Speed by magnetic markers

FizziQ activity · High school · 30 min

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Magnets placed along a track create peaks in the magnetometer signal of a smartphone on a moving cart; students use FizziQ to compute speed from the peak timing.

Learning objectives

- Measure a magnetic field with the smartphone magnetometer
- Calculate average speed from distance and time measurements
- Distinguish instantaneous speed from average speed
- Trace position and speed graphs from magnetic peak data
- Understand the $1/r^3$ decay of dipole magnetic fields

Instruments and sensors

Magnetometer · Magnetometer

Materials

- Smartphone or tablet with FizziQ
- Small magnets (neodymium or refrigerator magnets)
- A straight track (toy train rails, gutter, table edge)
- A moving object (toy train, cart)
- Tape measure and adhesive tape
- Note: the protocol remains adaptable to any comparable magnetic field data acquisition tool.

Protocol

1. Choose a straight track: toy train rail, gutter, curtain rod, or table edge.
2. Place magnets at regular intervals along the track (for example every 10 or 20 cm). Use a tape measure for precise placement.
3. Measure and note the distance d between two consecutive magnets.
4. Attach your smartphone to the moving object (toy train, cart). The magnetometer must pass close to the magnets. Identify which side of the phone has the sensor.
5. Open FizziQ and select the Magnetometer instrument. Ideally, use remote control from a second device.
6. Start the recording while the smartphone is stationary at the starting point.
7. Set the object in motion along the rail. The phone must pass at the same distance from each magnet.
8. Stop the recording at the end of the track, before removing the phone.
9. Observe the magnetic field versus time graph. You should see sharp peaks corresponding to each magnet passage.
10. From the time intervals between peaks and the known distance d, calculate the average speed in each interval: $v = d/\Delta t$. Plot speed versus time to analyze acceleration or deceleration.

Expected results

The magnetic field graph shows sharp, regularly spaced peaks corresponding to each magnet. For a toy train at constant speed, the intervals between peaks are equal. For an accelerating cart on an inclined plane, the intervals decrease as the object speeds up. Speed precision is typically ±2-5% depending on the regularity of magnet placement and motion.

Questions

- How does the shape of the peaks change if you modify the distance between the sensor and the magnets?
- Why does the $1/r^3$ decay allow precise detection of individual magnets?
- What is the difference between average speed and instantaneous speed in this experiment?
- How could you use this technique to measure acceleration?
- Why are neodymium magnets better than ferrite magnets for this experiment?
- What industrial applications use a similar magnetic detection principle?

Going further

- Study the acceleration of a cart on an inclined plane and compare with $a = g \sin \theta$
- Measure the deceleration of a launched object to determine the friction coefficient
- Use non-uniform magnet spacing to create a higher-resolution speed measurement at specific points
- Compare the speed measured magnetically with GPS speed or video analysis
- Investigate how the peak amplitude depends on the sensor-magnet distance