of a Permanent Magnet (The Law of Static Magnetism)

Krinav Makwana

Government Engineering College, Bharuch, Gujarat, India.

Abstract: This research paper gives information about behaviour of ferromagnetic materials (The given experiment in this paper is done by using “Iron” as a ferromagnetic material.) in a magnetic field of a permanent magnet. The word “Behaviour”, in this paper is used for the characteristic of ferromagnetic materials to behave as a Magnet in a magnetic field of a permanent magnet.

Keywords: Behaviour of ferromagnetic materials, discussion, experiment, friction & inertia, gravity, intensity of magnetization of a ferromagnetic material, magnetic field of a permanent magnet, results, the law of static magnetism.

I. INTRODUCTION

Magnet is one of the most important elements these days. The properties & characteristics of magnets also help us to enhance the way of living of human being. So, we must know all the important characteristics of magnets to improve the capability of human being to live life more comfortably & to increase the capacity of the machines work on the basis of properties of magnets. In this paper the characteristic of a magnet described is, all the magnetic materials behave as a magnet in a magnetic field of a permanent magnet & it is briefly explained in this paper that how far distance from a magnet, any magnetic material behaves as a magnet. This property of a permanent magnet is explained by an experiment in this paper. This paper also includes results of an experiment, brief discussion about an experiment, conclusion & the law of static magnetism.

II. EXPERIMENT

A. Aim

To study about the behaviour of ferromagnetic materials in a magnetic field of a permanent magnet. i.e., how far distance from a magnet, any magnetic material behaves as a magnet.

B. Equipment

A Permanent Magnet, a small nail (Iron) & a big nail (Iron) in comparison to a small nail equipped, cardboard or paper (white), pen/pencil.

C. Procedure

Firstly take a simple permanent magnet. Now take a small nail of Iron & put both magnet & a nail on a white paper. Now fix the place of a permanent magnet on a paper & slide a small nail towards any one pole of a magnet (i.e., North Pole N or South Pole S) slowly. Mark the distance between nail & a magnet from where a nail is attracted towards a magnet. Refer Fig. 1.

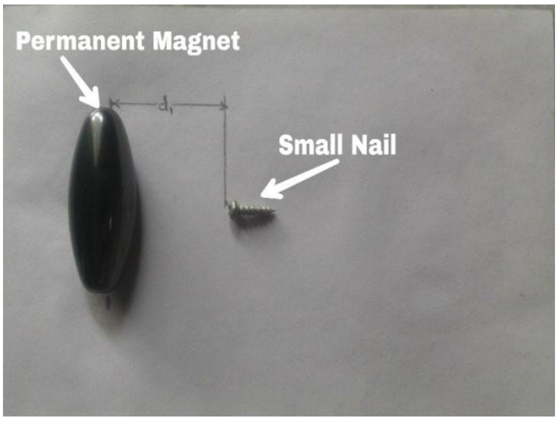

Fig. 1 The distance between small nail & a magnet from where a nail is attracted towards magnet (d_1)

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

IARJSET

International Advanced Research Journal in Science, Engineering and Technology

2nd International Conference on Advances in Mechanical Engineering (ICAME-2016)

Amrutvahini College of Engineering, Sangamner

Vol. 3, Special Issue 1, March 2016

Now take a big nail as compared to a small nail taken & repeat the same procedure for this big nail. Mark the distance between nail & a magnet from where a nail is attracted towards a magnet. Refer Fig. 2.

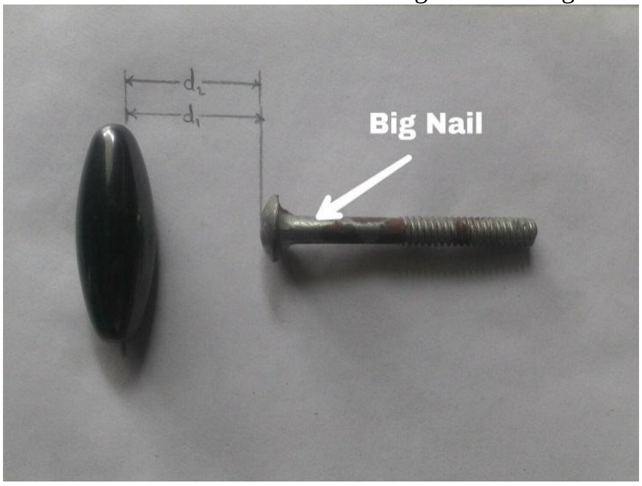

Fig. 2 The distance between big nail & a magnet from where a nail is attracted towards a magnet (d_2)

Now, fix the place of a magnet as before & put a small nail on one pole of a magnet. Small nail will be stay there because of magnetic force acting between magnet & a nail. Then, take a big nail & try to pull slowly a small nail away from the magnet by attaching big nail to a small nail. Big nail will attract a small nail because it will behave as a magnet in a magnetic field. Continue pulling a small nail until it is fallen down from big nail. Mark the distance from a magnet to where small nail fell from big nail. Refer Fig. 3(a) & Fig. 3(b).

