Doing Physics Experiments and Learning with Smartphones

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Introduction

The use of mobile devices in teaching and learning follows and increasing trend.

In physics teaching, smartphones and tablets can be used not only as knowledge facilitators, but also as powerfull experimental tools thanks to their sensors: accelerometer, gyroscope, magnetometer, sound, light, ...

Students can use their own smartphones either in teaching laboratories or in daily activities.

Using the smartphone can foster conceptual learning

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Smartphones in the Classroom Help Students See Inside the Black Box – Chromium

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APS NEWS

Smartphones in the Classroom Help Students See Inside the Black Box

By Tamela Maciel

Cell phones have proliferated among high school and college students, and these pocket-size computers have become essential tools in physics classrooms. Sporting a range of sensors, smartphones offer educators and students a familiar device that can perform many of the same functions as expensive lab equipment. However, advocates of smartphones in the lab are also stressing the need to teach students how phone sensors work in order to properly interpret their results.

"Ironically, nearly all students walk into [physics] laboratories in possession of a personal device with many — if not all — of the data collection capabilities they need: their smartphones," said Colleen Lanz Countryman, a physics education Ph.D. student and physics lab instructor at North Carolina State University.

Most smartphones today come equipped with internal sensors that can measure acceleration, orientation, audio volume, light density, and even magnetic field strength. Smartphone apps like SensorLog and AndroSensor can record and store data from the sensors for further analysis.

Lanz Countryman observes that limited funding is pushing teachers to think twice about investing in expensive lab equipment, and that smartphones may help fill the gap. She notes that, "In the past few years … I have noticed an increase in curiosity regarding the utilization of smartphones in labs." In the classroom, Lanz Countryman has observed that smartphone labs "spark initial excitement" among students who are curious to discover "unknown capabilities of their own devices."

Physics teachers and education researchers commonly believe that students learn a physics concept more deeply if it is explored experimentally with familiar everyday tools. "Results of pilot studies in physics (both high school and university level) show that using such devices as experimental tools could foster conceptual learning," said physics education researchers Jochen Kuhn and Patrik Vogt in an email. Kuhn and Vogt are also the editors of iPhysicsLabs, a column dedicated to smartphone physics in *The Physics Teacher* journal.

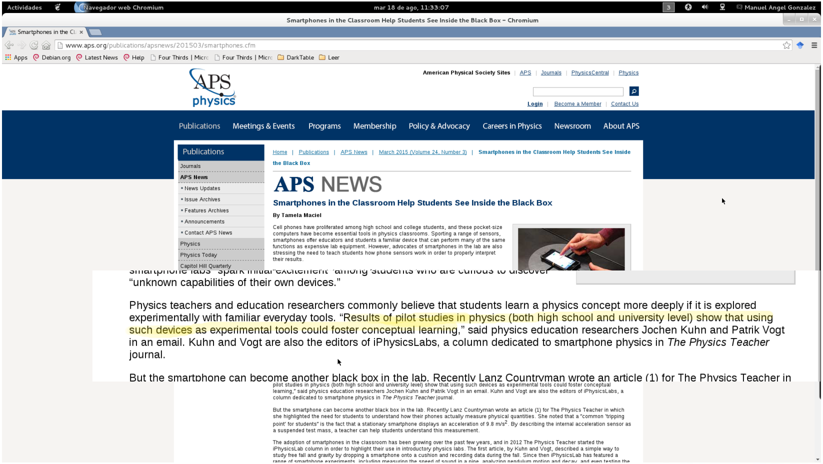
But the smartphone can become another black box in the lab. Recently Lanz Countryman wrote an article (1) for The Physics Teacher in which she highlighted the need for students to understand how their phones actually measure physical quantities. She noted that a "common 'tripping point' for students" is the fact that a stationary smartphone displays an acceleration of 9.8 m/s^2. By describing the internal acceleration sensor as a suspended test mass, a teacher can help students understand this measurement.

