Magnetic detection of objects

FizziQ activity · Middle school · 35 min

Scan to open in FizziQ

Turning the smartphone magnetometer into a metal detector, middle school students locate hidden ferromagnetic objects and analyse field variations with FizziQ.

Learning objectives

- Use the smartphone magnetometer to detect hidden ferromagnetic objects
- Map the magnetic field variations across a search area and identify anomalies
- Understand the difference between ferromagnetic and non-ferromagnetic materials
- Investigate how the size and distance of a metallic object affect the magnetic signal
- Connect the experiment to real-world applications of magnetic detection technology

Instruments and sensors

Absolute magnetic field meter · Magnetometer

Materials

- Smartphone or tablet with the FizziQ app (magnetometer measurement)
- Various metal objects of different sizes and compositions (iron nail, steel scissors, aluminium can, copper coin, small magnet)
- A blanket, cover, or sandbox to hide the objects
- Note: the protocol remains adaptable to any comparable magnetic field measurement tool.

Protocol

1. Open FizziQ and select the Magnetometer sensor. Choose the absolute magnetic field (total magnitude) for the easiest detection.
2. Before hiding any objects, take a baseline reading of the local magnetic field. Walk around the search area and note the background value (typically 25-65 µT). Record this as your reference.
3. Ask a partner to hide 3-5 metallic objects of different types and sizes (iron nail, steel scissors, aluminium can, copper coin, small magnet) under a blanket or in a sandbox.
4. Stand at one edge of the search area. Hold the smartphone at a constant height of about 5-10 cm above the surface.
5. Move the smartphone slowly and systematically across the area in parallel lines, like mowing a lawn. Watch the magnetometer reading for any increase above the baseline.
6. When you detect an anomaly (a reading significantly higher than baseline), mark the location and record the peak magnetic field value.
7. After scanning the entire area, reveal the hidden objects and check which ones you successfully located.
8. Note which objects were detected and which were missed. Ferromagnetic objects (iron, steel, nickel) should produce strong signals, while non-ferromagnetic metals (aluminium, copper) may be undetectable.
9. For each detected object, measure the detection distance: at what height above the object does the anomaly become undetectable?
10. Create a table recording: object type, material, approximate mass, peak field value, and detection distance.
11. Repeat with the objects at different depths (under 1, 2, or 3 layers of fabric or centimeters of sand) and observe how the signal decreases.

12. Discuss why some metals are magnetic and others are not, and how real metal detectors overcome this limitation.

Expected results

Ferromagnetic objects (iron nails, steel tools, nickel coins) should produce clear magnetic anomalies of 5-50 μT above the baseline, easily detectable at distances of 5-15 cm. Larger objects and stronger magnets produce larger anomalies detectable at greater distances. Non-ferromagnetic metals (aluminium, copper, brass) will produce little or no detectable signal with a magnetometer, as they do not create static magnetic disturbances. The detection distance decreases rapidly with depth, following approximately an inverse cube law (the field from a magnetic dipole decreases as $1/r^3$). Students should find that a small iron nail is detectable at about 5 cm, while a larger steel tool may be detected at 15-20 cm.

Questions

- Why can the magnetometer detect iron and steel objects but not aluminium or copper ones?
- How does the detection distance depend on the size of the hidden object? Why?
- What is the difference between ferromagnetic, paramagnetic, and diamagnetic materials?
- How do professional metal detectors work differently from a magnetometer?
- Could you use this technique to find buried archaeological artifacts?
- Why does the magnetic signal decrease so rapidly with distance from the object?

Going further

- Create a magnetic field map of the search area by recording values on a grid and plotting them as a heat map
- Compare the magnetometer sensitivity to different metals: iron, steel, nickel, cobalt, aluminium, copper
- Test whether the orientation of the hidden object affects the detected signal
- Use the experiment to find hidden magnets and determine their polarity
- Investigate magnetic shielding by wrapping objects in aluminium foil and testing detection