FIELD TRIP

TO

MAWMIHTHIED, SOHRA

EAST KHASI HILLS DISTRICT

MEGHALAYA

DATE: 1st APRIL 2023

SUBMITTED BY:

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We would like to express our deep and sincere gratitude to our principal, Dr. D.K.B Mukhim who granted us permission to go to this field trip.

Our deepest gratitude also goes to the Department of Physics and teachers for their utmost guidance and help. The teachers were the foundation bricks for this field trip in terms of guidance for students and understanding of the field area.

INTRODUCTION

On April 1st 2023, a field trip to Sohra, East Khasi Hills District, Meghalaya was organized by the "Physics Department" of Lady Keane College. The aim of this field trip is to reinforce experiential and contextual learning to the student with experience outside their everyday activities.

We assembled together in the college campus around 8am. We started our journey around 9:15 am and stop at Mylliem for breakfast and continued our journey, we then reached our destination around 11:15am.This was followed by touring the Prut Falls for a while and performed the experiment a little far from the falls in a suitable place under the guidance of our teachers. The outcome of the experiment is that we are able to determined the magnetic moment of a bar magnet(μ) and the value of horizontal component of the Earth's magnetic field(H) using vibration and deflection magnetometer.

Along the way we visited Lyngksiar Falls and Lynksiar Cave which is 16km away from them Prut Falls. Both the falls and cave were enchanting. On our way back home, we stop at Mylliem and had tea and snacks. Around 9:30pm we reached the college campus and departed to our own places.

The field trip has been a memorable excursion for us in the comprehension of enigmatic theoretical knowledge.

GEOMAGNETIC STUDY AT PRUT FALLS, SOHRA

Prut falls is located at Mawmihthied, Sohra at a latitude of $25^0$18'45'' N and longitude $91^0$41'35''E. To completely determine the magnetic field of the earth at a given place, three parameters are required. These parameters are called the magnetic elements of the earth which are listed below:

i. Magnetic declination
ii. Magnetic inclination
iii. Horizontal component of earth's magnetic field.

Magnetic declination

Magnetic declination of the earth or magnetic variation is the angle formed between the magnetic north of the compass and the true geographical north. The value of the declination changes with location and time.

The value of declination is
(i) Positive if the magnetic north is along the east side of the true north.
(ii) Negative if the magnetic north is along the west side of the true north.

Isogonic lines join points on the earth's surface which have a common declination value that is also constant. Agonic lines are lines along with the value of declination is zero.

How does magnetic declination vary?

The value of the magnetic declination depends on the place and time. This is because some locations may have more iron ore deposits which can strongly influence the earth's declination. It also depends on how much time has passed.

Methods to determine the magnetic declination of the earth

1) By direct measurement:- This method measures the declination at a particular location by directly referring to the celestial poles. The celestial poles are points in the sky around which stars resolve. These show the true north and south directions, the North star or star pole indicates the approximate position of the north celestial pole. A declinometer is used to find the value of the magnetic declination of the earth.

With a map:

A map is a way to get a rough estimate of local declination. The declination can be measured using an isogonic chart of the particular continent or the world. Isogonic lines will be illustrated in aeronautical and nautical charts with the help of an illustration, local declination can be found on large – scale local maps.

By a compass:

A compass embodies three varieties of bearings: true bearing, magnetic bearing and compass bearing.

These three values are related by the equations

$T = M + V$

$M = C + D$

$T = C + V + D$ (general relation for all the bearings)

where C is the compass bearing

M is the magnetic bearing
V is the magnetic variation
T is the true bearing
D is the compass deviation
The variation and deviation can be determined by
• If $V < 0$ and $D < 0$ then it is westerly variation and deviation.
• If $V > 0$ and $D > 0$ then it is easterly variation and deviation.

Magnetic inclination

Magnetic dip results from the tendency of a magnet to align itself with lines of the magnetic field. As the planet's magnetic field lines are not parallel to the surface, the northern end of a compass needle will point downward. That is in the northern hemisphere it is a positive dip or upward while in the southern hemisphere it is a negative dip. The range of dip is from -90 degrees at the North Magnetic Pole to +90 degrees at the South Magnetic Pole. The contour lines along which the dip measured at the planet's surface is equal are referred to as isoclinic lines. The points locus which is having a zero dip is known as the magnetic equator or aclinic line .