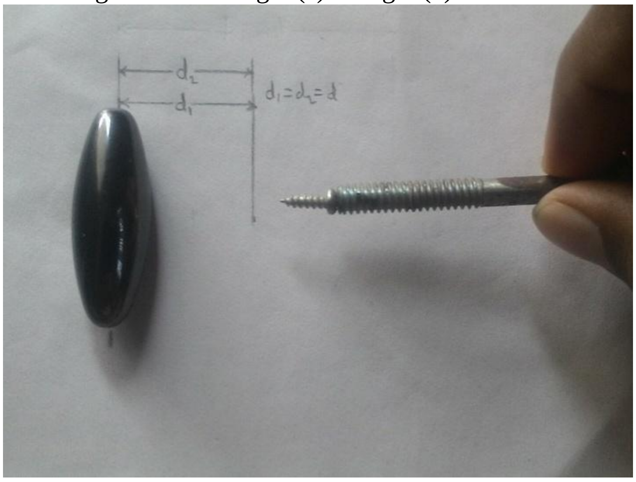

Fig. 3(a) Pulling of a small nail away from the magnet by big nail

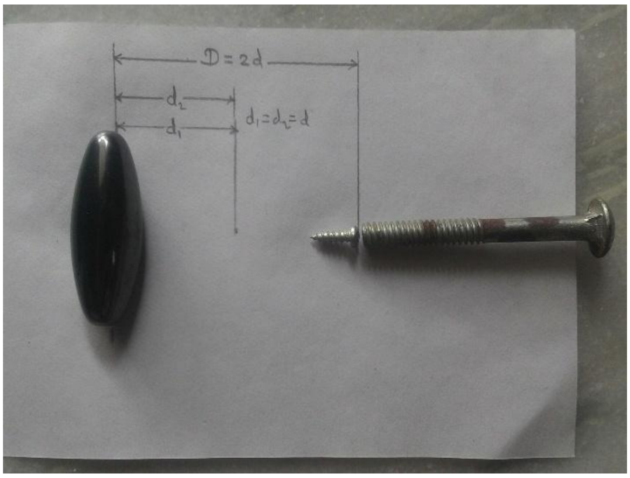

Fig. 3(b) The distance from a magnet to where small nail fell/detached from big nail (D)

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
IARJSET
International Advanced Research Journal in Science, Engineering and Technology
2nd International Conference on Advances in Mechanical Engineering (ICAME-2016)
Amrutvahini College of Engineering, Sangamner
Vol. 3, Special Issue 1, March 2016

D. Important care to be taken during experiment to get more accurate results

While sliding nail towards magnet as per the first paragraph of Procedure, the direction of sliding of a nail must be perpendicular to the pole of a magnet towards which a nail is to be slid. i.e., the distance between nail & magnet must be minimum while sliding to get more accurate results. While pulling small nail away from magnet by big nail as per the third paragraph of Procedure, the care must be taken is that the area of contact between small nail & big nail must be minimum as possible as can be done. Nails used in the experiment must be stored far away from the magnet. Nails can be magnetised in a magnetic field when they are kept in a magnetic field for a long time. Magnetised nails can lead to inaccurate results. Nails used in the experiment must be of a pure iron. i.e., iron must not be rusted. The magnet used in experiment must be so capable that it can attract nail from the far distance that can be measured or marked easily. The surface on which the whole experiment is done must be of low friction co-efficient to reduce effects of friction.

E. Results

As per the procedure explained, the results can be achieved. Fig. 1, Fig. 2 & Fig. 3(a), Fig. 3(b) shows the results achieved by direct observations. By observation I have seen that the distance between small nail & magnet as well as the distance between big nail & magnet would be approximately the same (There can be minor difference between two distances due to friction effects.) while the nails are being slid towards one of the poles of magnet & magnet starts attracting/pulling the nails, & this distance will be approximately ½ of the distance between the system of two nails (small nail & big nail) & magnet, while the system of nails is being pulled away from magnet & two nails has been detached. It means when the system of two nails is being pulled away from magnet, small nail will fall down from big nail after travelling approximately the double distance of that the distance between individual nails & magnet when magnet starts attracting/pulling the nails.

