# Smartphones – the Geophysics Lab in Your Students' Pocket

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AGU FALL MEETING
New Orleans
11-15 Dec. 2017 What will *you* discover?

ED21B-0278

## "Darn! I wish we could do that in class..."

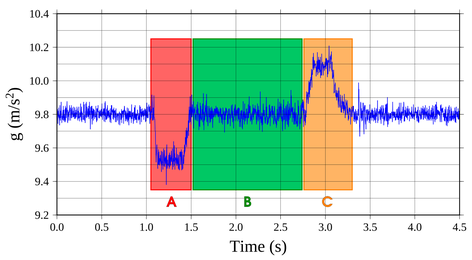
Smartphones, which students own and are (perhaps unduly) comfortable with, have many otherwise expensive instruments as built-in sensors. These instruments are nifty tools that make labs easier, faster, and more fun. We use smartphones in several labs in an introductory geophysics class.

Here, we demonstrate three activities in an introductory geophysics class at Northwestern University. These applications illustrate the potential for using smartphones in a wide variety of geophysics teaching, much as their value is being increasingly recognized in other educational applications.

## 1. Measuring $g$

**Goal:** Learn how gravity measurements represent accelerations.

Students used their smartphones to measure the acceleration of gravity in a moving elevator. They used an app (G-Sensor Logger) to save values of $g$ recorded by the accelerometers in their smartphones as a function of time.



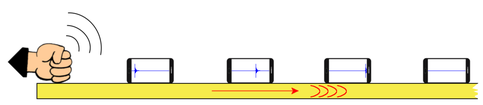

**Students:**

1. **Learned to calibrate their instruments.**
2. **Extracted and analyzed time series.**
3. **Interpreted the segments in their plots.**

## 2. Measuring Seismic Wave Velocity

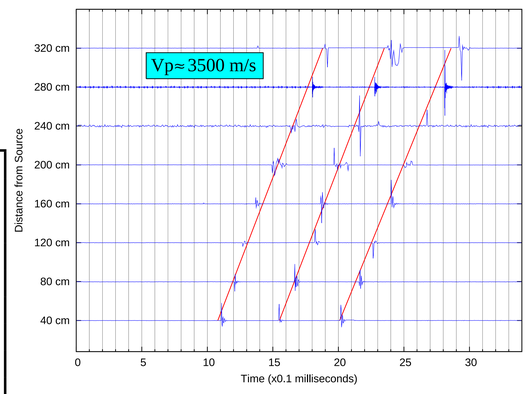
**Goal:** Learn about seismic data acquisition & interpret seismic records.

The class measured the speed of sound (P-waves) in a wooden table using a linear array of smartphones similar to the procedure used in reflection seismology. The students made an approximately 3 m long, equally spaced, array of smartphones and used their seismometer apps (iSeismometer) to record vibration signals from pounding on the table at one end of the array. They then extracted and saved the recorded time-series from their phones. These text files were uploaded onto Google Drive to share with everyone in the class. Connecting the first arrivals on the record section gave the velocity of the table as $\sim$ 3500 m/s.



**Students:**

1. **Learned that different instruments record the same signal differently.**
2. **Learned to interpret seismic arrival times.**
3. **Designed "better arrays" to record better seismic shots.**

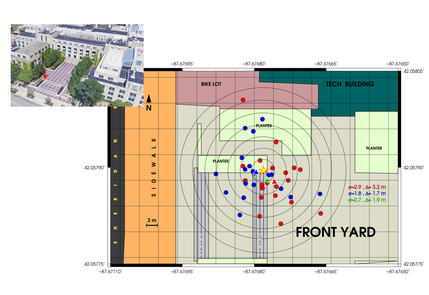



The compressed seismic section from the experiment. The red lines connect the first arrivals throughout the three shots.

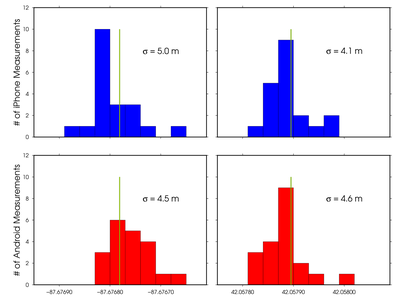
## 3. Positioning – Accuracy and Precision

**Goal:** Learn concepts of *accuracy* vs. *precision* using geographic data.

Students used their smartphones to make measurements, at least 6 hours apart, of the latitude and longitude of the southeast corner of a planter in front of a university building. Then they extracted the coordinates using the Google Maps app, entered their results in a spreadsheet, and shared them with their labmates on Google Drive.




Cumulative dataset of coordinates, with Androids and iPhones. The yellow star shows the geospatial reference.




Histograms assessing which of the measurement groups are more precise and/or accurate.

**Students:**

1. **Learned how to make and extract coordinate measurements.**
2. **Analyzed the distribution of coordinates from their measurements.**

## The Road ahead

Smartphones let educators develop creative pedagogy in the active learning process. Such applications can, in some cases, replace computer simulations with real data. Instructors have two options: forget about these nifty tools and keep doing labs in the old ways, or benefit from smartphones as mini-computers and tiny, powerful instruments. Our advice to instructors is to see whether smartphones work in their applications.

**ACKNOWLEDGMENT** We are grateful to Richard V. Sailor for suggesting the idea of the elevator activity.

**REFERENCE** Salaree, A., Stein, S., Saloor, N., & Elling, R., 2017, Turn your smartphone into a geophysics lab, *Astronomy & Geophysics*, **58**(6), 6.35–6.36