Five Smartphone Physics Lessons for Teaching NGSS' DCI Forces and Motion

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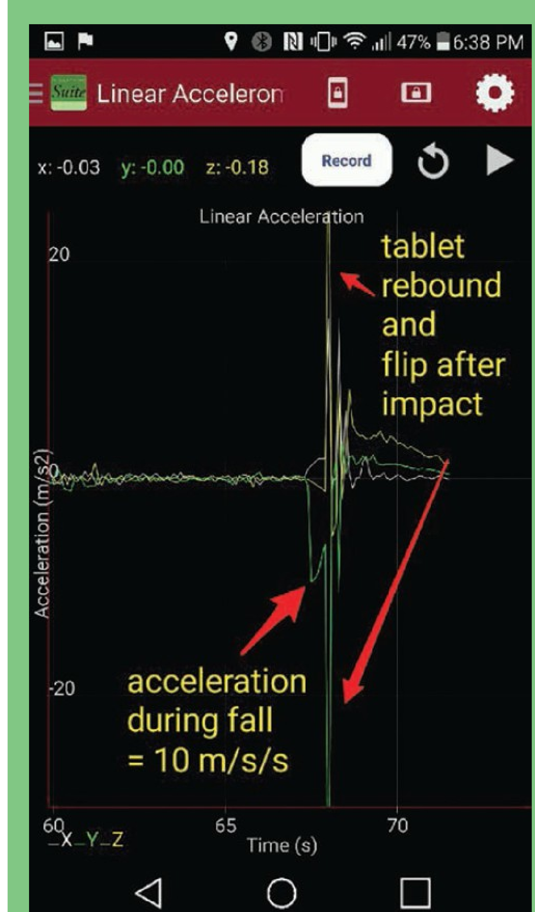
#1 DETERMINE ACCELERATION DUE TO GRAVITY... IN YOUR HOME



The acceleration, with a value of about 9.8 m/s/s, can usually be seen immediately before the mobile device's much greater impact force with the sofa or bed.

"How should the mobile device be held upon dropping?"

"Which axis is measuring acceleration due to gravity?"

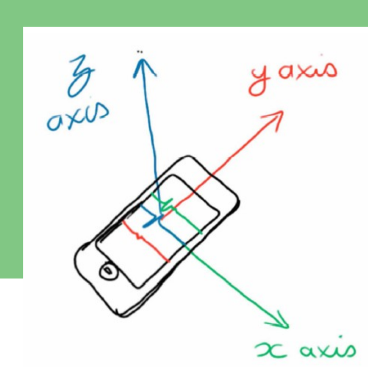
Because the fall time is relatively short, students are challenged to find the relevant data corresponding to the fall and must pinch to zoom in to see the acceleration value.

"How to best determine the acceleration due to gravity when each mobile device gives slightly different results?"

"Why some students get positive accelerations, while others get negative values?"

Students can also compare accelerations for devices of significantly different masses, such as a small smartphone and a large tablet, helping them to connect to NGSS standard HS-PS2 and to determine both the cause of acceleration and which variables influence (or do not influence) it.

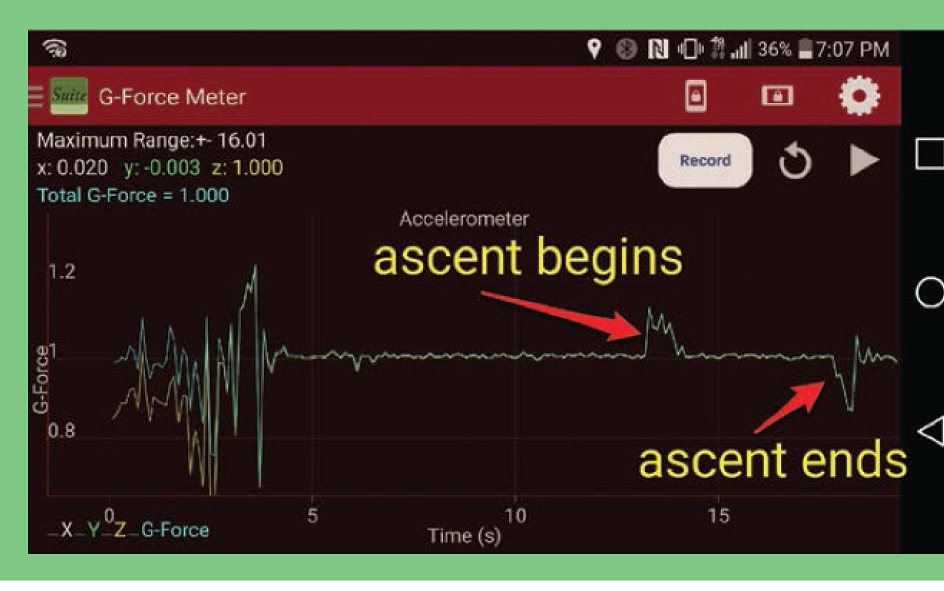
- Engage students in data collection in various environments.
- Allow students to make meaning from data.
- Mobile-sensor data can be easily shared for later uploading into data-analysis software.
- Encourage parents to become involved in at-home data collection.
- Mobile devices not only help us better integrate technology in the classroom but also increase our opportunities for student achievement and engagement.
- We hope you find the same to be true in your own classes.



