Devising new technique as an emerging trend to perform Physics experiment in a simpler and unconventional manner

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Abstract- *Education is a critical component that contributes extensively in the human development indices. The educational pedagogies must be dynamic and be able to create independent learners.*

Physics is stimulating and the world today increasingly depends on it. Sadly, many students feel uncomfortable with the subject and are skeptical about pursuing it as a career option in their later life. Hence, it is of utmost importance that we dispose of these inhibitions by bringing in new, out of the box techniques, which are in accordance with educational standards, the world over. Along with this, these techniques will also serve as the new emerging trend in the field of Physics.

Usually, school students are required to do a certain number of experiments specified in syllabus and the experiments are performed by the students in a guided manner without putting much thought inthe extrapolation of concepts or finding alternative methods of determining the same physical quantity by simpler and innovative method.

The experiment being presented in this paper is based upon the above philosophy, wherein different magnetic fields B1, B2, B3,..... at the centre of circular coil are produced using different values of current in a coil (keeping the direction of current constant) and by reversing current (keeping magnitude of current constant). A small magnet is made to vibrate in combined magnetic fields B due to current and Earth's magnetic field H. Vibration of magnet in a magnetic field and production of magnetic field perpendicular to the plane of coil due to current are the key concepts used in the experiment.

In this paper, for determining the horizontal component of earth's magnetic field (H) and hence magnetic moment of magnet (M), a set of new equations has been derived which suggest simple method of determination of H and M, which are the backbone of the experiment. The value of H using first method, when direction of current is reversed (magnitude remains same) comes out to be H(experimental) = 3.15E-05 and using second method, when changing currents is applied (direction remains same), H(experimental) = 3.02E-05. The theoretical value of H is 3.20E-05, which clearly indicates that both, theoretical and experimental values are nearly same.

Thus, this approach will serve as a catalyst in the process of concept-building since it provides a precedent, for adopting this technique for other experiments as well. This new methodology will henceforth enhance the experience hands-on experiments, and impart ever-lasting learning in the field of Physics.

***Keywords*:** Horizontal component of earth's magnetic field (H)[2], magnetic moment (M)[1], vibrational magnetometer.

Introduction

The conventional approach to determine H and M used Tangent galvanometer and Vibrationalmagnetometer [3] but our novel methodology of determining H and M uses newly derived equationsto develop the experimental setup as per the requirement of known andunknown physical quantities in mathematical equations. This brings to fore, a new way of performingexperiments easily using simple instruments with the aid of newly derived equations, while keeping hands-on learning intact.

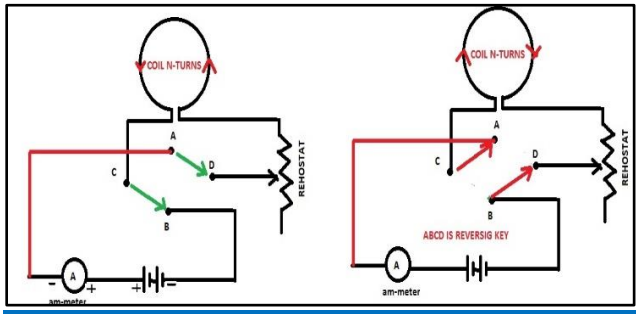
In this paper, the experiment being presented depends upon the precept, wherein different magnetic fields B1, B2 , B3,..... at the centre of circular coil are produced using different values of current in a coil (keeping the direction of current constant) and by reversing current (keeping magnitude of current constant). A small magnet is made to vibrate in combined magnetic fields B due to current and Earth's magnetic field H. Vibration of magnet in a magnetic field and production of magnetic field perpendicular to the plane of coil due to current are the key concepts used in the experiment.

Objectives

To develop the thought process of concept-building among the students and provides a precedent, for adopting this technique for other experiments as well. This new methodology will henceforth enhance the experience of hands-on experiments and impart ever-lasting learning in the field of Physics.

Methods and Procedure:

Circuit Diagram



Circuit diagram

1st Method

Time period T_1 of vibration of a magnet of magnetic moment M and moment of inertia I in a magnetic field H + B is given by

$$T_1 = 2\pi\sqrt{\frac{I}{M(H+B)}} \text{---------- (1)}$$

Time period T_2 of vibration of a magnet of magnetic moment M and moment of inertia I in a magnetic field H - B is given by

$$T_2 = 2\pi\sqrt{\frac{I}{M(H-B)}} \text{---------- (2)}$$

This gives $T_1^2 = \frac{4\pi^2 I}{M(H+B)}$ And $T_2^2 = \frac{4\pi^2 I}{M(H-B)}$ $\Rightarrow \frac{T_2^2}{T_1^2} = \frac{H+B}{H-B}$

Using Componendo and Dividendo $\frac{T_2^2+T_1^2}{T_2^2-T_1^2} = \frac{H}{B}$ $\Rightarrow H = \frac{T_2^2+T_1^2}{T_2^2-T_1^2}B$

$$H = \frac{\mu_0 ni}{2r} * \frac{T_2^2+T_1^2}{T_2^2-T_1^2} \text{..... (3)}$$

Since $\mu_0 = 4\pi(10^{-7})$,therefore, knowing all the values in above equation we can calculate H.

