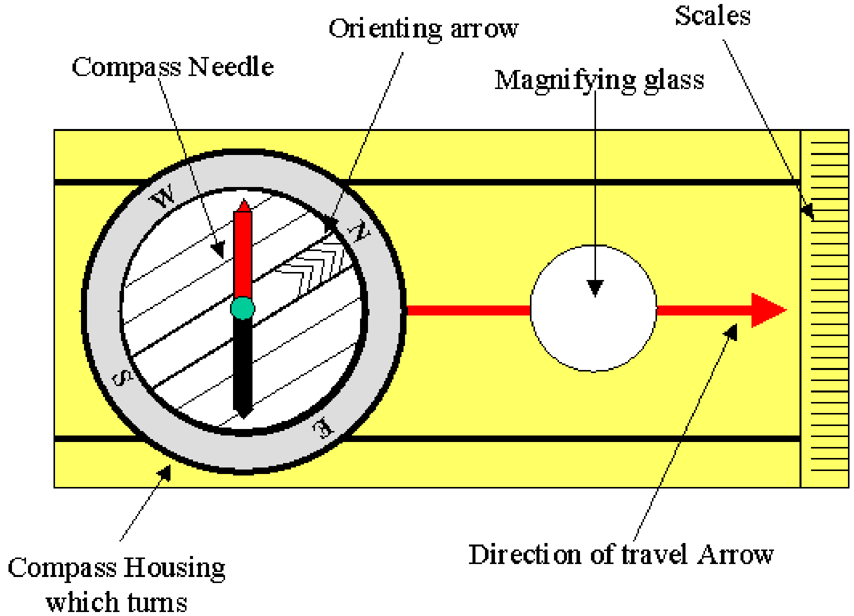
Student Name ______________________________ ***Date*** ________

Navigating the Earth with a Compass



A compass, like the one sketched above, is one of the oldest pieces of human technology that is based on measuring something 'invisible' – Earth's magnetic field. Navigators have used compasses for centuries, and learned quite a lot about how they work and what Earth's magnetic field looks like. This activity will get you acquainted with Earth's magnetism in a very direct way. Your teacher will review with you the basic use of a compass. Use the above figure of a typical compass to "get your bearings."

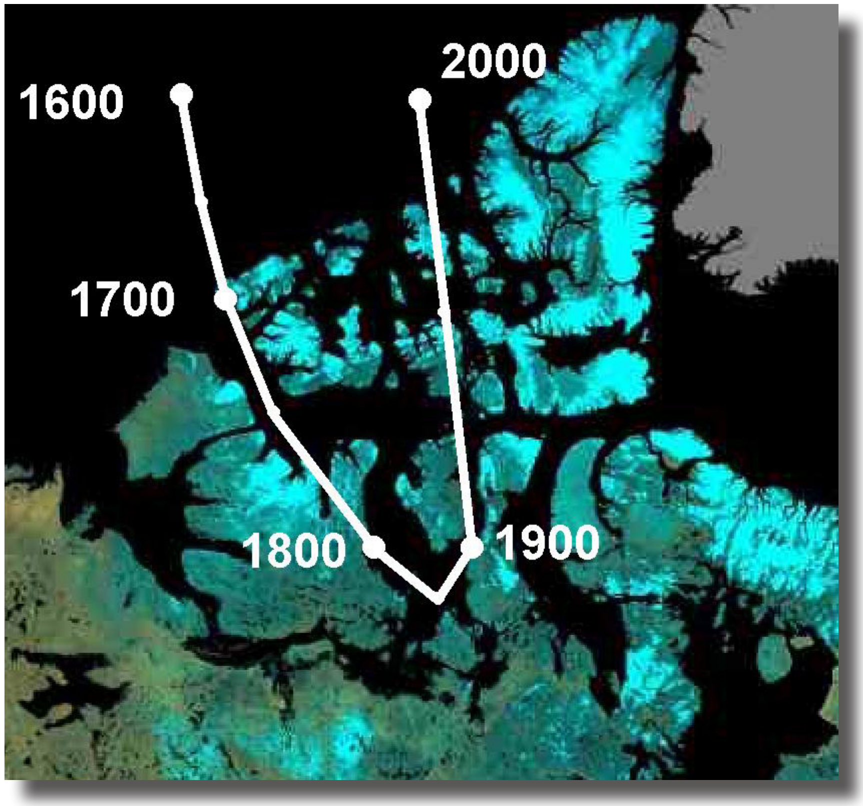
Part A: In your school yard, and without letting anyone see you, take a bearing on a particular object (tree, building, car, etc.) located a few hundred yards away. Note the bearing in "degrees," and write the answer in the box below:

