Measuring vertical velocities of elevators using smartphone pressure sensors

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American Association of Physics Teachers
Summer Meeting 2018
Washington, DC. July 28 – August 1

Smartphones in Physics

mobile physics lab →
that can be used everywhere!

..allows to experiment in
non-traditional places...

Primary sensors:

- **Accelerometer** → acceleration
- **Gyroscope** → angular velocity
- **Magnetometer** → magnetic field
- **Microphone** → sound
- **Photometer** → light intensity
- **Camera** → Video analysis / Spectra
- **Barometer** → pressure

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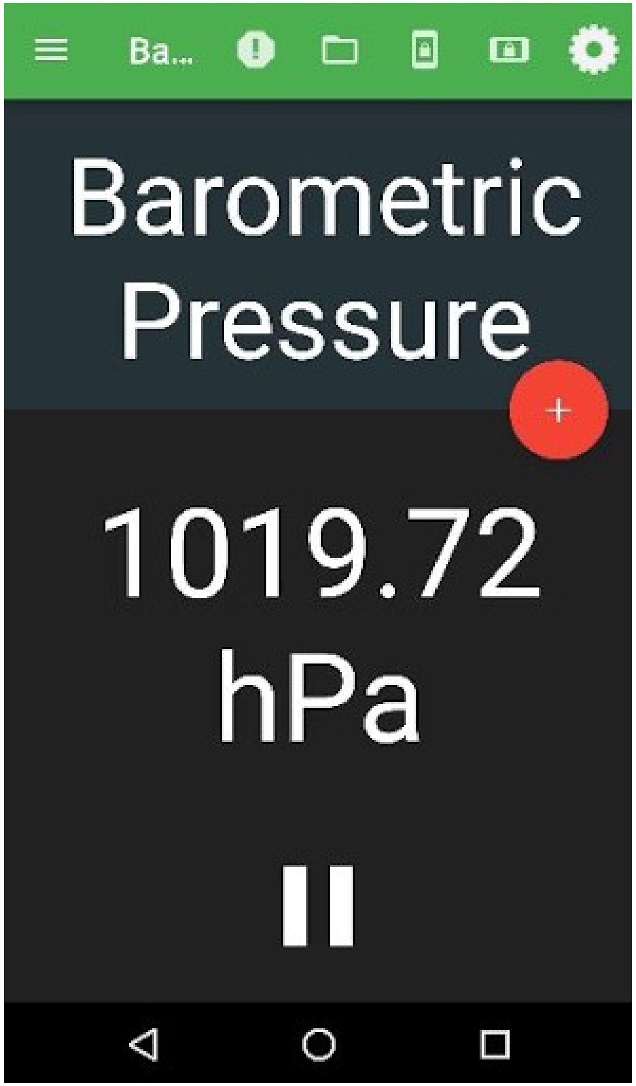
Barometer