F. Discussion

In the above experiment results can be varied due to the effects of friction & inertia acting on the system. To avoid the effects of friction & inertia, I have another experiment explained below. By comparing the results of this experiment with the results of above experiment I can ensure that the results are accurate enough. Firstly take a permanent magnet & a small nail (as above). Put small nail on a flat surface freely. Fix white cardboard or a paper perpendicular to the surface to mark the distances. Now, take magnet & start moving magnet from some height towards small nail downwards & mark the distance between nail & magnet from where magnet starts attracting/pulling small nail upwards towards magnet. Then repeat this process for big nail & mark the distance between nail & magnet from where magnet starts attracting/pulling big nail towards magnet. Now, put small nail on magnet & try to pull small nail away from magnet by big nail as done before in above explained experiment & mark the distance between magnet & a system of two nails, where the nails are detached. Refer Fig. 4(a), Fig. 4(b) & Fig. 4(c).

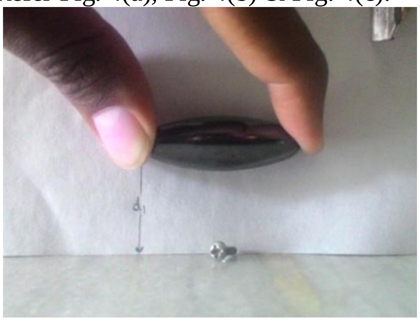

Fig. 4(a) The distance between nail & magnet from where magnet starts attracting/pulling small nail (d_1)

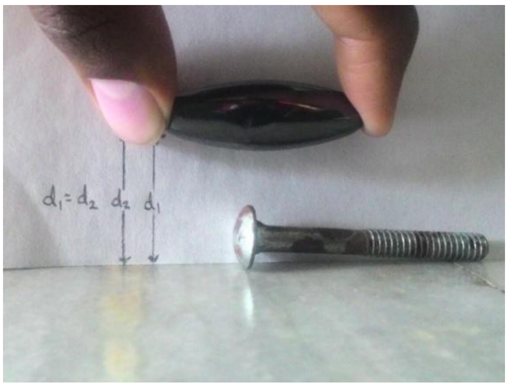

Fig. 4(b) The distance between nail & magnet from where magnet starts attracting/pulling big nail (d_2)

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
IARJSET
International Advanced Research Journal in Science, Engineering and Technology
2nd International Conference on Advances in Mechanical Engineering (ICAME-2016)
Amrutvahini College of Engineering, Sangamner
Vol. 3, Special Issue 1, March 2016

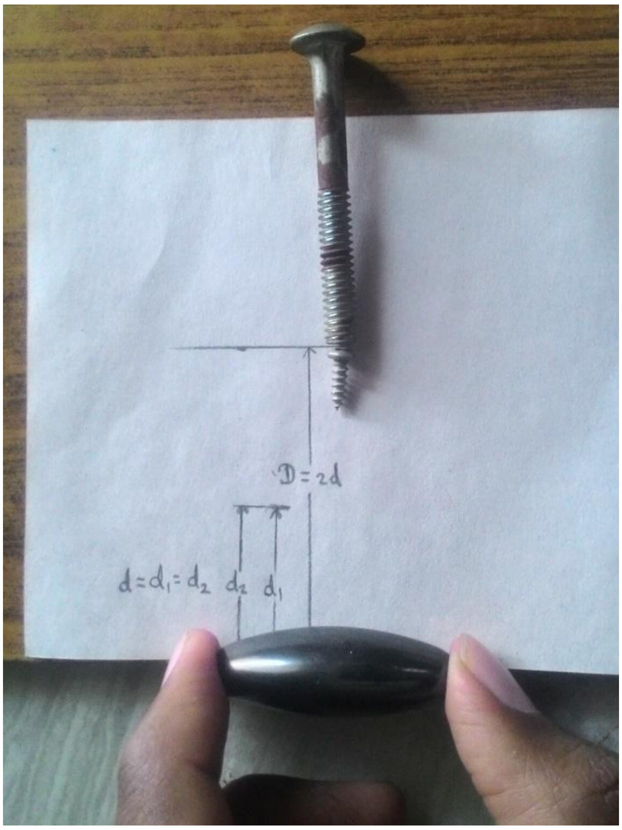

Fig. 4(c) The distance from a magnet to where small nail fell/detached from big nail (D)

By observing the results, I have seen that the distances between individual nails & magnet from where magnet starts attracting/pulling nails are approximately the same & this distance is approximately ½ of the distance between the system of two nails & magnet where the nails has been detached. By comparing the results of this experiment & the first experiment, I have seen that the results are same for both of the experiments. It ensures that the results are almost accurate. In this experiment the effects of friction & inertia are avoided but instead of friction the effects of gravity will take place in this case. But, gravitational force is the weakest force among all the 4 main forces including magnetic force. So, it can be neglected. Because the relative measurements for small & big nail won't be affected much in this experiment due to effects of gravity.