Hand this paper to your classmate and have them stand in the same spot you did, and use the bearing to figure out the object at which you were looking. Don't make it easy for them by selecting an isolated object!

Part B: During a "magnetic storm," bearings can suddenly change by up to 5 degrees. Work with a partner to develop a way to determine if a magnetic storm is occuring by using a compass. Write up your idea. Test it over several days by comparing your results with the magnetic storm dial on the following website: http://sprg.ssl.berkeley.edu/dst_index/. Write up a description of whether or not your idea worked.

Student Name ______________________________ ***Date*** ________

Geomagnetism I: Polar Wander



The Earth rotates around an axis through its center. This axis passes through the surface at the North and South Geographic Poles. The magnetic North and South poles are not the same as the geographic poles. In fact, the magnetic poles change in strength and move over time. The curve in the figure above gives the location of Earth's magnetic pole in the Northern Hemisphere as it has moved during the last 400 years! The scale of the above plot is approximately 1 centimeter represents 163 km.

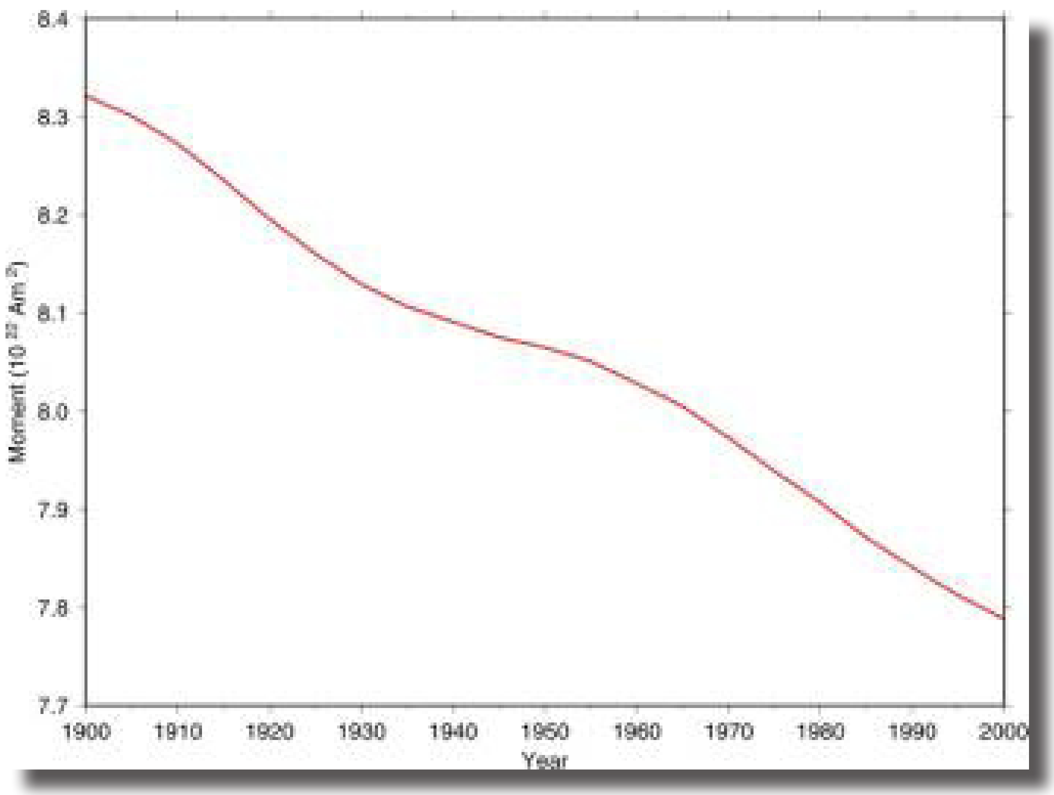
1) What is the total distance that the magnetic pole wandered from 1600 AD to 2000 AD?