The dip angle which is also called magnetic dip or magnetic inclination is the angle made by our planet's magnetic field lines with the horizontal. The angle of dip generally varies from point to point at the surface of the earth and provides information about the movement of the earth's magnetic field.

The phenomenon is especially very important in aviation as it causes the compass of the airplane to give a erroneous readings during banked turns and air speed changes. The latter errors generally occur because the card of the compass tilts on its mount when under acceleration.

The needle compasses are often weighed during manufacture to compensate for magnetic dip so we can say that they will balance roughly horizontally. This balancing is usually said to be latitude-dependent.

Angle of dip, commonly known as magnetic dip, is the angle formed by the earth's magnetic field lines intersecting the horizontal, when the horizontal component and the vertical component of the earth's magnetic field are equal.

The angle of declination between the magnetic field and the horizontal is measured in the vertical plane aligned with magnetic north.

The compass needle is said to point to the magnetic north pole by a lot of people. This is not geographically true. The compass at the position points in the direction of the horizontal component of the earth's magnetic field. The geomagnetic field and dip graphics below show how the compass needle aligns with the Earth's magnetic field lines.

Magnetic declination is the angle formed by true north (the line leading to the geographical North Pole) and the compass direction of travel points (the horizontal component of the magnetic field). When using a map and compass, you must account for this declination. There are zones of compass unreliability as you near the magnetic north or south poles, where the compass begins to operate strangely and eventually becomes ineffective.

In addition to secular variations of the magnetic field, magnetic declination or Dip also undergoes more rapid variations due to interactions with the sun. The angle of dip is horizontal component of earth's magnetic field becomes zero.

Aim: Determination of angle of dip at a place by using dip circle.

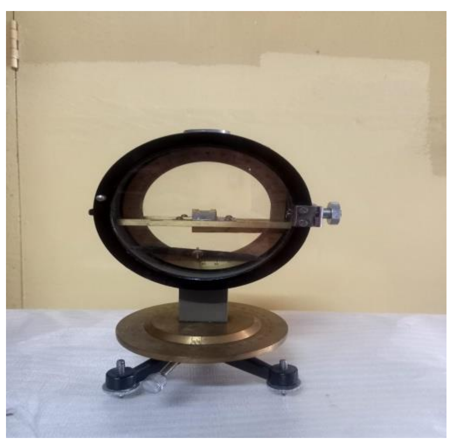


Fig 1: Dip Circle

Setting up the Dip circle: It consists of a long magnetic needle NS capable of rotation about a horizontal axis which passes (approximately) through the centre of gravity and at right angles to the length of the needle [Fig. 1]. The two ends of the axis rest on two agate knife-edges so that the needle may rotate with as little friction as possible. A vertical circular scale is fixed by the side of the needle and this scale is graduated in four quadrants from 0^{o} to 90^{o} so that (0^{o}-0^{o}) line is horizontal while (90^o-90^o) line is vertical. By this scale the positions of the two ends of the needle can be recorded. The whole structure, in which the needle NS and the vertical scale are fixed can be rotated about a vertical axis and this angle of rotation can be recorded by a vernier which moves with the structure on a horizontal scale marked on the base A and graduated from 0o to 360% There are three leveling screws underneath the base by which the base of the instrument can be leveled with the help of a spirit level fixed at the top of the base.

PROCEDURE

a. The base is made horizontal by the three leveling screws at the base and the spirit level.

b. The structure is rotated until the upper end of the needle just reads 90^o (this time lower end of the needle may not read 90^o). The reading of the base scale is noted.
c. The structure is again rotated a little to make the lower end of the needle just read 90o. The reading of the base scale is again noted.
d. The needle is now reversed in its bearings and again the operation (b) and (c) are repeated. Thus we get four readings of the base scale. Let the mean of these four readings be θ
e. The structure i.e. the vertical frame containing the needle is now rotated by 180o and the operations (b) to (d) are repeated, when we get another four readings of the base scale. Let the mean of these four readings be θ'. [This θ' will differ from θ by about 180o for the base scale is graduated from 0o to 360^o].
f. Hence if mean of θ and $\theta'$and be taken i.e. ϕo=$(\theta+\theta')/2$ be found out, then the reading $\phi°$ of the base scale will correspond to that position of the structure in which the vertical plane of rotation of the needle will coincide with magnetic meridian.

