Introduction to smartphone magnetometry

Aims

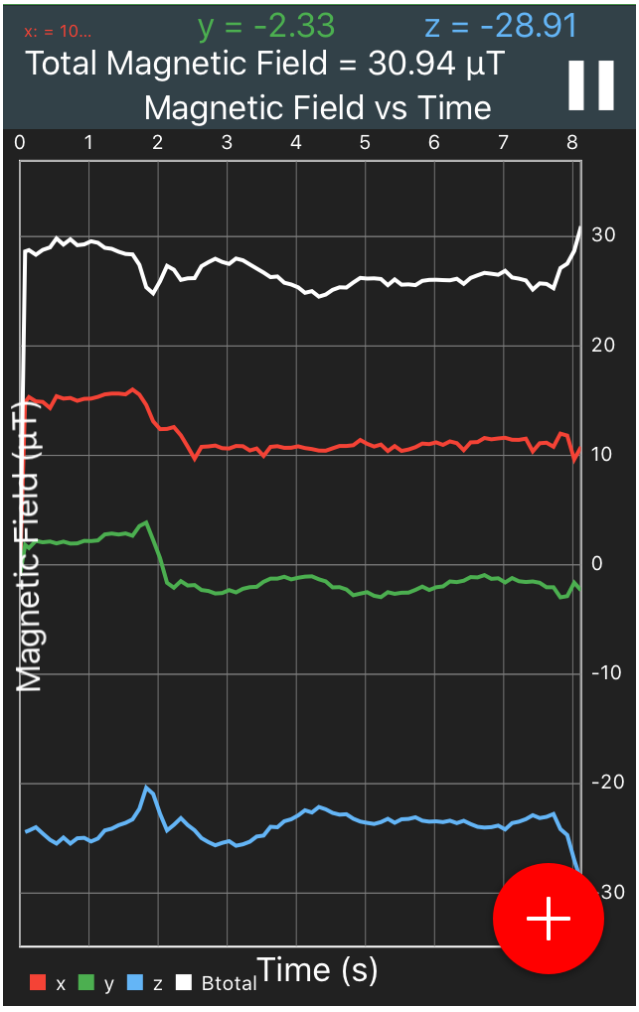
- Document the capabilities and limitations of the magnetometer sensor in your smartphone.
- Measure the ambient geomagnetic field, and observe that it has a vertical as well as a horizontal component.
- Observe how local magnetic sources create 'anomalies' by changing the direction and strength of the ambient magnetic field

You will need:

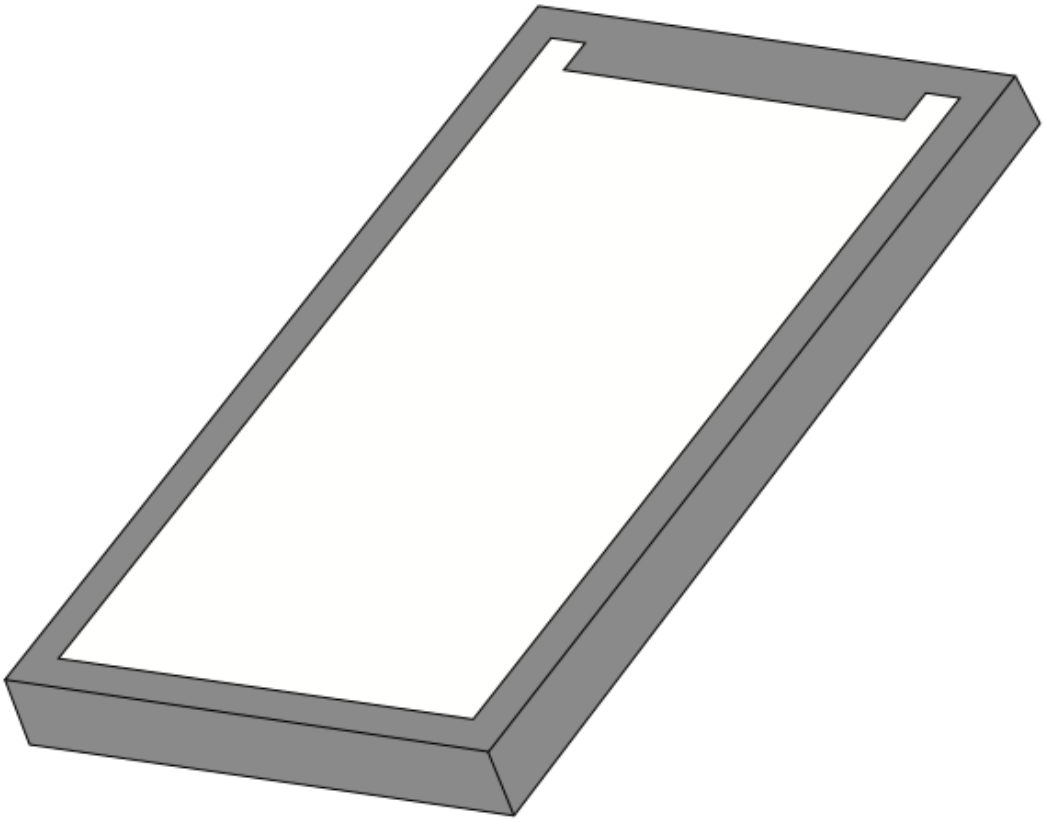
- Your smartphone (Android or iOS) - you may want to remove it from any external case for the best results.
- The Physics ToolBox Sensor Suite app installed on your smartphone.
- A small magnetic source: good examples include a bottle cap or an ear-bud.

1. Where is the sensor?

- On your Smartphone, open the Physics Toolbox Suite and select 'Magnetometer'. You should get an animated graph showing the variation in the total magnetic field strength over time (white), based on individual measurements along three orthogonal axes (red, green, blue).



- Take your magnetic source and move it in an organised pattern around the underside of your phone, monitoring the display. When you are directly underneath the sensor, you will see a peak in the magnetic intensity. Mark the approximate position on the figure below.



- Repeat this procedure, holding your magnetic source further away. What is the furthest distance that you can still see a peak when it is under the sensor? What does this exercise tell you about the sensitivity of this sensor?

2. What physical directions are represented by x, y and z on the display?

The x, y and z readings represent measurements of the magnetic field in three directions: two in the plane defined by the surface of your smartphone, and one along a perpendicular line through it. You can establish the orientation of these axes by rotating your phone whilst monitoring the displayed magnetic readings.

- Hold your smartphone level, with the bottom horizontal, and slowly spin around in a circle. Sketch, or take a screenshot, of how the x, y and z readings change as the phone rotates.
- Hold the phone vertically upright and repeat the exercise.

Using this information, add arrows representing the three measurement axes to your marked sensor position in the figure above. Explain your reasoning.

