Earth's Magnetic Field Pre-Lab Work

The objective is to measure the Earth's magnetic field using a tangent galvanometer and a dip needle.

The Earth's magnetic field can crudely be represented as being generated by a large bar magnet located at the center of the Earth. The south pole of this magnet points generally towards the geographic north pole – hence the north pole of a compass needle is attracted to it and points north. Geomagnetic North is off from the Earth's Geographic North by approximately 11 degrees.

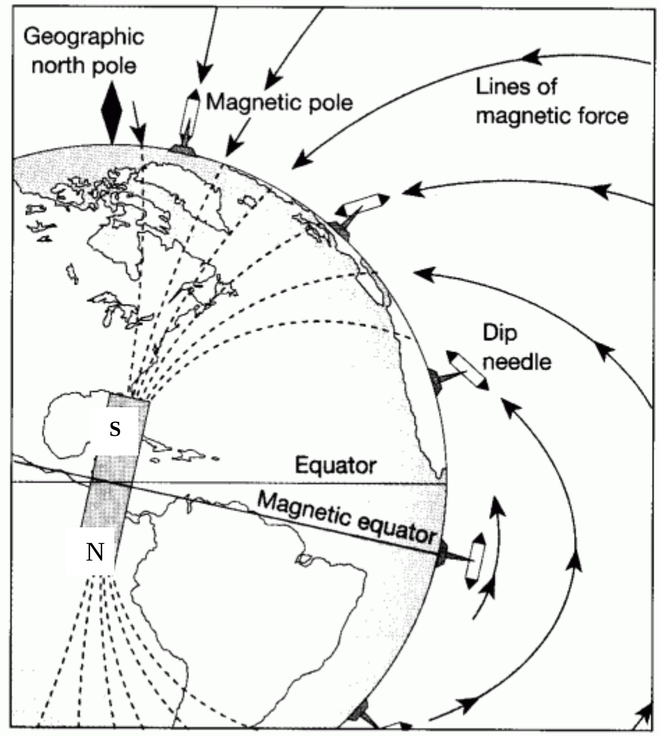
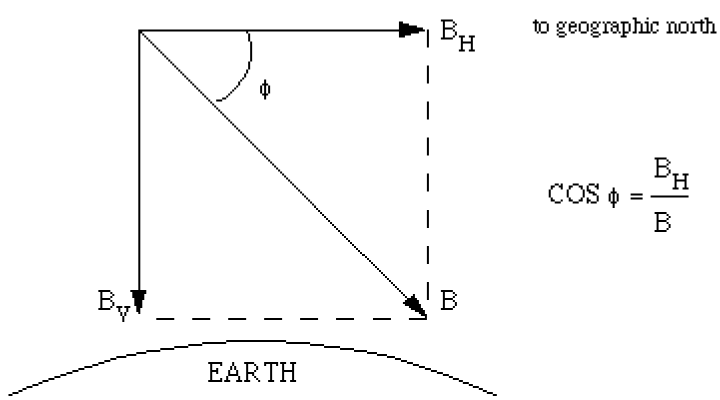


FIGURE 18.9
The earth's magnetic field causes a dip needle (compass oriented in a vertical plane) to align with the lines of magnetic force. The dip angle decreases uniformly from 90 degrees at the magnetic poles to 0 degrees at the magnetic equator.

The magnitude of the Earth's magnetic field is different in different places. It is so irregular that it must be measured in many places to get a satisfactory picture of its distribution. Magnetic inclination (dip angle, ϕ, is shown) is the angle between the horizontal plane and the total field vector, measured positive into Earth.

At the magnetic poles, a dip needle stands vertical (dip=90 degrees), the horizontal intensity is zero, and a compass does not show direction. At the north magnetic pole, the north end of the dip needle is down; at the south magnetic pole, the north end is up. At the magnetic equator the dip or inclination is zero.

The strength of the magnetic field is strongest near the poles and weakest near the equator. The **Earth's magnetic field intensity is roughly between 25,000 - 65,000 nT**. The parameters describing the direction of the magnetic field are declination (D) and inclination (I). Magnetic declination is the angle between magnetic north and geographic north. D and I are measured in **units of degrees, positive east for D and positive down for I**. The intensity of the total field (F) is described by the horizontal component (H), vertical component (Z), and the north (X) and east (Y) components of the horizontal intensity. The intensity of the total field **B** can also be described by the horizontal component B_H , a vertical component B_V, and the dip angle, ϕ, as shown.



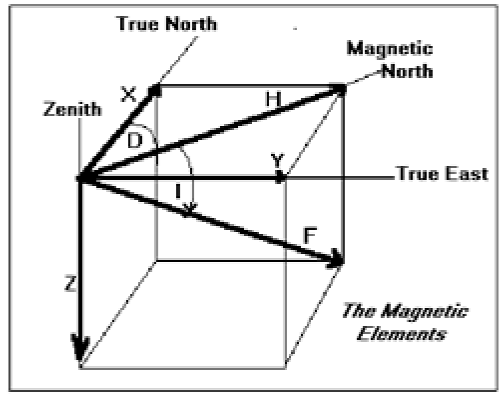
The relationships between the components are:

$$B_H = \sqrt{X^2 + Y^2}, \quad B = \sqrt{B_H^2 + B_V^2}, \quad \cos\phi = \frac{B_H}{B}$$

Unlike the Earth's geographic equator, the magnetic equator is not fixed, but slowly changes. There is evidence that the Earth's magnetic field is becoming weaker at an accelerating rate. There is also evidence that the poles flip.

Prelab: Due at the start of Lab! Print Name:______________________________

1. Find the Earth’s magnetic field from this NOAA magnetic field calculator.
http://www.ngdc.noaa.gov/geomag-web/#igrfwmm
Use zip code (95404) first to generate the latitude and longitude. Use an elevation (.05 m) for SRJC.



Record the values for the **B (**given as F), B_H (given as H, and its components X(+N) and Y(+E)) and B_V (given as Z(+D). View your results in list format. Put your results in the table below. The inclination I is dip angle, ϕ,

$$B_H = \sqrt{X^2 + Y^2}, \quad B = \sqrt{B_H^2 + B_V^2}, \quad \cos\phi = \frac{B_H}{B}$$

D (deg)	I (deg)	H (nt)	X (nt)	Y (nt)	Z (nt)	F (nt)

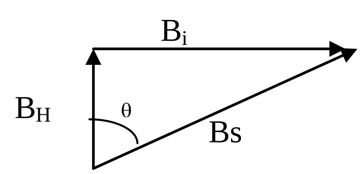
Answer the following:

a) What is the dip angle in degrees and minutes? ______________________

b) What component of the B field is strongest at SRJC? ____________________

c) Calculate the ‘true values’ of B_H, B_V and B from the above equations. Show your work and put your results in the table below.

2. We will be using a clever device to measure the Earth’s Magnetic Field. We will use a tangent galvanometer which consists of circular loop to produce an external magnetic field. By placing a compass in the loop, the needle will be deflected by the external field produced by the loop, as shown. If the horizontal component of the magnetic field of the earth is B_H and the external magnetic field (generated by the loop) is Bi, the magnetic needle of a compass will be directed toward B_S (the total magnetic field due to B_H and B_i), as shown in the vector diagram. By measuring θ and calculating the value of Bi from: $Bi = \mu_0 NI/(2R)$ one can measure the horizontal component of the Earth’s local magnetic field.



<u>Solve this problem:</u>

A 0.50A current flows through a circular loop with radius of 10 cm and 15 loops.
a) Find the Magnetic field produced by the circular loop. Show your calculation.
b) The magnetic field produced by the circular loop is perpendicular to the horizontal component of the earth’s magnetic field and it deflects a compass needle 63 degrees from its neutral position. What is the value of the horizontal component of the Earth’s magnetic field? How does this compare with the value given by NOAA? What is the percent difference? Show your calculations.
c) Your dip needle gives you an inclination angle of 71.0 degrees. Calculate the total magnetic field of the Earth. What is your percent difference with NOAA? Show your calculations. Put your results in the table below.

Quantity	Measured Value	NOAA Value	% Difference
B_H (nT)			
Inclination (degree)			
Bv (nT)			
B (nT)			