

Problem 1) A car travels along a path such that its speed is 30 miles per hour north and 25 miles per hour west. What is the total speed of the car along its actual path?

Problem 2) A jet plane takes off from O'Hare International Airport in Chicago. It is headed in a direction due West with a speed of 550 miles per hour. There is a wind blowing from the south to the north at a speed of 150 miles per hour.

A) Use vector addition to diagram the two vectors and calculate the resultant vector, which is the jets speed relative to the ground.

B) What is the direction of the jet's velocity vector relative to the ground?

Problem 3) On a piece of paper, iron filings are sprinkled to reveal the magnetic field of a bar magnet. At a particular point on the paper, the magnetic field vector is given by:

$$\mathbf{B1} = -15 \text{ gauss } \mathbf{X} + 10 \text{ gauss } \mathbf{Y}$$

On a second piece of paper, the iron filings from a second magnet are revealed using iron filings. At the same point on the paper as for the first magnet, a measurement is made of the magnetic field vector and it is given by

$$\mathbf{B2} = 26 \text{ gauss } \mathbf{X} - 5 \text{ gauss } \mathbf{Y}$$

A) If both magnets were placed under a third piece of paper at the same location, and iron filings were sprinkled on the paper, what would be net sum of the two magnetic fields at the point used in the first two papers?

B) What would be the difference in magnetic field strengths between the two magnets at the measurement point?

C) Which bar magnet has the strongest magnetic field?

3-Dimensional Vector Addition

1. Take a strip of paper 1-inch wide and cut it to a length of 12 inches.
2. Using the ruler, mark 11 black lines one inch apart along the length of the strip. Flip the strip of paper over and copy these lines on this other side of the strip so that if the paper were transparent, the lines would overlap.
3. With the blue marker mark the first 3 lines with the letter 'X', color blue the edge of the paper with the marks, and put half of an arrow head pointing at the third line. This represents the **x** vector.
4. With the red marker, mark the next 5 lines with the letter 'Y', color red the edge of the paper with these marks, and put half of an arrow head pointing at the last of the 5 lines. This represents the **y** vector.
5. With the black marker, mark the final 4 lines with the letter 'Z', color black the edge of the paper with these marks, and put half of an arrow head pointing at the last line. This represents the **z** vector.
6. Repeat this on the back side of the strip making sure that the X's, Y's and Z' match up on both sides as if the paper were transparent.
7. At the first 3rd line where the blue arrow head points, fold the strip into a right-angle such that the red edge of the paper lines up with the 3rd line.
8. At the end of the next 5 lines, where the red arrow head points, fold the strip into a right-angle such that the paper is folded "down" at the red arrow head and the black arrow is pointing out of the plane of the other two vectors using the right-hand rule (x=pointer finger, y=middle finger, z=thumb).
9. With a second strip of paper 1-inch wide, connect the beginning of the folded strip and the end of the folded strip and trim the second strip so that it exactly meets each end. Draw a large arrow along the second strip between the beginning of the blue vector and the end of the black vector (arrow head).
10. Use the compass to orient the x, y, and z vectors so that x is pointing towards magnetic north, y towards magnetic east, and z down.

Answer the following questions:

1. Explain what this procedure represents in terms of vectors.
2. What is the final resultant vector's value in inches? List two ways of determining its value.
3. What does this vector represent?
4. Repeat this procedure for $x=3.5$ in, $y=1$ in, and $z=7.5$ in. What is the final vector's value?

Student's Name _____ Date _____

A model of the THEMIS magnetometers XYZ vector coordinates

Goal: Make a visual representation of Earth's magnetic field.

1 – You should either use the x, y, z magnetometer plot your teacher handed out, or go to the THEMIS school data page and pick the school closest to yours:

http://ds9.ssl.berkeley.edu/themis/classroom_geons_data.html

Look at a x, y, z, 24-hour magnetometer data plot from that school's location. Choose either the real-time data or the archived data depending on the quality of the data. You want to find data closest to a straight line as you can (there never be a completely straight line).

2 – Guess the average magnetic field values (B) for the 24 hours in each of the x, y, z plots by reading off the middle-range values over the 24-hours of the magnetometer data for x, y, z (Bx, By, Bz). In the next activity you will do this more precisely. Write down your values here, remembering units.

Bx = ----- By = ----- Bz = -----

3 – With the materials given to you by your teacher, work with a partner to come up with a way to make a 3-D model of the total magnetic field vector in the magnetometer school's location. Orient your model to the magnetic x, y, and z coordinate system. You will show the class your model and explain your model and the procedure you used to make it. Keep notes as you work through your ideas.