- Less attention
- Included in some smartphones →
- Indoor location

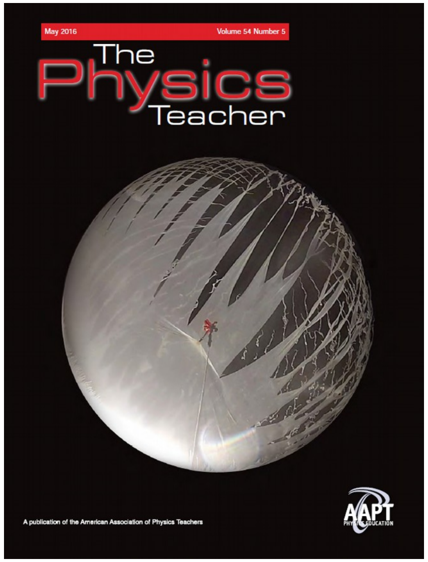


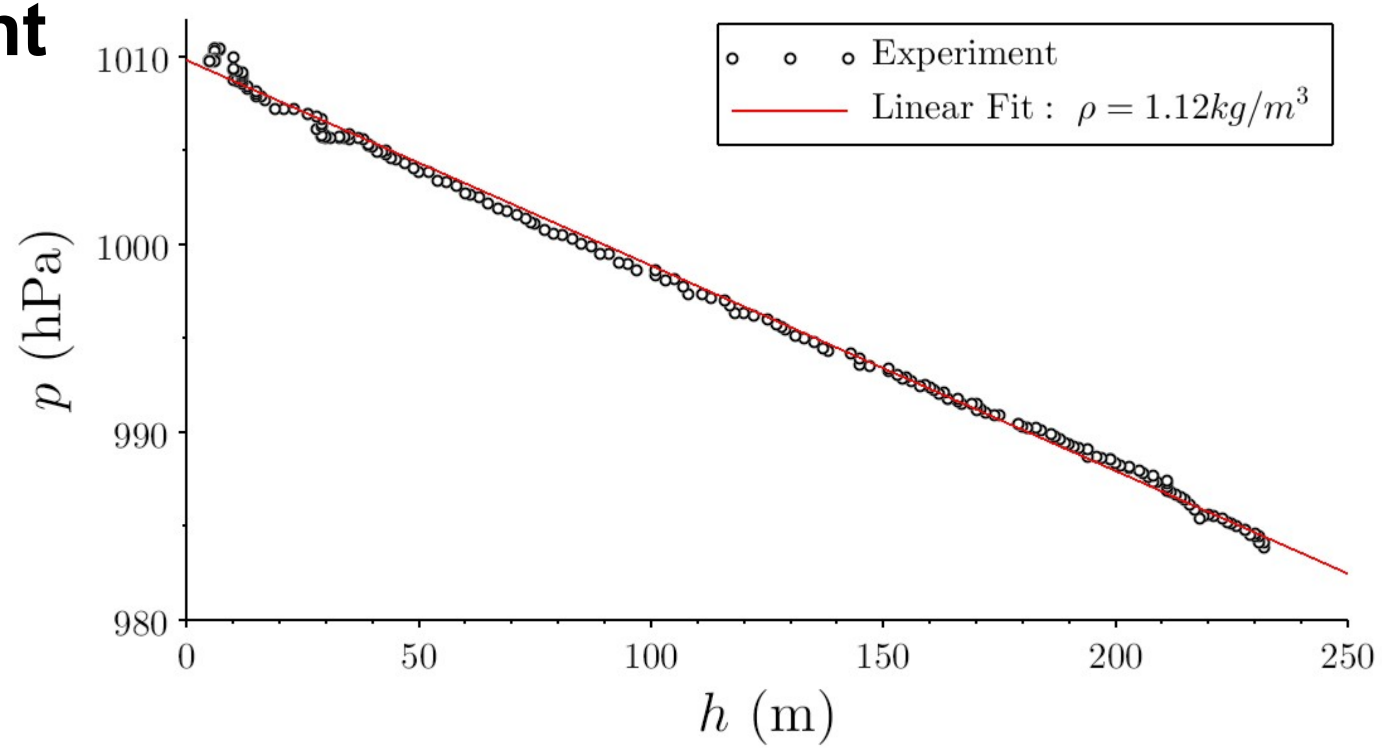
A previous experiment: exploring the atmosphere

- Smartphone attached to a dron
- Simultaneous measurements of altitude and pressure
- GPS and pressure

What did we get?