Measurement of dip

Procedure

a. One face of the needle (NS) is anyhow marked, after completing the former adjustment of setting the vertical plane of rotation of the needle, in the magnetic meridian. The marked face is directed towards east and the readings α_1 and α_2 corresponding to the two ends of the needle are noted from the vertical scale by the side of the needle.
b. The needle is reversed in its bearings and again reading α_3 and α_4 corresponding to the two ends of the needle are noted from the vertical scale. Thus we altogether get four readings and the mean of these four readings say α is found out.
c. The structure is now rotated by 180^0 and the operations (a) and (b) are repeated, when we get another four reading β_1, β_2, β_3, β_4.The mean of these four readings are noted. Let this mean reading be β. Then the mean of α and β be found out. Thus we get $\psi_1 = (\alpha+\beta)/2$. If the centre of gravity of the needle is not displaced along the axial line of the needle, then ψ_1 would be the dip at the given place.
d. To correct for any error arising out of the displacement of e.g. along the axial line of the needle, the needle should be demagnetized and again magnetized with the polarities reversed. The entire operations from (a) to (c) are to be repeated to get another set of

eight reading and let the mean of which be $\psi 2$. The correct value of dip at the given place would be, $\psi = (\psi_1 + \psi 2)/2$.

Experimental data:

TABLE 1: To bring the vertical plane of rotation of needle in the magnetic meridian

No. of obs		Needle reading	Main scale reading	Vernier scale reading	Total reading	Mean
1	Front	Upper 90° Lower 90◦	39 42	5×0.01 4×0.01	39.05 42.04	$\theta 1 = 43.79$
2	Reverse	Upper 90° Lower 90	45 49	5×0.01 4×0.01	45.05 49.04	
After rotation by 180°						
1	Front	Upper 90° Lower 90	227 224	4×0.01 4×0.01	227.04 224.04	$\theta 2 = 222.7$
2	Reverse	Upper 90° Lower 90	221 219	5×0.01 4×0.01	221.05 219.04	

Magnetic meridian (ϕ) = $\frac{43.79+222.7}{2}$

=133.29

Table 2: Measurement of angle of dip

No. of observation	Needle reading	Upper end	Lower end	Dip at a given place
1.	Front	41	41	41

Result: The dip at a given place is 41^0

Precautions

1. There should not be any friction at the bearing of the needle.
2. Leveling should be accurately made to make the box vertical so that the needle may rotate about the axis freely.
3. All magnetic substance should be removed from the working table.

Sources of error

1. There may be friction at the bearing of the needle.
2. Leveling may not be vertical.
3. Magnetic substance may be present in the vicinity of the working table

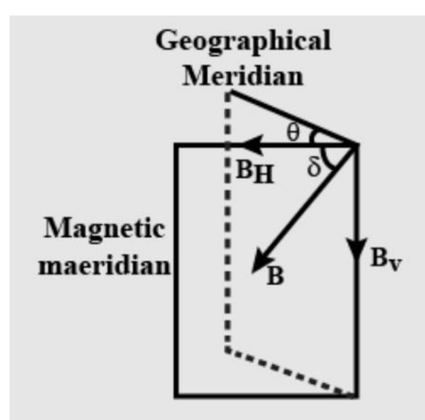
Horizontal component of earth's magnetic field

The shape of earth's magnetic field is approximately similar to the magnetized ball's field. Earth's magnetic poles drift slowly. Presently they are closed to geographic poles.

Earth's magnetic field is directed horizontally and vertically on magnetic poles. In other places of our planet, the vector of magnetic inductions is tilted concerning the vertical direction, i.e. it has both horizontal and vertical components. The direction of the horizontal component of the induction of earth's magnetic field is also called the direction of a magnetic meridian. The angle of inclination is the angle between the direction of the horizontal component of earth's magnetic induction and horizontal plane. The angle between geographic and magnetic meridians in the same place is called the angle of declination. The magnetic needle that can rotate around its vertical axis only turns in horizontal plane due to the horizontal component BH of earth's magnetic fields. This property of magnetic needle (compass needle) is exploited in a tangent galvanometer for measuring the horizontal component of Earth's magnetic field.

The angle of dip at a certain place where the horizontal and vertical component of the earth's magnetic field is 45^0.

The rotation of Earth on its axis causes these electric currents to form a magnetic field which extends around the planet. The magnetic field is extremely important to sustaining life on Earth. Without it, we would be exposed to high amount of radiation from the Sun and our atmosphere would be free to leak into space.



There are two components to explain the intensity of the earth's magnetic field.
1. Vertical component (v)
2. Horizontal component (H)

$$\tan\delta = \frac{B_v}{B_H}$$
$$\sin\delta = \frac{B_v}{B}$$

$$\cos\delta = \frac{B_H}{B}$$

$$\sin^2\delta + \cos^2\delta = \frac{B_H^2}{B^2} + \frac{B_v^2}{B^2}$$

$$1 = \frac{B_H^2}{B^2} + \frac{B_v^2}{B^2}$$

$$B = \sqrt{B_H^2 + B_v^2}$$

Aim: Determination of magnetic moment of a bar magnet (M) and the value of horizontal component of the earth's magnetic field (H) using deflection and vibration magnetometer

Apparatus: Bar magnet, vibration and deflection magnetometer, slide calipers, stopwatch, balance and weight box.

Theory: If a short bar magnet (of length 2l) is placed on a deflection magnetometer at the end on position at a distance r from the centre of a magnet (figure 1) and if M be the moment of the bar magnet and H be the horizontal component of the earth's field at the place, then from the theory of the magnetometer

$$\frac{M}{H} = \frac{(r^2 - l^2)^2}{2r} \times \tan\Theta \qquad \text{(i)}$$

Where Θ is the deflection of the needle from the magnetic meridian.

Again, if that bar magnet is suspended in a vibration magnetometer and then its time period of oscillation (T) is measured, then from the theory of oscillation in a vibration of magnetometer,

$$T = 2\pi\sqrt{\frac{I}{MH}} \qquad \text{(ii)}$$

Where I is the moment of inertia of the magnet about the axis of suspension

Fig 2: Deflection Magnetometer

Fig 3: Bar Magnets

Fig 4: Vibration Magnetometer

From (ii): $MH=4\pi^2\frac{I}{T^2}$ (iii)

From equation (i) and (iii),

$$M=\sqrt{MH \times \frac{M}{H}} \quad \text{(iv)}$$

And, $$H=\sqrt{MH \div \frac{M}{H}} \quad \text{(v)}$$

Measuring the quantities of equation (iv) and (v)

From the magnetometer and knowing the geometrical dimension of the magnet, the values of H and M can be obtained.

Procedure:

a. At first, the length (l') and breath (b') of the bar magnet are determined. The geometrical length being multiplied by 0.86 gives the magnetic length. Its mass is also determined by a balance (m). From its geometrical moment of inertia (I) is determined from the relation.

$$I =\frac{mass}{12}(\text{length}^2+\text{breadth}^2)$$

b. The magnetometer is then made horizontal and it is so set that its arms are at right angle to the magnetic meridian. At this position, the pointer will be parallel to the arms and will be read (0,0).
c. The bar magnet is next set on one of the arm at a contain distance from the center of the needle. Let the north pole of the magnet first point to the needle. This will cause a deflection of the needle. The magnet is place at such a distance that the deflection of the

needle is around 45°. The reading of the two ends of the pointer and the scale reading (r_1 and r_2) of the two ends of the bar magnet are noted.