Answer the following questions:

1. Explain how your model shows the resultant magnetic field vector from the data.
2. What does it mean if By is negative?
3. What is the main direction of the magnetic field at the school's location where the magnetometer is buried?
4. Add the Bx and By vectors. The magnitude of this resultant vector is the value of the H-vector in the HDZ Compass Coordinate system on the HDZ plots for the school location you chose. Does your calculation or model give the same magnetic field magnitude for H for this days data?

How strong does a magnetic storm have to be before it is detectable with a simple soda bottle magnetometer?

Basic Idea:

During a magnetic storm of severity $K_p = 8$ or 9 , the Themis data display will show large changes in the magnetic D-component. This means that, if you had a sensitive compass, you would see your magnetic bearing change by the number of degrees indicated by the THEMIS D-component display. The soda bottle magnetometer works like a compass and directly shows the change in the magnetic bearing as the reflected spot of light from the magnetic sensor card swings away from its normal quiet-time position. Depending on the severity of the magnetic storm, this deflection can amount to several centimeters or more if you are careful to set up the magnetometer correctly in an undisturbed environment.

1 - Wait for a strong magnetic deflection in the D-component on the THEMIS display, and simultaneously look for a large deviation in the light spot position on the soda bottle magnetometer.

2 - In a table, note the magnitude of the D-component deflection on the THEMIS display, and in a separate column, the number of centimeters of a soda bottle magnetometer deflection of the light spot. (Use the accompanying blank table) Provide table, and make additional copies as needed. Even better, enter the data into a Microsoft EXCEL spreadsheet!)

3 - Try to include the time of maximum D-component deviation, and include in your table the severity of this magnetic storm in terms of the K_p and Dst indices, which you can find at:

K_p today = http://www.sec.noaa.gov/rt_plots/kp_3d.html

Dst today = <http://swdcd.db.kugi.kyoto-u.ac.jp/dst/dir/dst1/q/Dstqthism.html>

4 - Correlate the K_p and Dst values for magnetic storms with the THEMIS D-component and soda bottle deflections to 'calibrate' your observations. How many degrees of soda bottle deflection equal one degree as measured by the D-component? (Hint: Draw a graph with the D-component on the vertical and soda bottle deflection on the horizontal axis and find the slope of the line through the data.)

Soda Bottle Magnetometer Data Table for

Month _____ Year _____

Sample	Day	Local Time	UT	Deflection (cm)	Degrees	THEMIS 'D' Component
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						

The A index is determined by the maximum strength of the X component minus the minimum strength of the X component for a three hour time period. ($X_{\max} - X_{\min}$). For our Activity we will determine the Max-Min strength for a 24 hour time period. Thus, in a sense, your reading will be similar to an A index average. Using the following table we can convert the A- index component strength difference directly to a K index.

Table of Conversion for Boulder magnetometer

The K-index is related to the maximum fluctuations of horizontal components observed on a magnetometer relative to a quiet day

Procedure:

Finding the A-index

1 - Print off a days-worth of XYZ data from a THEMIS magnetometer site as close to your school as possible. To do this, visit the THEMIS education data website: http://ds9.ssl.berkeley.edu/themis/classroom_geons_data.html

From here you can either choose real-time data, that means data that is being taken and plotted right now. Or you can choose archived data - data from a previous day. To use the real-time data, find the "Site-Specific GEONS Real-Time Data" and click on the link under "24-hour Plots" for the station closest to your school. A map indicating the location of these magnetometer sites can be found at the bottom of this web page. Three plots will come up. You can click on them to make a larger version and then if you right click (PC), <CTRL>-click (Mac) you can save the images on your computer and print from your computer.

To use the archived data, go to "GEONS Archive Data" and click on "archive data page." Here, you will fill out a form. On the left side of the form, click on the "Day Plot" button. Click on the "Start Date/Time" button and then choose the date you want to look at. Note that the time for a "Day Plot" is not important since all day plots go from 12 midnight UT to 11:59pm UT. On the right side of the form, choose the School town you want and then click on the "XYZ" button. Then click on "Start Mag Search." If data is not available for the date you chose, try another date until you find some data. Once you have selected the XYZ data you want to work with, either print the plot from the web site or save the image to your computer and print from your computer.

Continued on next page

2 - Using a clear metric ruler 15 mm length, place the ruler horizontally across the X-scale of the graph.

3 - Using a sharp pencil select the highest reading of the X component that does not look like a human made signal. To check if it is a human-made signal, compare with neighboring magnetometers to see if other magnetometers have the same signal. If they do, it is most likely NOT a human made signal and it can be used as the highest reading of the X-component scale. Place a horizontal line across the x-component plot that touches this highest reading.

