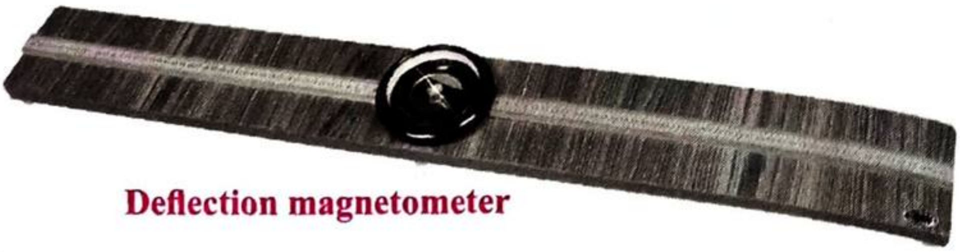
EXPERIMENT NO. 10
DETERMINATION OF MAGNETIC MOMENT OF A SHORT BAR MAGNET (DIPOLE) USING A DEFLECTION MAGNETOMETER

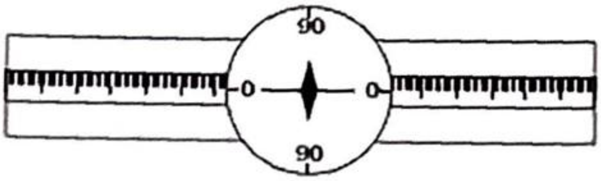
Aim: To calculate the magnetic moment of a given magnet using the deflection magnetometer.

Apparatus: Deflection magnetometer, bar magnets, meter scale.

Diagram:



Deflection magnetometer



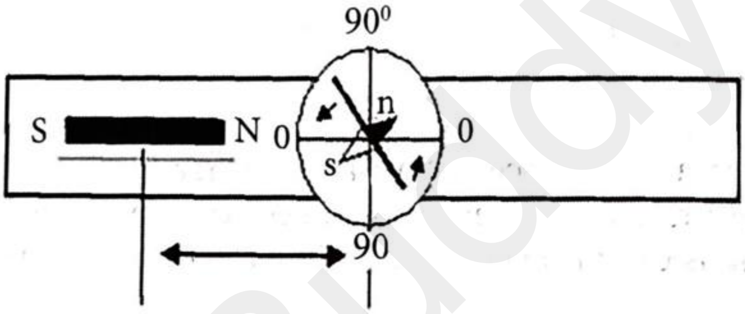


Fig 10.1 For tan A position

Theory:

Tangent law:

Consider a bar magnet(dipole) with magnetic moment M in a region where there are two perpendicular horizontal magnetic fields, an external field B and the horizontal component of the earth's field BH . If no external field B is present, the bar magnet will align along B_H. Due to field B the magnet experiences a torque, which deflects it from its original position by an angle θ. Then we have the relation $B = B_H \tan\theta$.

Deflection Magnetometer:

It consists of large compass, with a small magnetic needle pivoted at the centre of a circular scale so that the needle is free to rotate in a horizontal plane. A large aluminium pointer is rigidly fixed perpendicular to the magnetic needle. The circular scale is graduated in degrees ($0^0 - 0^0$) and ($90^0 - 90^0$) readings are marked at the ends of two perpendicular diameters. The compass box is placed at the centre of a wooden board one meter long. The wooden board has a millimetre scale along its axis such that the zero of the scale is at the centre of the compass box.

Tan A position

In Tan-A position (figure 10.1), prior to placement of magnet, the compass box rotated so that the ($0^0 - 0^0$) line is parallel to the arm of the magnetometer. Then the magnetometer as a whole is rotated till pointer reads ($0^0 - 0^0$).The bar magnet is placed horizontally on the arm of the deflection magnetometer (parallel to the arm) so that the deflection on the aluminium pointer is θ^0

Since the magnet is a dipole and placed on the axis its magnetic induction B at a distance 'd' from the centre of the magnetometer ($0^0 - 0^0$) to the centre of the dipole is given as

$$B_{axis} = \frac{\mu_0}{4\pi} \frac{2md}{(d^2 - l^2)^2}$$

Where $2l$ is the length of the magnet.

For a short magnetic dipole

$l << d$

$$B_{axis} = \frac{\mu_0}{4\pi} \frac{2M}{d^3}$$

By Tangent Law

$$B_{axis} = B_H \tan\theta \quad , \quad B_H \tan\theta = \frac{\mu_0}{4\pi} \frac{2M}{d^3}$$

$$M = \frac{B_H \tan\theta}{2\frac{\mu_0}{4\pi}} d^3 \qquad \text{since } \frac{\mu_0}{4\pi} = 10^{-7}$$

$$M = \frac{B_H \tan\theta}{2 \times 10^{-7}} d^3$$

Procedure :

1. The bar magnet is placed at the same height as the magnetic needle is tan A position.
2. The other magnetic materials should be kept as far away as possible from the magnetometer.
3. The distance of the magnet should be adjusted so that the pointer points at 45^0-45^0.
4. The distance should be noted as d_1.
5. The same magnet should be placed by reversing its position (that means if it was N-S previously it should now be placed as S-N and vice versa). The distance should be noted as d_2.
6. The experiment should be repeated with another bar magnet.