The adoption of smartphones in the classroom has been growing over the past few years, and in 2012 The Physics Teacher started the iPhysicsLab column in order to highlight their use in introductory physics labs. The first article, by Kuhn and Vogt, described a simple way to study free fall and gravity by dropping a smartphone onto a cushion and recording data during the fall. Since then iPhysicsLab has featured a range of smartphone experiments, including measuring the speed of sound in a pipe, analyzing pendulum motion and decay, and even testing the

Photo: Colleen Lanz Countryman/NCSU

Physics lab students use the smartphone gyroscope sensor to measure angular velocity at North Carolina State University.

Using the smartphone can foster conceptual learning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and has a positive influence on students' motivation

MPTL'20 International Conference on Multimedia in Physics Teaching and Learning
LMU
September 9–11, 2015, Munich, Germany

Invited Symposium iMP
Contribution 4A1

Room A (D Z003)
Thu, 10 Sep, 14:00–14:15

iMobilePhysics:
Possibilities and Limits of Using Smartphone and Tablet-PC as Experimental Tools

Jochen Kuhn[1] and Andreas Müller[2]
[1]University of Kaiserslautern, Germany, [2]University of Geneva, Switzerland

We expect the motivation as well as the learning outcome to be increased by using smartphones as experimental tools, compared to traditional physics class with experiments of the same content. This is based first on the theoretical framework of context based learning, after which the connection of an experimental tool to everyday life has a positive influence on motivation. In this aspect, self-efficacy as one important component of motivation is of special

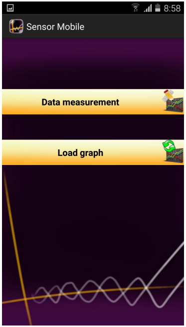
Our work

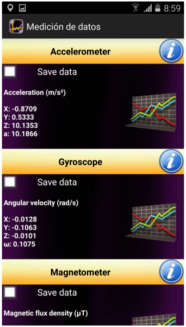
Tecnología, Innovación y Aprendizaje.

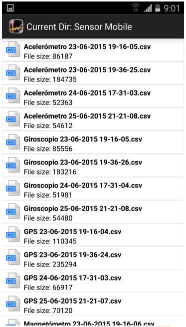
- Developing apps:
    - Learning apps with theory, examples, tests, simulations, ...
    - (learning) Apps to use the smartphone as an experimental tool.

- Thinking on how to use the smartphone in laboratory or everyday activities experiments.

Some of our works: SensorMobile







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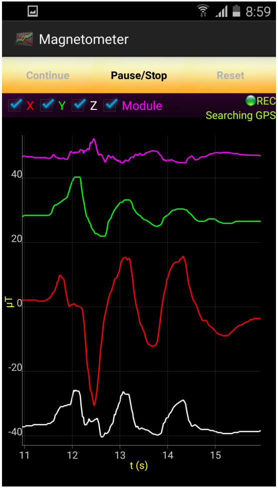