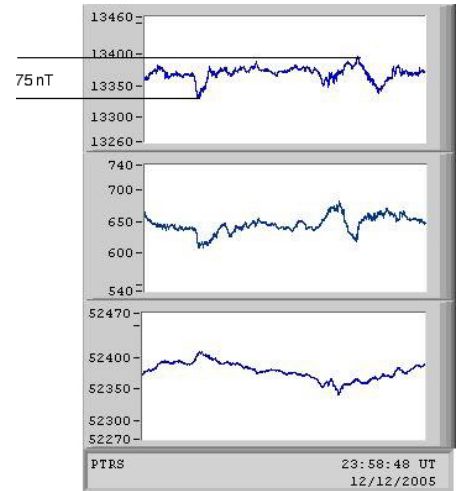
4 - Repeat 3, but for the lowest x-component reading. At this point, your x-component plot will have two horizontal lines, one touching the maximum x-component reading and one touching the minimum x-component reading.

5 - Using the metric ruler, measure the distance between the two horizontal lines. Then use the ruler to determine the scale of mm to nT on your x-component plot (for example 1 mm = 5 nT). Using this scale determine the difference in nT from the maximum x-component reading to the minimum x-component reading in nT. We call this "nT diff." See the plot on this page as an example.

K-Conversion:

6 - Now that you have "nT diff." you can use the conversion table on this page to obtain an approximate K-index value. This is the strength of the magnetic storm on your magnetometer.

7 - Compare this information to the Kp index (http://www.sec.noaa.gov/rt_plots/kp_3d.html) Try to predict the possibility of the people in the town where the magnetometer is located of seeing an aurora display on the night of the data you choose.



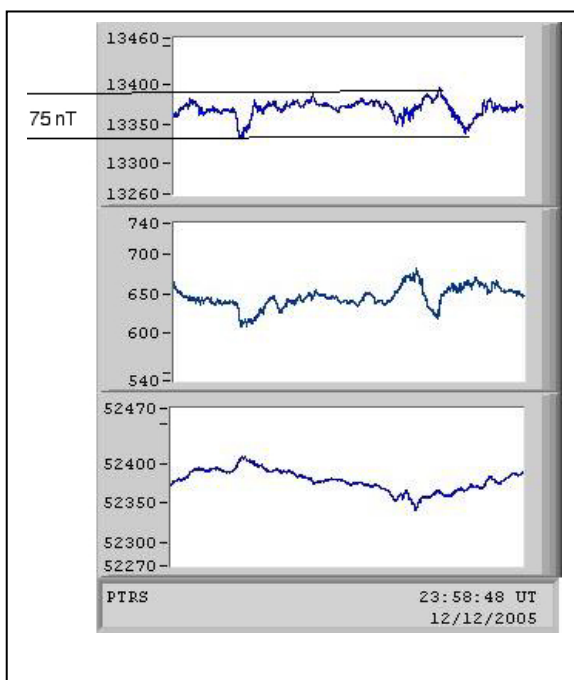
K index	nT diff.
0	0-5
1	5-10
2	10-20
3	20-40
4	40-70
5	70-120
6	120-200
7	200-330
8	330-500
9	>500

Data collection procedure:

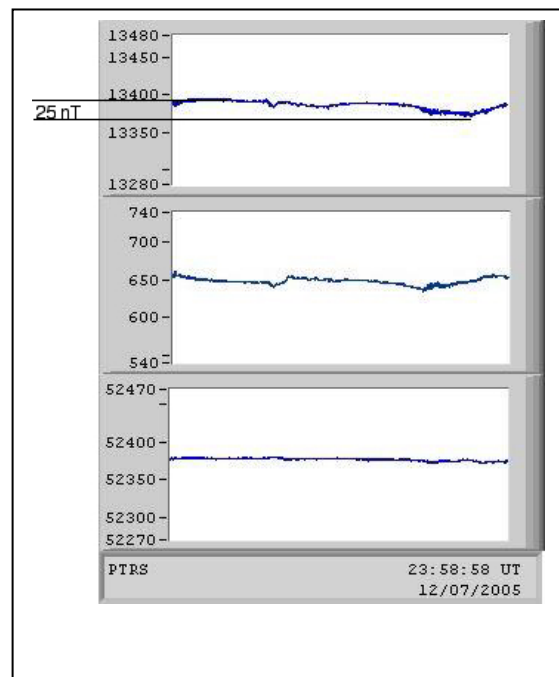
1. Make paper copies of the XYZ plots archived by THEMIS at:
<http://sprg.ssl.berkeley.edu/themis/GEONS> (use 24 hour plot options)
2. Determine a maximum, minimum nT difference for the X component from what you would consider a quiet day. It may help to do **Activity 18** first to determine a quiet day for your data. Remember you want to determine the undisturbed magnetic field strength for your area.

A quiet day for Petersburg AK was determined to be less than 50 nT difference.

A quiet day for Loysburg PA was determined to be less than 30 nT difference.



