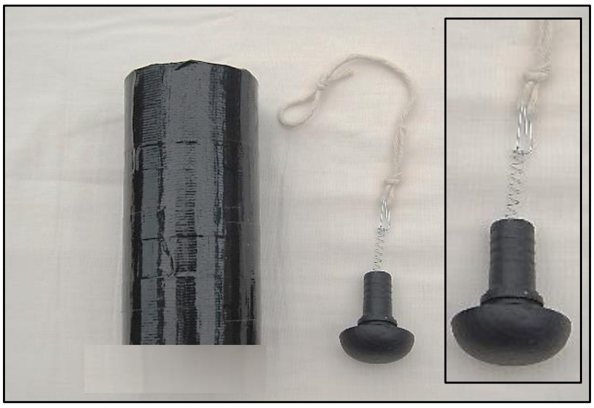
# Modelling remote sensing geophysics
## Using a mock gravimeter and magnetometer set up in the classroom



A mock gravimeter.

Make a mock gravimeter, as shown in the photo. This version has a cardboard tube covered in black tape for its body, and a ‘sensor’ made from a black-painted hose connector stuck to a rounded cupboard knob, attached to a spring from an old ball-point pen and a piece of string with a loop tied in the end.

The gravimeter ‘works’ by hanging the ‘sensor’ through the hole in the tube so it can be seen dangling below the mouth of the tube and holding it in place on the outside of the tube with your thumb. As you move the ‘gravimeter’ over a dense object, allow the sensor to fall a little using your thumb. When you move it over lighter objects, make it rise again. This shows that the ‘sensor’ is pulled down by more dense materials.

The ‘magnetometer’ is a Magnaprobe™ or a magnetised needle on a thread, as in the photo.

A ‘magnetometer’ Magnaprobe™ or magnetised needle on a thread.

Partially bury a piece of dense rock (e.g. gabbro or basalt) in a tray of less-dense sediment, or sand, as in the photo, having first taped a magnetised needle to the dense rock. Then ‘fly’ your gravimeter backwards and forwards over the area, in a series of parallel traverses, simulating the geophysical survey track of an aircraft.

*(All photos: Chris King.)*

A dense rock (piece of gabbro) buried in a less-dense ‘rock’ (loose sand) with a magnetised needle taped to it. In use the rock is buried so that only its upper surface is visible.

As the gravimeter passes over the dense rock, show it being ‘pulled down’, rising again as it ‘flies’ beyond the dense rock – so the gravimeter ‘remotely senses’ the dense rock beneath.

Repeat the flying traverses with the ‘magneto-meter’, showing how the Magnaprobe™ or magnetised needle remotely senses the ‘magnetic’ rock beneath, by being deflected from its normal orientation.

These demonstrations show how a gravimeter and a magnetometer can detect rocks that are more dense and/ or more magnetic than the surrounding rocks.

Finally, ‘fly’ your ‘gravimeter’ and ‘magnetometer’ in turn across an area of a map with another dense rock with a magnetised needle beneath - showing how the ‘gravimeter’ is pulled down in the area and the ‘magnetometer’ senses the magnetism. This shows that there must be an area of dense magnetic rocks beneath the map area, such as gabbro or basalt.


Map of part of Somerset, UK – a magnetised needle is taped beneath one part of the map.

In the map of part of Somerset, UK in the photo, the rock with the magnetised needle is beneath the area of the map where the Magnaprobe™ is lying. This is the area which, geologically, is underlain by igneous rocks, which would be detected by the geophysical remote sensing of a gravimeter and a magnetometer.

## The back up

**Title:** Modelling remote sensing geophysics.

**Subtitle:** Using a mock gravimeter and magnetometer set up in the classroom.

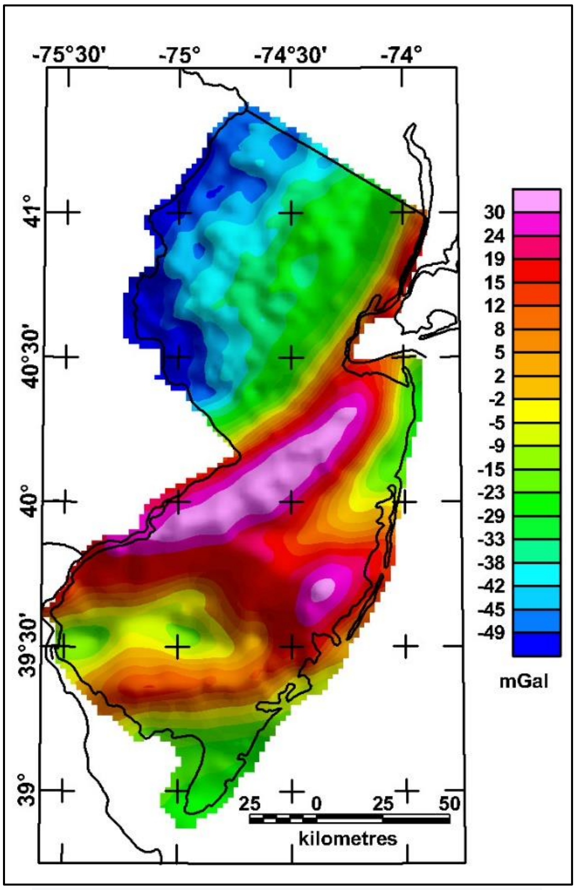
**Topic:** Use a mock gravimeter and magnetometer to demonstrate the principles of the remote sensing of buried rocks by measuring gravity and magnetism.

