Magnetic north by magnetometer

FizziQ activity · Middle school · 30 min

Scan to open in FizziQ

Rotating a smartphone through 360° in FizziQ, middle school students find where the horizontal magnetic field peaks, then check that magnetic heading with a compass.

Learning objectives

- Determine the direction of magnetic north using the smartphone magnetometer
- Identify the horizontal component of the Earth's magnetic field and understand its role in orientation
- Compare the magnetometer-based direction with a traditional compass reading
- Understand the concept of magnetic declination (difference between magnetic and geographic north)
- Explore how magnetic interference from nearby objects affects the readings

Instruments and sensors

Magnetometer (horizontal field component) · Magnetometer

Materials

- Smartphone with the FizziQ application
- A classic compass for comparison (optional)
- A space without magnetic disturbances
- Note: the protocol remains adaptable to any comparable magnetic field measurement tool.

Protocol

1. Find an outdoor location away from buildings, vehicles, and metal structures. These create magnetic interference that distorts compass readings.
2. Open FizziQ and select the Magnetometer sensor. Choose the horizontal component (Bx or By, depending on phone orientation).
3. Hold the smartphone horizontally at waist height. Slowly rotate your body and the phone through a complete 360° turn, observing how the horizontal field component changes.
4. Identify the orientation where the horizontal magnetic field is maximum. This direction points toward magnetic north.
5. Mark this direction with a physical reference (a stick, a line on the ground, or a landmark).
6. If you have a traditional compass, compare its north indication with your magnetometer-based direction. They should agree within ±5°.
7. Record the maximum horizontal field value (typically 15-25 µT in mid-latitudes).
8. Now investigate magnetic interference: bring a metal object (keys, scissors, or a magnet) close to the phone and observe how the readings change.
9. Walk around the outdoor area and note any locations where the magnetic field direction shifts unexpectedly. These indicate underground metal or magnetic anomalies.
10. Look up the magnetic declination for your location (the angle between magnetic north and geographic north). At your latitude, this may be 0-5° or more.
11. If visible, identify geographic north using the sun's position or a known landmark, and verify the declination angle.
12. Discuss why magnetic north shifts over time and what causes the Earth's magnetic field.

Expected results

The horizontal magnetic field component should vary smoothly as the phone rotates, reaching a maximum when pointing toward magnetic north and a minimum when pointing south. The maximum value is typically 15-25 μT in mid-latitude locations. The magnetometer-based north direction should agree with a traditional compass within ±5°, assuming no nearby magnetic interference. Near buildings, cars, or metal structures, the readings may be distorted by 10-30° or more. The magnetic declination varies by location and changes slowly over time; in Western Europe it is currently about 0-3° east.

Questions

- Why does the horizontal component of the magnetic field reach its maximum when the phone points north?
- What causes the difference between magnetic north and geographic north (magnetic declination)?
- Why can magnetic interference from buildings and vehicles affect compass readings?
- How has the position of the magnetic north pole changed over historical time?
- What generates the Earth's magnetic field, and why does it slowly change?
- How do modern ships and aircraft compensate for magnetic declination in their navigation systems?

Going further

- Create a magnetic field map of the schoolyard, noting areas with strong interference
- Compare the magnetometer readings inside a building versus outside to quantify magnetic shielding
- Build a simple physical compass using a magnetized needle on water and compare with the smartphone
- Investigate how the vertical component of the magnetic field varies as you change the phone's tilt angle
- Research the history of the magnetic compass and its role in global exploration