2) What is the average speed of the wander from 1600 AD to 2000 AD?

Inquiry Problem: The probability of seeing an aurora is highest in a circular belt centered on the Magnetic Pole, with a radius of 800 km. Explore how the viewing of aurora will change over the next 100 years, at the present rate of polar wander.

Student Name _______________________ ***Date*** ________

The Declining Magnetic Field



Earth's magnetic field is declining in strength. Some scientists think that it may actually vanish in the near future, and be replaced by a growing magnetic field with an opposite magnetic polarity – a phenomenon called a Magnetic Reversal. The above graph shows the measured strength of Earth's magnetic field since 1900, measured in multiples of 10^{22} Ampere x meters^{2}.

Question 1 – By how much has the field changed in intensity between 1900 and 2000?

Question 2 – What has been the rate of this change per year, in terms of its percentage change per year?

Question 3 – Based on your answer to Question 2, how many years from now will it take for the field to decrease to zero strength?

Question 4 – What will be the year when the field reaches zero strength?

Inquiry Problem – What effects do you think will happen when Earth's magnetic field vanishes temporarily for a few decades or centuries? Support your conjecture with evidence from relevant information sources.

Student Name ______________________________ **Date** ________

Geomagnetism II: Magnetic Reversals

Geologists have measured the strength of Earth's magnetic field going back thousands of years. They do this by measuring its fossil traces left in the rock deposits around the world whose ages can be accurately dated. These measurements are shown in the table below. The units used to represent the magnetic dipole strength in the table below are 10^{22} Ampere x meters^2. Today's strength (Time = 0.0) has a value of 8.0 x 10^{22} Ampere x meters^2 on the vertical scale. The "Time" columns indicate how many thousands of years *before* the present time that the field was at the indicated strength. For example, the first table entry '20' means 20,000 years ago, at which time the strength was 12.0 x 10^{22} Ampere x meters^2.

Create a graph of Time (in years) versus Magnetic Field Strength using the table below. Remember to mark your x- and y-axis with labels and units.

Time	Strength	Time	Strength	Time	Strength	Time	Strength
0	8.0	220	5.7	440	6.3	660	7.0
20	12.0	240	6.5	460	7.0	680	3.5
40	3.2	260	4.5	480	6.0	700	5.0
60	5.0	280	5.0	500	5.7	720	5.5
80	6.6	300	6.0	520	4.6	740	8.2
100	3.8	320	5.8	540	3.8	760	6.5
120	4.3	340	6.4	560	4.2	780	0.5
140	6.5	360	8.5	580	4.7	800	3.4
160	6.3	380	5.0	600	6.0		
180	2.2	400	7.5	620	5.5		
200	6.0	420	8.4	640	8.5		

From the tabulated entries above, answer the following questions:

1. What is the range of the magnetic field strength?
2. What is the average value of the magnetic field strength?
3. How many times has the magnetic strength dipped below 1/2 of its current value of 12.0 x 10^{22} Ampere x meters^2 ?
4. When was the last time that the magnetic field strength reached 1/3 of its current level?
5. When was the last time the magnetic strength was close to zero?
6. When did the fastest change in the magnetic field strength occur in the last 800,000 years?

Inquiry Problem: Do you think the magnetic field strength will actually reach zero? Using the plotted data, explain your reasoning.