- Data compared with:
  - International Standard Atmosphere (ISA)
  - Constant density
  - Isothermal
- Adiabatic gradient



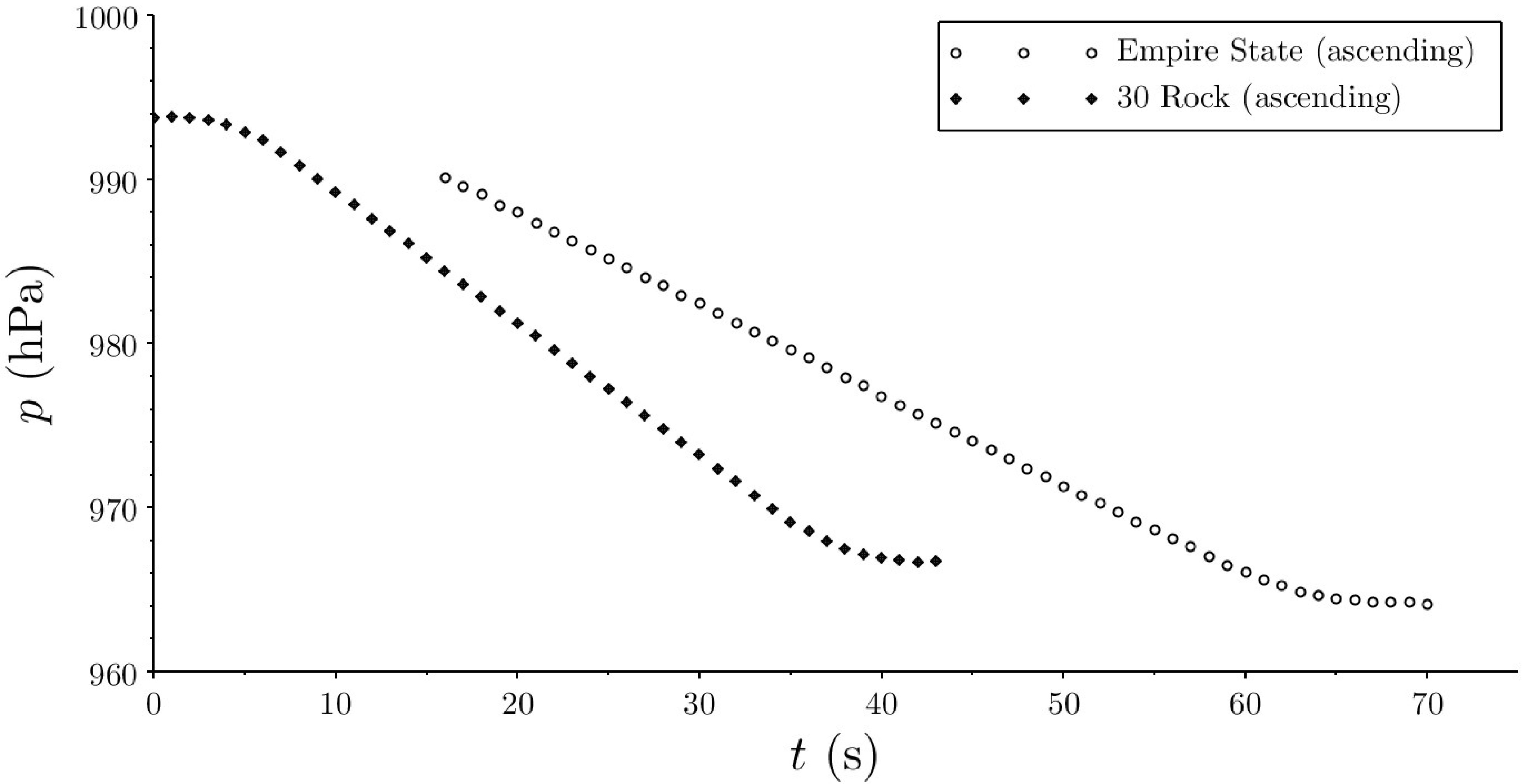


New York, New York

Pressure in elevators

- Empire State Building
- Top of the Rock (Rockefeller Center)