**Age range of pupils:** 14 years upwards

**Time needed to complete activity**: 10 minutes

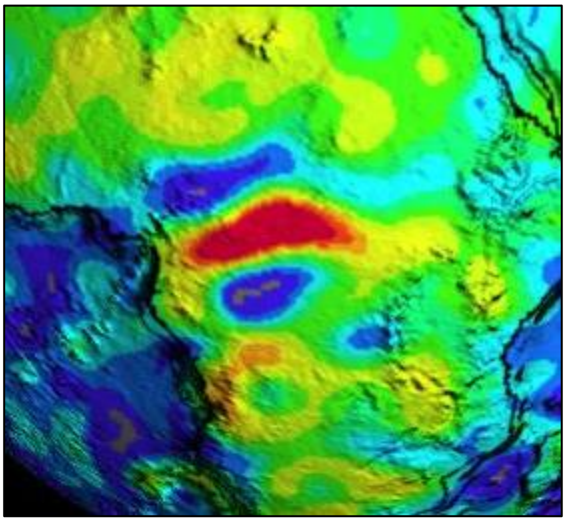
**Pupil learning outcomes:** Pupils can:
- explain how a gravimeter and a magnetometer work;
- explain how gravimeters and magnetometers are used in remote sensing, and the effects caused by rocks of differing density and magnetisation.

**Context:**
This method models how gravity and magnetic anomalies are identified by geophysical remote sensing. Data from such geophysical sensing is used to plot gravity and magnetic anomaly maps, like the ones shown.




Gravity anomaly map of the state of New Jersey, USA (pink = high gravity, indicating dense rocks, blue = low gravity, indicating less dense rocks).

*Image in the public domain – released by the United States government.*



A model of the Bangui magnetic anomaly in the Central African Republic, based on satellite measurements (red = high magnetisation, blue = low).

*This file is in the public domain because it was solely created by NASA.*


Aerial magnetic anomaly detector on a US navy helicopter.

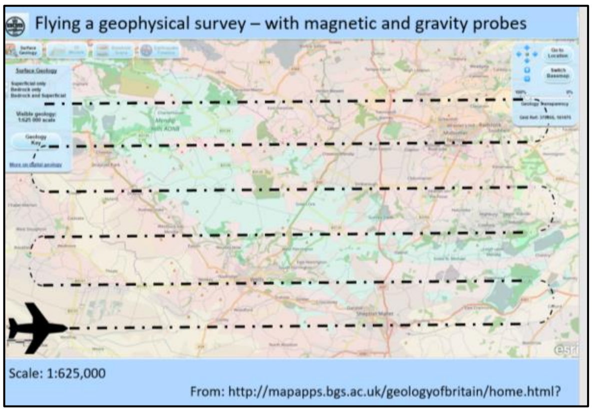
*Image by Don S. Montgomery, USN, in the public domain.*

Note that early gravimeters used a mass on a spring, as demonstrated here. Modern gravimeters use piezo-electric sensors as in the airborne gravity meter below.

Gravimeter on a British Antarctic Survey aircraft.

*Image from: Aero_grav-e1436523909415.jpg with permission of the British Antarctic Survey.*

Geophysical surveys are flown along parallel traverse lines as shown below.




**Following up the activity:**
'Fly' the mock gravimeter and 'magnetometer' over gravity and magnetic anomaly maps like those above (where a magnetised needle has been taped under a magnetic anomaly) to illustrate the links between these geophysical surveying methods and the maps.

**Underlying principles:**
- A gravimeter works like a mass suspended on a spring balance. When this set up is above a large amount of dense material, the local gravitational effect pulls the mass down more than the average, so a very sensitive spring balance would register greater mass. Similarly, above areas of low density, the gravitational pull on the mass is reduced, resulting in a lower mass measurement.
- A magnetometer is simply a sophisticated magnetic sensor. Any sensor which detects magnetic effects is acting like a magnetometer.
- After surveying, points of equal gravity or magnetism can be contoured to produce gravity or magnetic anomaly maps.
- The unit shown on the gravity anomaly map (mGal) is the milligal, named after Galileo. One milligal = $10^{-5}$ m.s$^{-2}$
- Magnetic and gravity anomalies do not always coincide.

**Thinking skill development:**
The linking of the effects on sensing devices to the phenomena that cause them is a construction skill. The method described using model devices can be used to understand the principles through bridging skills.

**Resource list:**
- 'homemade' mock gravimeter, using a cardboard tube, something that looks like a mass, a spring (e.g. from an old ball-point pen) and string
- a Magnaprobe™ or a magnetised needle on a thread
- two other magnetised needles (to magnetise a steel needle, stroke it several times in one direction with one pole of a magnet)
- a magnet
- sticky tape
- a specimen of dense dark-coloured rock
- sand in a tray
- a map

**Useful links:**
http://www.bbc.co.uk/news/science-environment-38333629 (for recent gravity work in Antarctica)

**Source:** The 'mock gravimeter' was demonstrated by Pete Loader; the rest of the activity was devised by Chris King of the Earthlearningidea Team.