Also, using MOI, $I = \left(\frac{L^2+B^2}{12}\right) * m$ andequations 1 or 2 we can calculate M.

2nd Method

If B_1 and B_2 are magnetic fields for currents i_1 and i_2 in the direction of H, then

$$T_1^2 = \frac{4\pi^2 I}{M(H+B_1)}$$

And $T_2^2 = \frac{4\pi^2 I}{M(H+B_2)}$ $\Rightarrow \frac{T_2^2}{T_1^2} = \frac{H+B_1}{H+B_2}$

$$\text{H}(T_1^2 - T_2^2) = B_2T_2^2 - B_1T_1^2 = \frac{\mu_0 ni_2T_2^2}{2r} - \frac{\mu_0 ni_1T_1^2}{2r}$$

$$H = \frac{\mu_0 n}{2r}\left(\frac{i_2T_2^2 - i_1T_1^2}{T_1^2 - T_2^2}\right) \text{..... (4)}$$

Knowing everything in above equation we can calculate H and then M.

Observations

Method-1: H by Reversing Current

μ_o (MU-NOT)	N	r(cm)	r(m)
1.25714E-06	20	4.5	0.045

S.NO	CURRENT (A)	H + B		H - B		
		TIME FOR 10 VIBRATIONS (t1)(s)	T1=t1/10(s)	TIME FOR 10 VIBRATIONS (t2)(s)	T2=t2/10 (s)	H (Tesla)
1	0.5	8.79	0.879	8.87	0.887	3.12E-05
2	0.75	9.07	0.907	9.19	0.919	3.23E-05
3	1	9.81	0.981	9.99	0.999	3.11E-05

Mean H(exp)	3.15E-05
Avg H (Actual)	3.20E-05

Method-2: H by Changing Current

μ_o MU-NOT	N	r(cm)	r(m)				
1.25714E-06	20	4.5	0.045				
		H + B1			H + B2		
S.NO	I1 (A)	TIME FOR 10 VIBRATIONS (t1) (s)	T1=t1/10 (s)	I2 (A)	TIME FOR 10 VIBRATIONS (t2)(s)	T2=t2/10(s)	H (Tesla)
1	0.5	9.34	0.934	1	9.30	0.930	3.25E-05
2	0.75	9.37	0.937	1.25	9.33	0.933	3.25E-05
3	1	9.32	0.932	1.5	9.28	0.928	3.22E-05

Mean experimental H	3.24E-05
Actual Avg Value of H	3.20E-05

Calculation of Magnetic Moment:

Since, $T_1^2 = \frac{4\pi^2 I}{M(H+B)}$ Hence, $M = \frac{4\pi^2 I}{T_1^2(H+B)}$

But, $I = \left(\frac{L^2+B^2}{12}\right) * m$,

For bar magnet, L = 1.61 cm (using Vernier calliper), B = 0.25 cm, m= 0.50 g.

Here, I, T^2_1,H , B are known quantities , so magnetic moment can be calculated, which comes out to be, M = 77.553 × 10^{-4} Am^2

Results & Discussion:

1. In first method, when direction of current is reversed (magnitude remains same)

   H (experimental) = 3.15E-05
   H (theoretical) = 3.20E-05

2. In second method, when changing currents is applied (direction remains same)

   H (experimental) = 3.02E-05
   H (theoretical) = 3.20E-05

Conclusions

1. The theoretical and experimental value of H are nearly the same, hence the new way of determining H is correct.
2. This experimental method and the newly derived equations for determining H and Mserve as a monotony breaker of the olden ways [4]. Hence it is an emerging trend in the true sense.
3. This new approach lays the foundation that is applicable to all other Physics experiments that have been performed in the past years using the old conventional methods.

Refrences

Prabha, S. (2018). Variation of the magnetic moment of a bar magnet with its inclination with the magnetic meridian of the Earth. *Physics Education,* 54(1), 013003.

Gvishiani, A. D., &Lukianova, R. Y. (2015). Geoinformatics and observations of the Earth's magnetic field*: The Russian segment. Izvestiya, Physics of the Solid Earth,* 51(2), 157-175.

Zelinka, T., and Janák, F. (1979). Analysis of the magnetometric vibration method. *StudiaGeophysicaetGeodaetica*, 23(3), 299-300.

Bates, L. F. (1931). A simple apparatus for the measurement of the horizontal component of the Earth's magnetic field. *Journal of Scientific Instruments,* 8(10), 324.