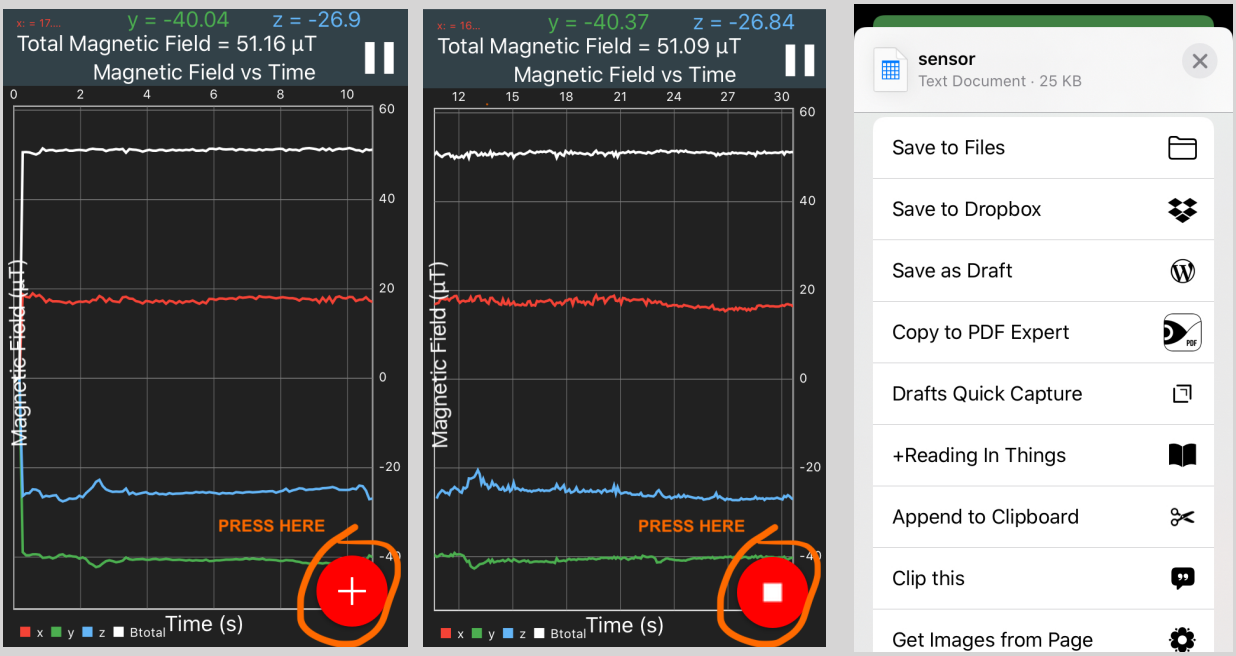
HOW TO RECORD MAGNETOMETER DATA

You can take a snap measurement by waiting for the readings to stabilise and taking a screenshot: Instructions for iOS - Instructions for Android

This method is simple, but has some disadvantages. What are they?

Fortunately, the Physics Toolbox Suite also gives you the option to record data and save it to a .csv file.

- Position the phone and wait for the readings to stabilise.
- Press the red circle in the bottom right corner of the screen to start recording ('a pop-up should inform you that 'data recording has started').
- Wait a few seconds and then press the red circle in the bottom right corner of the screen to stop the recoding.
- This will bring up a share screen that you can use to save the file to a location for later retrieval (e.g. Dropbox)



Procedure for saving measurements to a .csv file for later analysis (iPhone SE shown; appearance may vary for other phones/OSes)

3. Measure the ambient geomagnetic field

- Outside, find a relatively flat location away from obvious sources of magnetic interference (overhead cables, manhole covers, cars, etc.)
- Lay your smartphone on the ground and record a few seconds of data according to the procedure described above.
- On your smartphone or (if possible) another computer, import the .csv file you saved into a spreadsheet such as Google Sheets or Excel.
- Fill out the table below with the average, maximum and minimum values for the x, y, z components and the total field intensity.

RECORD LENGTH: **seconds**

	Average Value	**Max Value**	**Min Value**
Bx			
By			
Bz			
Btotal			

What is the smallest variation in magnetic field intensity your smartphone can reliably measure?

4. Find the inclination of the ambient field

Referring back to your answers in Part 2, calculate the horizontal and vertical components of the field. What do their relative values tell you about the vertical orientation of the ambient magnetic field in your region?

Horizontal field B_H:

Vertical field B_V:

Calculate the inclination of the ambient field, then use the NOAA magnetic field calculator page (https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#igrfwmm) to find the predicted inclination for your current location, for the current day. Make sure that you click on the 'Magnetic Field' tab to get estimates for all field components.

Calculated inclination outside:

Predicted inclination:

How close are your measured/calculated field parameters to the predicted reference field values?

5. Measure the ambient field inside your house

Inside your house, place your phone on a flat surface (floor or table), and repeat steps 3. and 4. Are your answers different? If so, why?

DESCRIBE LOCATION:

RECORD LENGTH: **seconds**

	Average Value	**Max Value**	**Min Value**
Bx			
By			
Bz			
Btotal			

Horizontal field B_H:

Vertical field B_V:

Calculated inclination inside: