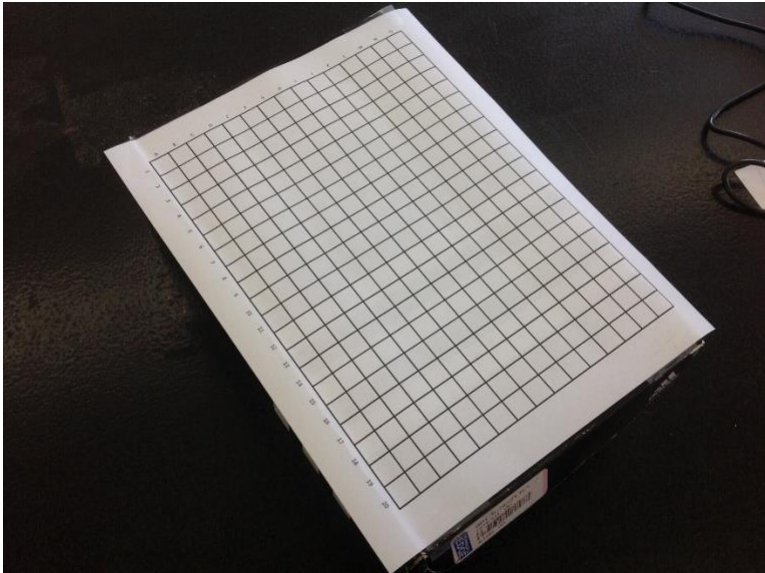


## Getting MAD about Magnetics

- Tape the magnets onto the bottom of the shoe box and close the lid

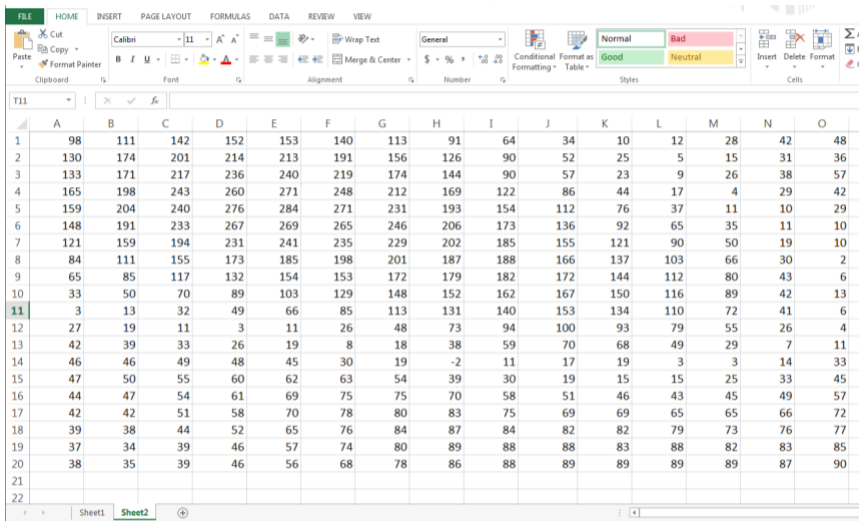


- Tape the graph paper onto the top of the shoe box

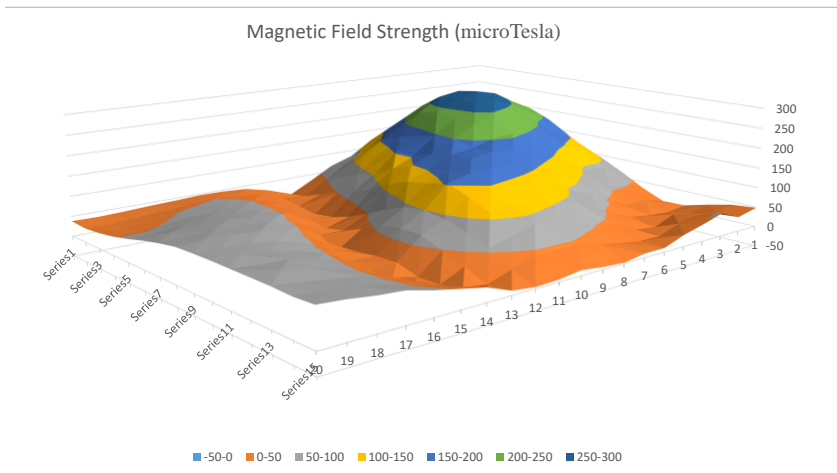


- Download PhyPhox from the App Store or Play Store to your smartphone
- Open the PhyPhox app and under Raw Sensors select *Magnetometer*
- Select ABSOLUTE at the top and click play button to begin measuring
- Magnetic sensor position varies from smartphone to smartphone so for consistency place the top left corner of the phone in each square and record the value in that square.
- Enter the data into an Excel spreadsheet

Example:



- From the Insert menu select a 3D surface plot
- Right click on the chart to bring up various formatting and viewing options



Notes:

- Be sure to gather data away from any sources of electromagnetic interference
- One, two, three, or more magnets can be used
- Instead of magnets of varying strength, identical magnets can be used – a much more predictable/regular plot is generated
- Recording 300 values is time consuming – use only part of the graph paper for a shorter activity
- For a much shorter activity, use either dataset here:  
<https://docs.google.com/spreadsheet/ccc?key=0AgePBM0TJqRSdFI0cGVoU21oZnZyU0xRY3otSXJtV2c&usp=sharing>

**Questions:** (Do not open the box ... yet.)

1. Where is the magnetic field the strongest on your plot?
2. Where is the magnetic field the weakest on your plot?
3. Sketch where you think magnets are located inside the box.  
Open the box and see if your sketch matches.
4. A magnetic field twice as strong would produce a "hill" how many times as tall?
5. Can magnetic field values be negative? If so, what does this mean?
6. Do magnetic fields add, subtract, multiply or divide? Give a reason for your answer.
7. Besides Tesla another unit for magnetic field strength is Gauss. 10,000 Gauss = 1 Tesla.  
Is a Gauss larger or smaller than a Tesla?
8. 500 microTesla = \_\_\_\_\_ Gauss.

**Acknowledgements:**

PolarTREC (Teachers and Researchers Exploring and Collaborating)

<http://www.polartrec.com/>

Arctic Research Consortium of the U.S. (ARCUS)

<http://www.arcus.org/arcus/index.html>

National Science Foundation

<http://www.nsf.gov/>

NASA's Operation IceBridge

[http://www.nasa.gov/mission\\_pages/icebridge/index.html](http://www.nasa.gov/mission_pages/icebridge/index.html)

Libertyville High School

<http://lhswildcats.org/>

Tim Spuck (PolarTREC 2012) who first came up with the idea of items in a box to simulate what Operation IceBridge's radar and lidar systems do. Link to Tim's excellent activity:

<http://www.polartrec.com/resources/lesson/seeing-what-you-cant-see>