Pressure while ascending

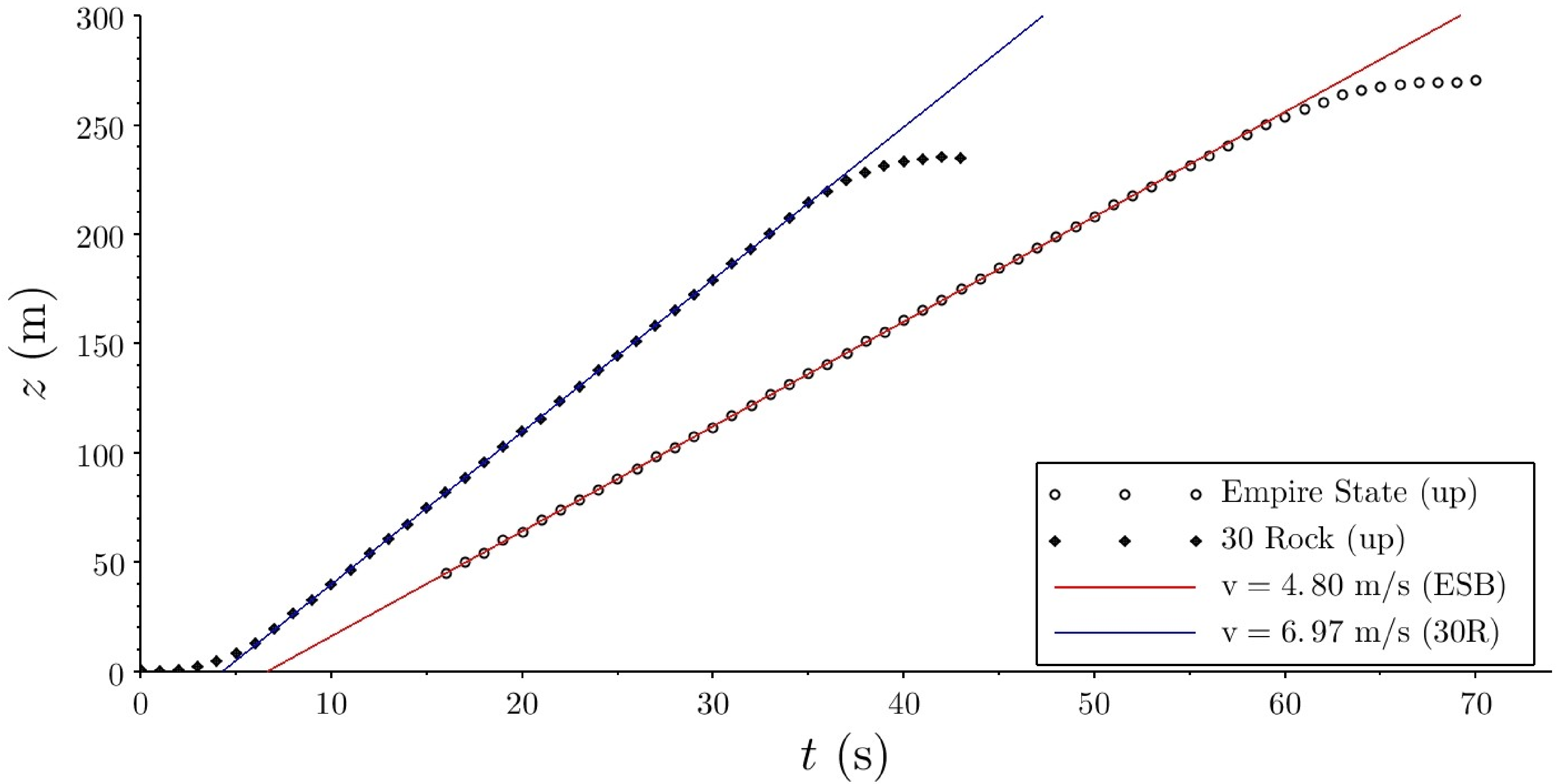


What else could we obtain?

