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A Demonstration for Pedagogy to Realize Maglev Technologies

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Abstract: *Magnetic levitation is an interesting phenomenon of lifting/ suspending objects without any physical contact using magnetic power, which finds multitude of applications in modern technologies. The objective of this article is to interactively demonstrate magnetic levitation using a simple experimental setup with intent to increase the efficacy of science and engineering pedagogy in teaching-learning process of magnetism for the realization of potential of physics in the making of advanced systems such as maglev trains, flying cars, maglev wind turbines and magnetic bearings.*

Keywords: *Magnetic Levitation, Demonstration, Pedagogy, Physics Education and Maglev Technologies*

1. INTRODUCTION

Demonstrations with active participation are efficient tools to deliver, receive and exchange information effectively in teaching-learning environments which stimulate learners to involve in it. Particularly, the projection of scientific principles would be more attractive and informative if they are demonstrated, though simple [1]. Scientific demonstrations provide a greater impact in the realization of many advanced technologies. Magnetic levitation (maglev) is a very interesting scientific phenomenon which possesses numerous applications in modern science, engineering and technology. Literature survey reveals that interactive demonstration of magnetic levitation phenomenon to the science and engineering pedagogy is not much reported in journals as well as text books in a simple form. Hence, this work is attempted. The objective of the article is primarily to demonstrate the principle of magnetic levitation in a very simple way. In addition, this paper could also assist the pedagogy to realize the fundamentals of magnetism such as: the concept of a magnetic dipole, its interaction with an external magnetic field, torque on a magnetic dipole (a current loop), magnetic flip and polarity of magnetic dipole. In addition, this article could also help active learners as well as teachers of graduate level for the realization of the principles of magnetic sensors, magnetic actuators, electromagnets and static and dynamic maglev systems. Though the demonstration appear to be simple, it conveys a bundle of potential information for the science and engineering pedagogy about magnetism from some of the basics of magnetism to the realization of the principles behind the advanced technologies such as maglev trains, flying cars, maglev wind turbines and magnetic bearings [2-6]. But, in the design of real time maglev systems, maintaining their mechanical stability and electronic control mechanisms are challenging factors, which are to be carefully designed to maintain the precise magnetic suspension motions. Many of the researchers have also presented various modeling techniques and mathematical treatments on maglev applications to handle different situations [7-13].

2. Block Diagram of Magnetic Levitation and Description

The block diagram of magnetic levitation demonstration experimental set-up used in our laboratory is shown in Figure.1.