An active day **12/12/05 Petersburg AK** shows a greater than 50 nT difference between X max and X min



An quiet day **12/07/05 Petersburg AK** shows a less than 50 nT difference between X max and X min

Data Reduction Suggestions:

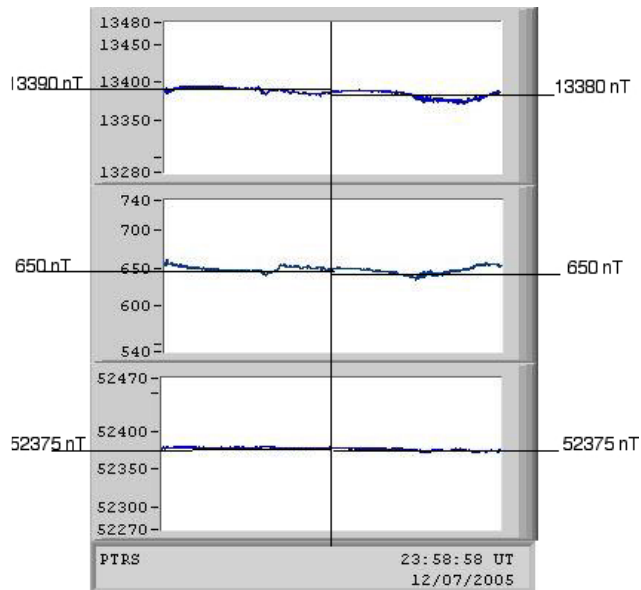
Divide each quiet day X, Y, Z, plot into half days.

1. Using a clear metric ruler, visually determine the average nT for each half day for each X, Y, Z plot. The scale is 1mm = 5 nT, unless you resize the plots.
2. Determine the average of the two half days and then take the average for each day for X,Y,Z, plots.

$$\begin{aligned} \text{X avg for the day} &= \\ 13390\text{nT} + 13380\text{ nT} / 2 &= \\ \mathbf{13385\text{ nT}} \end{aligned}$$

$$\begin{aligned} \text{Y avg for the day} &= \\ 650\text{ nT} + 650\text{ nT} / 2 &= \\ \mathbf{650\text{ nT}} \end{aligned}$$

$$\begin{aligned} \text{Z avg for the day} &= \\ 52375\text{ nT} + 52375\text{ nT} / 2 &= \\ \mathbf{52375\text{ nT}} \end{aligned}$$



3. Set up a spread sheet with a column for Date, X,Y,Z.
4. Using the spread sheet functions calculate B from the Pythagorean formula in the Teacher's Guide for this activity.

See the two tables that follow as examples.

Student's Name _____ Date _____

By comparing Planetary Kp indices with the local magnetometer spectrogram plots, you will answer the question: "Can local spectrogram plots be used to determine the global magnetic storminess?"

- 1) Go to: http://ds9.ssl.berkeley.edu/themis/classroom_geons_data.html
- 2) Read about the spectrogram plots.
- 3) Find the link to the archive data page and click on it
- 4) Fill in the form to find the 24-hour spectrogram plot for Ukiah, OR for Jan. 1, 2007. Keep this window open on a computer.
- 5) Go to http://ds9.ssl.berkeley.edu/themis/classroom_kp2007.html
- 6) Look at each plot of Kp indices and compare each day of indices with the 24-hour spectrogram from Ukiah, OR in January 2007, starting with Jan. 1 (see step 4). Make a table with 3 columns for: 1) the date, 2) the maximum Kp index, 3) a description of the amount of yellow, orange and red on each spectrogram for each day (note that a gradation from green (top, higher frequencies) to blue (bottom, lower frequencies) are background colors and mean there is no magnetic signature), and 4) if there was a "human-activity" signature for that day. Highlight the rows of days with red on the spectrograms.
- 7) Using the table you created in step 6, answer the following questions:
 - a) What days may have signatures made from human-interactions around the magnetometer?
 - b) What days had one or more 3-hour period of Kp=4 or greater?
 - c) Of the days with Kp=4 or greater, how many had red areas on the spectrogram?
 - d) What days had at least one 3-hr interval of Kp<4 with a spectrogram which had red on it and what were the kp-indices for these days?
 - e) What was special about the days with red on the spectrogram and a Maximum Kp of 3 or less associated?
 - f) Which day had the most red and what was the maximum Kp index for that day?
 - g) What days had no color besides the background color of the spectrogram and maybe a human-made signature and what was the maximum Kp index?
 - h) Why might the spectrogram continue to show red after a magnetic storm has subsided?
- 8) Look at the real-time spectrogram (the one made today) and from your previous research, guess the range of values of the Kp index. Write that down here:
- 9) Go to: http://www.sec.noaa.gov/rt_plots/kp_3d.html. Look up the Kp indices for today to see if your guess was correct. Explain if it was or not and whether you think local spectrograms can be used as an indication for global magnetic storminess.