Observation table:

Calculations :

Obs. No.	Magnet no	Distance d_1 d1	Distance d_2 d2	Mean d d3 d4	$M = \frac{B_H \tan\theta}{2 \times 10^{-7}} d^3$
1	M_1	13	18.0	~~18.2~~ ~~16.5~~	.0.9585
2	M_2	16	1.8	~~16.5~~ ~~15~~	0.7775

16.5 17.825

15 10.075

Result :

1. Magnetic moment of Magnet 1 = 0.9585
2. Magnetic moment of Magnet 2 = 0.7775

Precautions :

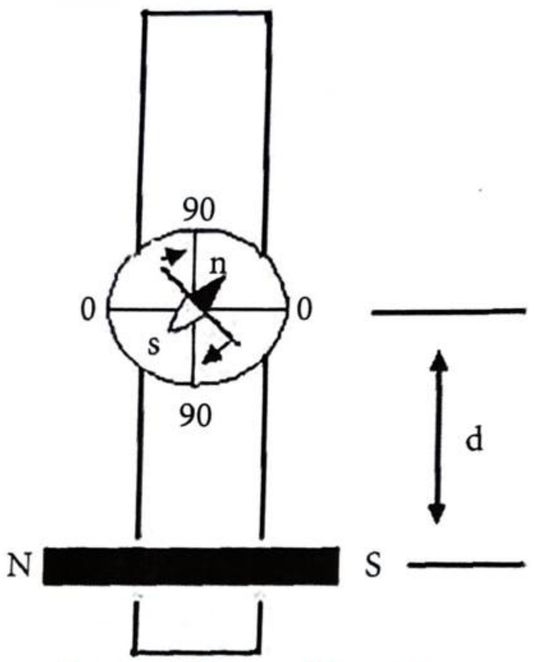
Check that setting of magnetometer in TanA position is properly done before keeping magnet on its arms.

Additional Experiment you can do :

Tan B position

In this position (figure below), prior to placement of the magnet, the compass box alone is rotated so that the (90^0-90^0) line is parallel to the arm of the magnetometer. Then the magnetometer as whole is rotated so that the pointer reads (0^0-0^0). Finally the, magnet is placed horizontally, perpendicular to the arm of the magnetometer and distance'd' is adjusted to get a reading θ on the pointer.

Diagram :



In this case

$$Beq = \frac{\mu_0}{4\pi} \frac{M}{d^3}$$

$$Beq = B_H \tan \theta$$

$$M = \frac{B_H \tan\theta}{10^{-7}} d^3$$

Fig 10.2 For tan B position

Procedure:

Repeat the above procedure for Tan B position.

Observation table:

Obs. No.	Magnet no	Distance d_1	Distance d_2	Mean d	$M = \frac{B_H \tan\theta}{10^{-7}} d^3$
1	M_1				
2	M_2				

Calculations :

$m = \frac{34 \tan\theta}{2 \times 10^{-7}} d^3$

$M_1 = \frac{3.4 \times 10^{-5} \tan 45}{2 \times 10^{-7}}$

$(0.178)^3 = 1.7 \times 10^2 \times (0.178)^3$

$= 0.9985\ Am^2$

$M_2 = \frac{3.4 \times 10^{-5} \tan 45}{2 \times 10^{-7}}$

$(0.1662)^3 = 1.7 \times 10^2 \times (0.166)$

$= 0.7775\ Am^2$

Result :

1. Magnetic moment of Magnet 1 = ____________
2. Magnetic moment of Magnet 2 = ____________

Multiple-choice Questions

1. Magnetic pole strength of a short magnetic dipole of length 4 cm and magnetic moment 10 Am^2 is ……………
   0.125 Am b)2.5 Am c) 0.025Am d)1.25Am

Questions

1. Explain what is Tan A and Tan B position of Deflection magnetometer.

In tan A position the bar magnet is placed horizontal parallel to the arm of the deffected magnet to meter and parallel to the magnetic lines of the deflection magnet to metre

2. How will you measure the reading of θ in a deflection magnetometer if the pointer is adjusted to 90-90 instead of 0-0 while doing initial adjustment?

- deflaction magnis metre bar type is deffector is attention angler time bar electrometre eight rangle with little electrocd mangnet Destre turved to the centre.
- A big aluminium red is a readity set perpendicular to the terris the needle around measured in the decrease.

Remark and sign of teacher: ……………………………………