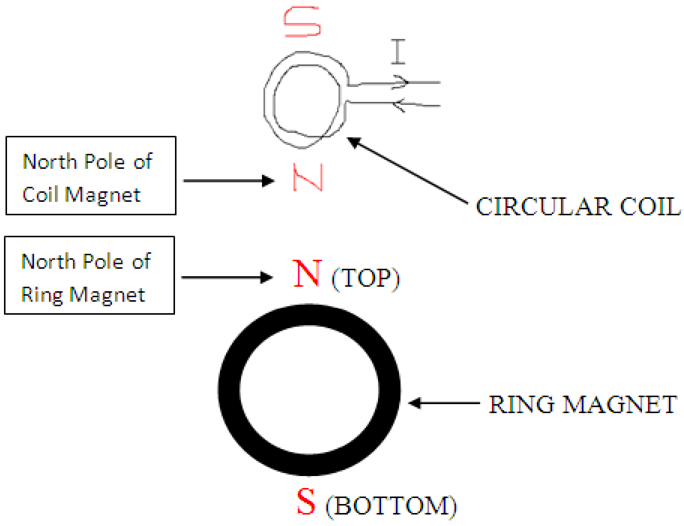

Fig.1. *Block diagram of magnetic levitation experimental set-up*

The set up consists of a ring magnet and an insulated circular copper coil. The ring magnet used for demonstration was taken by us from an unused speaker. The copper coil was wound on a non-conducting circular frame. The material of the frame must be selected in such a way it should be capable of withstanding joule's heating during the passage of current. A maximum direct current of 3 amperes was used by us for demonstration. When a current I is passed through the coil, it acts an electromagnet and in the absence of current it is simply an ordinary coil and not an electromagnet and hence no magnetic power is associated to that coil when the is no current flow through which. Initially, the coil is connected to an I.C. regulated d.c. power supply and the power supply is switched OFF. Now, the coil is not a magnet. In this condition, the coil is placed inside the central hole of the ring magnet freely without any contact with the magnet. Even though, the ring magnet is a permanent magnet, its magnetic field does not have any effect on the coil housed in its central hole during rest when there is no current in the coil. Whereas, if the power supply is switched ON, a current is activated in the coil and hence the coil now acts as an electromagnet/ magnetic dipole and the magnetic field associated with this magnetic dipole interacts with the magnetic field of the ring magnet. As a result of the interaction/ coupling effect of these two magnetic fields, an attraction or repulsion of the coil magnet by the ring magnet and vice versa takes place. Since the direction of current in the coil determines the magnetic polarity of the coil magnet, accordingly, it is attracted or repelled by the ring magnet. Upon switching ON the power supply, if same poles of ring magnet and coil magnet face each other, the coil is momentarily lifted/ jumped up against the gravity above the ring magnet from the rest position in the hole of ring magnet. This is called magnetic levitation/ suspension. In contra, if opposite poles face each other, then, both attract each other.

3. Experimental Set-Up and Demonstraion

The basic components required for this demonstration are, namely: an IC regulated d.c. power supply (12V, 3 A), an insulated copper wire wound on a ring-type non conducting frame to form a circular coil, a ring magnet, a non-magnetic stick and connecting wires. The copper wire of the coil was selected in such a way it could withstand a direct current of 3 amperes. The material of the non-conducting frame was also selected in such a way it should withstand joules heating; otherwise the frame may melt because of joules heating. If required, such winding with required specification can be obtained from any technician involved in electrical windings. The ring type magnet possesses a hole at the centre, wherein, the coil could be placed without any contact friction with the ring magnet. If the number of windings of coil is more, the response of the coil magnet is also more for magnetic coupling effects. After the coil is wound, suitable glue may be used to hold the windings from rewinding. If the coil wire could withstand more than 3 ampere current, then, a higher current supply also could be used. Since, magnetic field produced by a coil depends on magnitude of current flowing through which, more current can produce more magnetic field in the coil and the coil can produce better effect of magnetic levitation.

To demonstrate magnetic levitation phenomenon, the coil is connected to the power supply either directly or through a rheostat to control the current. The ring magnet is placed nearby the experimental arrangement. The ends of coils could be soldered with the connecting wires for better electrical contact. The photograph of experimental arrangement used in our laboratory for the demonstration is shown in Figure.2.

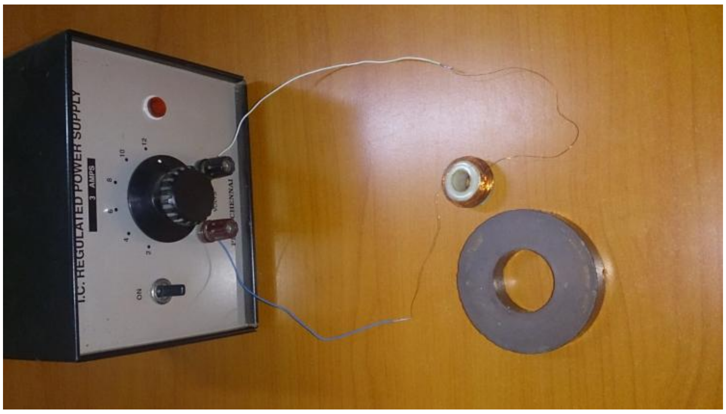

Fig.2. *Photograph of experimental arrangement*

When the power supply is switched ON and current is passed though the coil, the current carrying coil acts as a magnetic dipole. This magnetic dipole now could interact with the magnetic field of the ring magnet. The current is switched OFF and coil is placed inside the centre hole of ring magnet. The photograph of this situation is shown in Figure. 3.