#2 RELATE NET FORCE TO MOTION... IN AN ELEVATOR OR ON A ROLLER COASTER

Mobile devices simplify the understanding of "elevator" problems.
Misconception: "an elevator moving upward—even at constant velocity—must have a net upward force acting upon it."
To confront this misconception, students can use their mobile devices to observe changes in linear acceleration and g-force as they go up a level in an elevator.

Although students feel an initial increase in acceleration during the start of the ascent and observe a spike in g-force, the "middle" portion of the ride before the elevator begins to slow shows a constant g-force equal to 1. A graph of acceleration and g-force while moving upward at constant velocity looks identical to one produced by an elevator that is not moving at all.



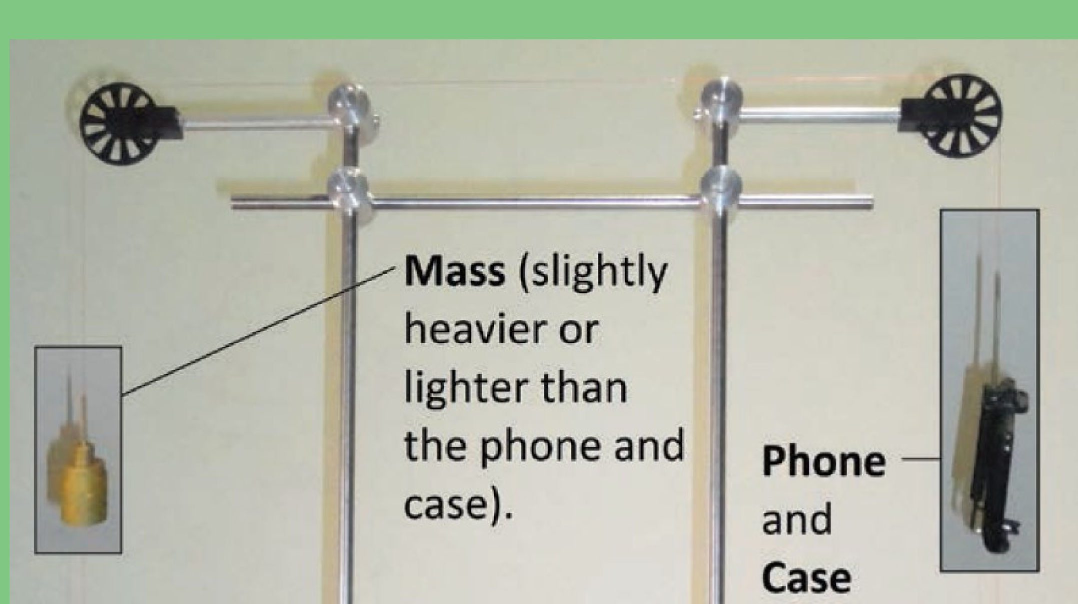
After collecting the data, students can compare their predictions with the actual graph and determine why there might be discrepancies between the two.

PRIMARY SENSORS
Accelerometers
Gyroscopes
Magnetometers
Barometer
Light sensor
Camera
Microphone
Proximity sensor
Thermometer
Hygrometer

More information:
www.vieyrasoftware.net
smarterphysics.blogspot.com

#3 PREDICT AND MEASURE ACCELERATIONS... IN THE LAB

The Atwood's machine can be simplified by using the mobile device itself as an accelerating mass.