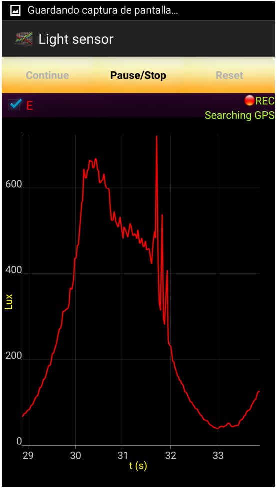

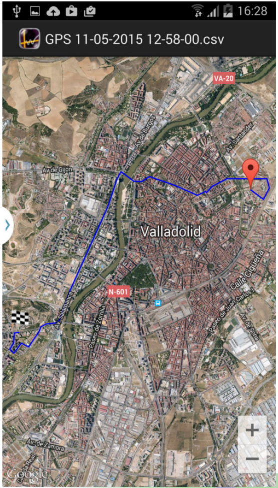

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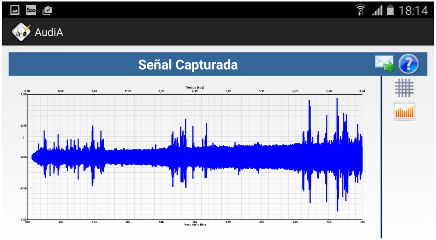
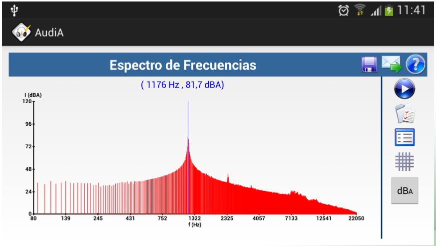
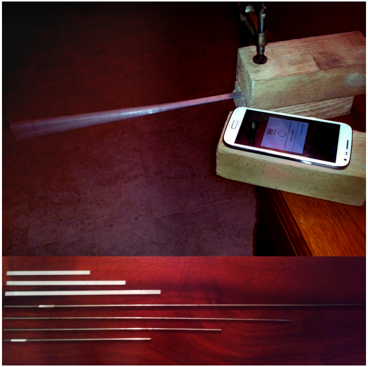




Examples of experiments: overtones of vibrating rods of different shapes and composition



$$\nu_n = \frac{ck}{L^2} C_n$$

$$c = \sqrt{\frac{Y}{\rho}}$$

$$C_n = \frac{r_n^2}{2\pi}$$

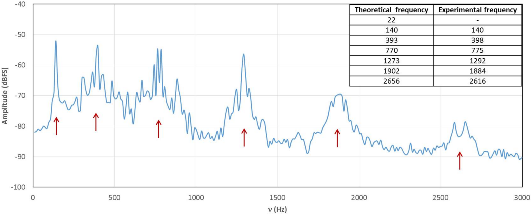
$$r_n = (2n-1)\frac{\pi}{2}$$

Rectangular rod: $k = \frac{\text{thickness}}{\sqrt{12}}$

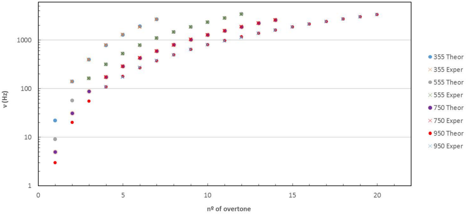
Cylindrical rod: $k = \frac{\text{radius}}{2}$

Examples of experiments: overtones of vibrating rods of different shapes and composition

Results: Sound recording and FFT for frequencies determination

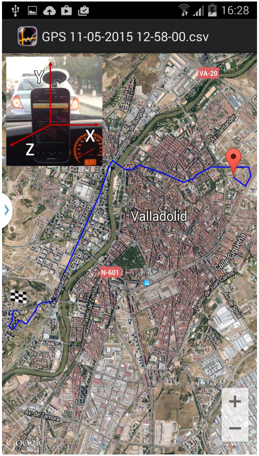


Theoretical frequency	Experimental frequency
22	-
140	140
393	398
770	775
1273	1292
1902	1884
2656	2616



Other experiments in everyday activities:

Traveling from home to the university



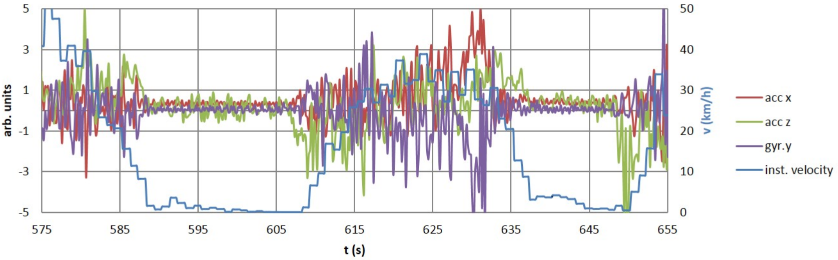
Different sensors: The students can measure simultaneously accelerations, light and sound intensities, magnetic fields, position, etc.

Analysis: Dependences, repeatability, experimental noise, ... all of them characteristics of the scientific experimental work.