Fig.3. *Photograph of coil housed inside the centre hole of circular magnet.*

A metallic stick placed near by the experimental set up is a non-magnetic type. This could be used to hold the magnetic objects wherever required during demonstration process without any interference by the magnetic fields. In general any non-magnetic stick could be used, i.e., either metallic or non-metallic type. The photograph of upper projection of the arrangement in Figure.3 is shown Figure.4.

Fig.4. *Photograph of upper projection of the arrangement*

Now, the non-magnetic stick is inserted in the centre hole of coil frame, vertically down, holding it on a hand at the top. It should be noted the rod should not be tightly inserted in the coil frame, which may obstruct free motion of the coil over the non-magnetic stick during levitation. The photograph of this situation is shown in figure.5.

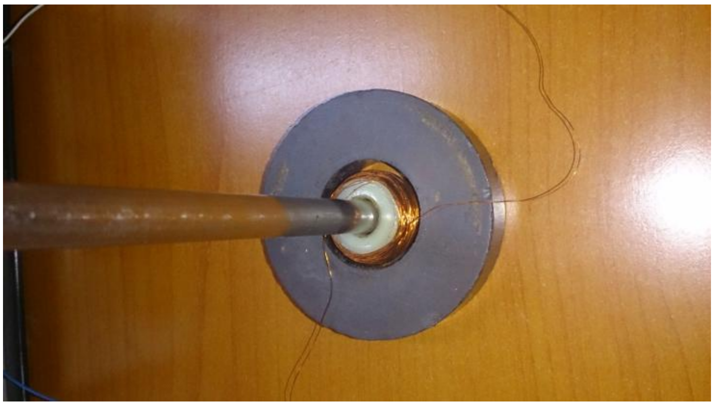

Fig.5. *Photograph of the experimental set-up along with inserted non-magnetic stick.*

Now, in this condition, the power supply is switched ON. It could be seen that the coil magnet is momentarily lifted up from the hole of the ring magnet and suspends in air above the ring magnet. This phenomenon is called magnetic levitation or magnetic suspension. This response of the coil magnet is the outcome of its magnetic field interaction with the magnetic field of ring magnet. The photograph of this situation is shown in figure.6.

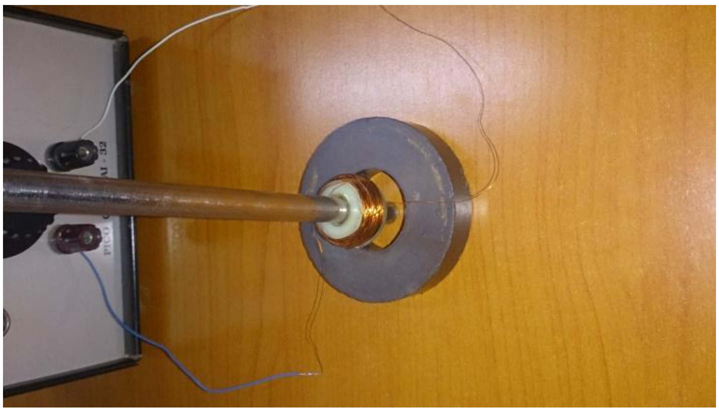

Fig.6. *Photograph of experimental set up with suspended coil*

Figure.6 indicates that the coil is fully lifted/ suspended by magnetic power. If now the power supply is now switched OFF, it could be seen that the coil sits back inside the hole of ring magnet. The switching ON and OFF of the power supply could be done multiple times and demonstration of magnetic levitation could be made more attractive.

4. CONCLUSION

Magnetic levitation possesses numerous applications in various fields of modern engineering designs and technologies. The focus of this article is primarily to demonstrate magnetic levitation phenomenon in a very simple way to enable science and engineering pedagogy to experimentally realize magnetic levitation and its potential applications. The paper also help the pedagogy to understand various principles and concepts of magnetism experimentally, such as, creation of a magnetic dipole, its interaction responses in an external magnetic field, magnetic sensors, magnetic actuators and electromagnets in addition to the realization of principles behind potential maglev applications such as maglev trains, flying cars, maglev wind turbines and magnetic bearings, thereby, this may hopefully actuate them to pursue research on maglev technologies to meet the magnetic demands of the society at present and also in the future.

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