Counterweight slightly less or more massive than the mobile device itself.

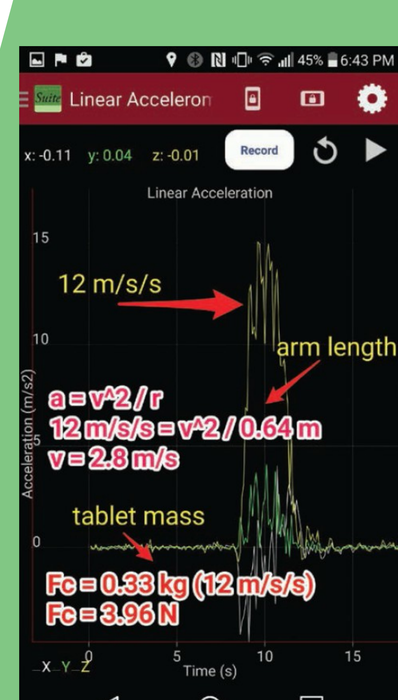
Students find that more massive systems with equal net forces have a smaller acceleration, and vice-versa.

This experience allows students to derive Newton's second law quantitatively through their inquiry experience by observing the effects of modifying system mass or net force (one at a time), as specified by NGSS performance expectation HS-PS2-1.

Teachers can also use this tool as an assessment. Once students have predicted the estimated acceleration of the entire system using the known masses, they can verify the results directly by looking at the acceleration reading on the mobile device.

#4 DETERMINE THE DIRECTION AND MAGNITUDE OF CENTRIPETAL ACCELERATION, CENTRIPETAL FORCE, AND TANGENTIAL VELOCITY... WHILE DANCING

To overcome the "centripetal force" misconception, students should hold their mobile device outward at arm's length while smoothly spinning with their bodies as the center of rotation, much like a ballerina pirouettes.



Students can then determine the direction of the acceleration and should infer from the graph that the net acceleration (and therefore the net force) is directed inward, toward the center of rotation.

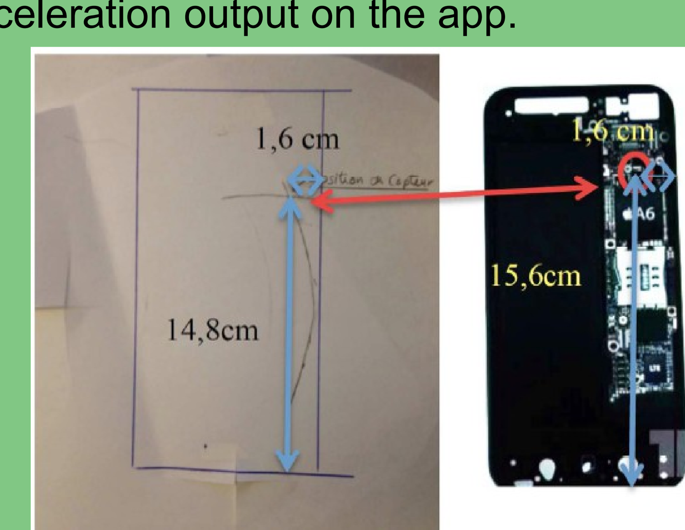
Students can also qualitatively determine the relationship between centripetal acceleration and tangential velocity by spinning more and more quickly and observing that the centripetal acceleration increases—helping them understand the relationship between centripetal acceleration and tangential velocity.

#5 DETERMINE THE PRECISE LOCATION OF THE ACCELEROMETER... WITH A RECORDER PLAYER

Identifying the location of the accelerometer is a learning experience in itself, and this challenge can be overcome with the use of a turntable.

Students place a piece of paper on a turntable with the phone atop it, oriented so that its long edge travels tangent to the circle it makes. The phone is then outlined on the paper so that the radius of rotation measuring the acceleration can later be compared to its placement within the phone.

For this challenge, ask students to either determine total acceleration by doing vector addition for the acceleration in the x and y dimensions or to directly read the total acceleration output on the app.



Using a variation of the equation for centripetal acceleration, students can solve for the radius that produces that acceleration and note the circle of that radius on the paper, using a pencil compass.
The same procedure is then repeated with the phone mounted 90° to its original position, and the radius is again noted. The intersection of these circles is the location of the phone's accelerometer chip.