Parabolic flight and microgravity

FizziQ activity · High school · 25 min

Scan to open in FizziQ

A phone tossed above a mattress records its own free fall: the FizziQ accelerometer on smartphone drops to near zero, showing why astronauts float in a parabola.

Learning objectives

- Record and analyze the acceleration during a brief parabolic flight of a smartphone
- Observe that the accelerometer reads approximately zero during free fall despite gravity still acting
- Identify the three phases of motion: launch, free flight (weightlessness), and landing impact
- Understand why free fall produces apparent weightlessness
- Connect the experiment to real parabolic flights and the physics of orbital motion

Instruments and sensors

Absolute acceleration · Accelerometer

Materials

- Smartphone with the FizziQ application
- A mattress or soft surface to securely catch the smartphone
- A clear space
- FizziQ experiment notebook
- Note: the protocol remains adaptable to any comparable accelerometer-based measurement tool.

Protocol

1. Prepare a thick mattress, cushion, or foam pad on the floor to safely catch the smartphone.
2. Open FizziQ and select the Accelerometer sensor with absolute acceleration. Set the sampling rate to maximum.
3. Place the smartphone in a protective padded sleeve (a thick sock with padding works well).
4. Hold the protected phone at waist height directly above the mattress. Start recording in FizziQ.
5. Wait 2 seconds (to record the resting phase), then gently toss the phone upward (about 30-50 cm height) so it lands on the mattress.
6. Let the phone settle, then stop recording after 2 more seconds.
7. Examine the acceleration graph. Identify three distinct phases: the resting phase (≈ 9.81 m/s²), the free flight phase (≈ 0 m/s²), and the impact spike (>> 9.81 m/s²).
8. Measure the duration of the free flight phase (the time the acceleration is near zero). For a 30 cm toss height, this should be about 0.5 seconds.
9. Calculate the expected free-flight duration using $t = 2 \times \sqrt{2h/g}$ for a toss of height h. Compare with the measured duration.
10. Repeat the experiment with different toss heights: 20 cm, 40 cm, and 60 cm. Record the free-flight duration for each.
11. Plot the free-flight duration versus toss height and verify the expected relationship.
12. Discuss: during the free flight, does gravity disappear? Why does the accelerometer read zero even though the phone is clearly decelerating (going up) and then accelerating (coming down)?

Expected results

During the free-flight phase, the absolute acceleration should drop to near 0 m/s² (typically 0.1-0.5 m/s² due to air resistance and phone rotation). For a 30 cm toss, the total airborne time should be about 0.49 seconds; for 60 cm, about 0.70 seconds. The resting phase before and after should show approximately 9.81 m/s². The impact spike can reach 20-100 m/s² depending on the cushioning. Students should observe that the free flight duration increases as the square root of the toss height. The key conceptual insight is that the accelerometer reads zero not because gravity is absent but because both the phone and its sensor are accelerating at exactly g, so there is no relative acceleration between them.

Questions

- Why does the accelerometer read approximately 9.81 m/s² when the phone is at rest on a table?
- Why does it read zero during free fall, even though gravity is clearly still acting on the phone?
- How does this experiment relate to the weightlessness experienced by astronauts on the ISS?
- What is Einstein's equivalence principle, and how does this experiment illustrate it?
- If you could throw the phone high enough and fast enough horizontally, what trajectory would it follow?
- How do Zero-G parabolic flight aircraft create 25 seconds of weightlessness?

Going further

- Compare the free-flight duration for toss heights from 10 cm to 1 meter and verify the √h relationship
- Record the acceleration during a trampoline jump and identify the weightless phases at the top of each bounce
- Analyze the acceleration graph during an elevator ride and identify moments of apparent weight change
- Calculate the acceleration during the impact with the mattress and estimate the peak force
- Investigate whether phone rotation during the toss affects the accelerometer reading