G. Conclusion

By above discussion & observing results of the experiment I can conclude that any ferromagnetic material behaves as a magnet along the perpendicular distance from magnet approximately the double of the distance between magnet & magnetic material along which magnet can attract/pull magnetic material towards magnet.

In other words, the intensity of magnetic field "B_d" at any point at the distance "d" from magnet in an axial direction is equal to the intensity of magnetization "M_D" of a ferromagnetic material at a point at the distance "D" from magnet in the same direction. Where, $D = 2d$.

Mathematically,

$$B_d = M_D \qquad (1)$$

But an equation of the intensity of magnetic field B_{axis} (measured in Tesla) of an ideal dipole along its axis is

$$B_{axis} = B_d = \frac{\mu_0}{4\pi}\frac{2m}{d^3} \qquad (2)$$

Where, μ_0 is the permeability constant ($4\pi \times 10^{-7}$ T m/A), d is the distance from the center of the dipole in meters and m is the magnetic moment.

$$\therefore\ M_D = \frac{\mu_0}{4\pi}\frac{2m}{d^3} \qquad (3)$$

i.e., $B_d = M_D$ [from "(1)"]

Now, we have an equation of the intensity of magnetization of a ferromagnetic material at a point at the distance D from magnet/dipole (i.e.,M_D). Where, $D = 2d$.

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

IARJSET

International Advanced Research Journal in Science, Engineering and Technology

2nd International Conference on Advances in Mechanical Engineering (ICAME-2016)

Amrutvahini College of Engineering, Sangamner

Vol. 3, Special Issue 1, March 2016

In order to find an equation of the intensity of magnetization of a ferromagnetic material at a point at the distance d from magnet/dipole (i.e.,M_d), "d" from "(3)" must be replaced by "$^d/_2$". Because "(3)" is for the intensity of magnetization at a point at the distance d (i.e., M_D is for distance d) & if we want to find an equation of the intensity of magnetization at the distance ½ of that for "(3)" (i.e.,M_d), we must apply ½ distance of that for "(3)" in "(3)".

By replacing "d" by "$^d/_2$" in "(3)" we get,

$$M_d = \frac{\mu_0}{4\pi}\frac{2m}{\left(^d/_2\right)^3}$$

$$\therefore\ M_d = 8\frac{\mu_0}{4\pi}\frac{2m}{d^3}$$

$$\therefore\ M_d = 8B_d \qquad (4)$$

i.e., as per "(2)".

From above "(4)", I can conclude that the intensity of magnetization of a ferromagnetic material at a point at the distance d from magnet/dipole in an axial direction is equal to the intensity of magnetic field of a magnet at that point multiplied by 8.

III. THE LAW OF STATIC MAGNETISM

"Any ferromagnetic material behaves as a magnet along the perpendicular distance from magnet approximately the double of the distance between magnet & magnetic material along which magnet can attract/pull magnetic material towards magnet. "

OR

"The intensity of magnetization of a ferromagnetic material at a point at the distance d from magnet/dipole in an axial direction is equal to the intensity of magnetic field of a magnet at that point multiplied by 8."

Mathematically,

$$M_d = 8B_d$$

REFERENCES

[1]. https://en.m.wikipedia.org/wiki/Force_between_magnets?_e_pi_=7%2CPAGE_ID10%2C9328523998. Force between magnets, 14 February 2016.
[2]. https://en.m.wikipedia.org/wiki/Magnetic_field?_e_pi_=7%2CPAGE_ID10%2C9623137491. Magnetic field, 6 February 2016.
[3]. https://en.m.wikipedia.org/wiki/Magnetism?_e_pi_=7%2CPAGE_ID10%2C1134342386. Magnetism, 1 February 2016.
[4]. https://en.m.wikipedia.org/wiki/Ferromagnetism?_e_pi_=7%2CPAGE_ID10%2C9004679948. Ferromagnetism, 5 January 2016.
[5]. http://www.google.co.in/url?q=http://www2.vernier.com/sample_labs/PWV-31-COMP-magnetic_field_permanent_magnet.pdf&sa=U&ved=0ahUKEwi084bRov7KAhVM12MKHU_YAL0QFggOMAA&usg=AFQjCNGizd-6CVEtXm4bnDEtk0pj-cOtJAopen_window_by_link:. The magnetic field of a permanent magnet.
[6]. https://en.m.wikipedia.org/wiki/Magnet?_e_pi_=7%2CPAGE_ID10%2C1531370503. Magnet, 14 February 2016.

BIOGRAPHY

I was born in India in 1996. I have completed S.S.C. & H.S.C. from Gujarat Board in 2011 & 2013, respectively. Currently I'm a student of B.E., Mechanical Engineering, 3rd year at Government Engineering College, Bharuch.