Other experiments in everyday activities:

Traveling from home to the university

Some examples: A rough figure with many data (accelerometer, gyroscope, GPS, time)

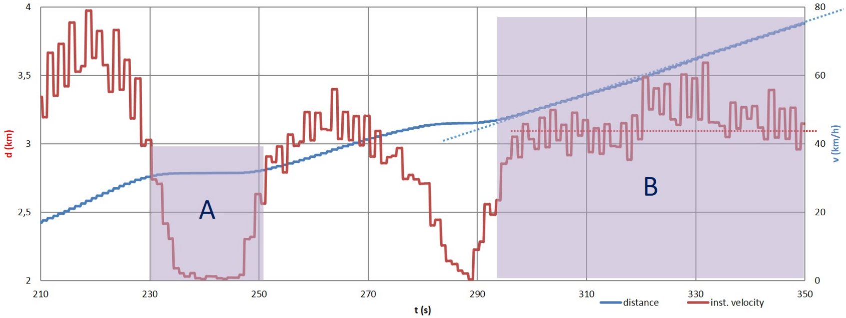


acceleration - gyroscope - magnetic field
speed - acceleration

Other experiments in everyday activities:

Traveling from home to the university

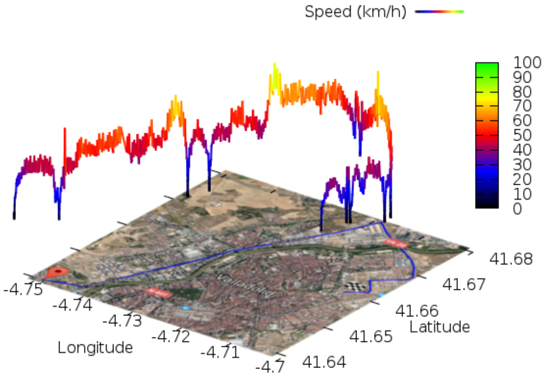
Some examples: Numerical relationships (accelerometer, GPS, time)



Other experiments in everyday activities:

Traveling from home to the university

Some examples: Dependences on the position (GPS, time)



Examples of experiments imagined and developed by high school students

Work with high school students:

- Analysis of available apps
- Simple <u>guided</u> laboratory experiments
- Free <u>autonomous</u> experimentation

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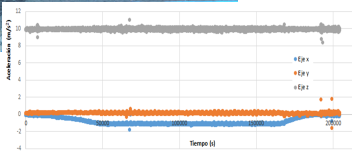
Measurement of acceleration and calculation of speed



Examples of experiments imagined and developed by high school students

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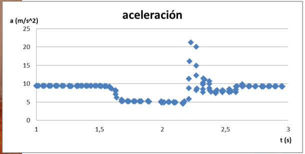
Measurement of acceleration and calculation of friction coefficient



Examples of experiments imagined and developed by high school students

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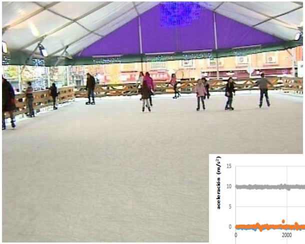
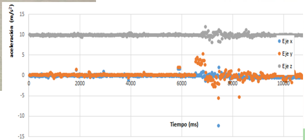
- Free autonomous experimentation

Measurement of acceleration and calculation of displacement and friction coefficient





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- Analysis of available apps
- Simple guided laboratory experiments
- Free autonomous experimentation

Measurement of resonant frequency for pipes of different lengths and calculation of the speed of sound

Longitud (m)	Frecuencia Hz	Velocidad del sonido (m/s)
1,12	73,7	330,17
0,78	104,5	328,13
0,42	196,5	330,12

Conclusions

Using mobile devices can rise interest on physics, ease its understanding and increase engagement in physics subjects, opening also the possibility of more active learning techniques.

By analyzing everyday activities, the students can observe nature, test their knowledge and acquire abilities necessary in the experimental work in the laboratory.

The use of smartphones as experimental tools can help building low cost laboratories and enhance learning in less favored environments.

To have reliable results on the influence on students' academic results and engagement more data are required: different students and conditions, more learning experiments ...

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