d. The magnet is turned and the south pole is made to face the needle then, keeping the values of r_1 and r_2 the same as before. The pointer readings are then noted again.
e. The magnet is then turn upside down (rotated through 180°) and then process of (iii) and (iv) are repeated.
f. The entire operation of equation (iii) and (iv) are then repeated with the magnet being placed on the other arm of the magnetometer. The values of r_1 and r_2 must remain the same as before while setting the magnet in this operation.
g. Thus by placing the magnet on either arms of the magnetometer in all 16 values of the pointer readings are obtained, from which the mean value of deflection (ϴ) of the needle is obtained.
h. The values of the deflection (ϴ) of the needle, the distance of the centre of the magnet (r) from the centre of the needle and the magnetic length (l) of the magnet being thus known, the value of $\frac{M}{H}$ is obtained from the equation (i).
i. The experiment is repeated with all the steps by changing the value of r i.e. by changing the position of the magnet on the arms of the magnetometer. Two more sets of readings are to be taken and from each set of reading the value of $\frac{M}{H}$ is obtained. The mean value of $\frac{M}{H}$ is does obtained.
j. The magnet is not suspended in the vibration magnetometer. It is to be seen that the axis of suspension passes through the centre of the magnet and the axis of the magnet is parallel to the line L_1, L_2.
k. Another spare magnet or a magnetic substance is brought close to the suspended magnet which causes the suspension system to oscillate.By means of a stopwatch, the time taken for 30 oscillations are noted, from which the time period (T) of the oscillation of the magnet is determined.
l. Substituting the values of I and T in equation (iii), the value of MH is obtained.
m. Finally, knowing the values of $\frac{M}{H}$, and MH the values of M and H are obtained individually from equation (iv) and (v).

OBSERVATION

TABLE 3: Determination of the moment of inertia of the magnet

Mass of bar magnet (in gms) m	Length of the magnet (in cm) l´	Mean length l' (in cm) l'	Breadth of the magnet b' (in cm)	Mean breadth b' (in cm)	Magnetic length 2l=l'x0.86 cm	Moment of inertia of the magnet I=m(l'^{2}+b'^{2})/12 gm cm^2
46.650	7.51 7.50 7.51	7.51	1.21 1.20 1.21	1.206	6.4551	224.67573

TABLE 4: Determination of time period (T) of oscillation of the magnet for finding MH

Nos. of observation	For the magnet, time for		Time period of the magnet T=t/30	Moment of inertia of the magnet (gm cm^2)	$MH = \frac{4\pi^2 I}{T2}$ (dyne cm)
	30 oscillation (in seconds)	Mean time t (in seconds)			
1 2	75 77	76	2.53	224.68	1,383.88

TABLE 5: Measurement of the deflection of the magnetometer and to find M/H

Number of observation	Position of the bar magnet		Mean	State of the magnet	Deflection of the needle in degree								deflection of the needle (S)
	End 1 (r_1) cm	End 2 (r_2) cm	$r = \frac{r_1+r_2}{2}$		Right arms				Left arms				
					South pole facing		North pole facing		South pole facing		North pole facing		
					End1	End2	End1	End2	End1	End2	End1	End2	
1	10	17.5	13.75	Face Up	87	90	78	76	85	84	88	85	84.375
				Face Down	87	90	79	77	85	84	90	85	
2	14	21.5	17.75	Face Up	80	82	80	78	85	82	84	87	82.3125
				Face Down	80	83	80	78	86	82	84	86	

Table 6: Determination of H

No. of observations	Position of the bar magnet, r (cm)	Deflection of the needle(°)	M/H $(dyne\ cm)$	M/H $(dyne\ cm)$
1	13.75	84.37	8006.97	9008.04
2	17.75	82.31	10009.11	

PRECAUTIONS

a. All magnets and magnetic materials should be removed from the vicinity of the magnetometer, otherwise, the Earth's field maybe distorted due to their presence.
b. The value of "r" should not be small and the value of "θ" should always be around 45^0.
c. The axis of the deflecting magnet and the needle must be at the same horizontal plane.
d. During oscillation of the vibration magnetometer, the amplitude should be small (less than 10^0).
e. The bar magnet should not be small.

SOURCE OF ERROR

a. All magnets and magnetic materials may not be removed from the vicinity of the magnetometer.
b. The value of "r" may be large and the value of "θ" may not be around 45^0.
c. The axis of the deflecting magnet and the needle may not be at the same horizontal plane.
d. During oscillation of the vibration magnetometer, the amplitude maybe large.
e. The bar magnet maybe large.

Conclusion: The magnetic declination in the vicinity of Prut falls is , angle of dip is 41^0 and the horizontal component is 0.355 oersted.