Equation of state (lowest order) → **altitude** as a function of **pressure**

Using also the **time**,
we obtain the **vertical velocity**

Altitude (time) → speed



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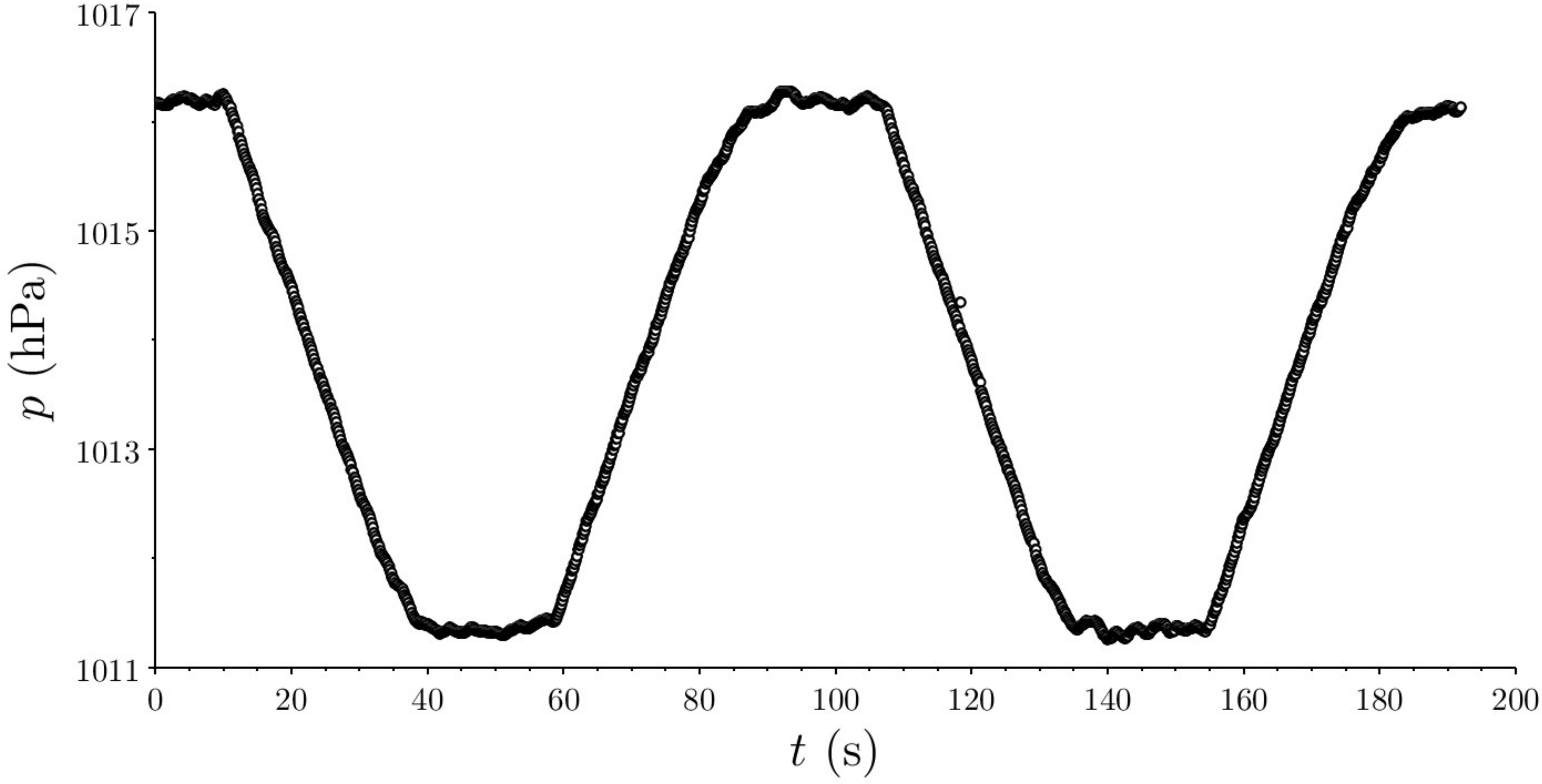
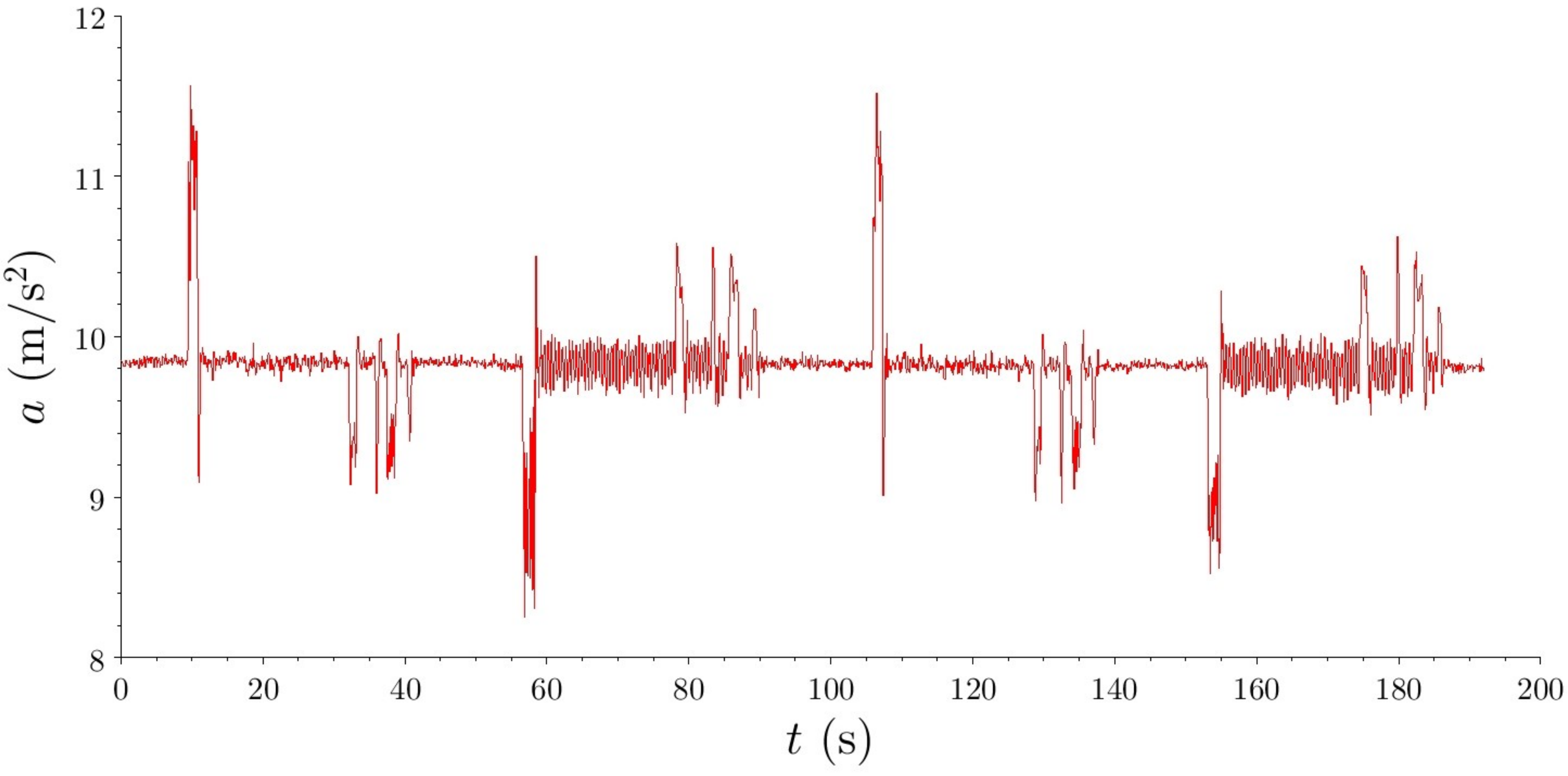
Meanwhile in Montevideo

Faculty of Sciences

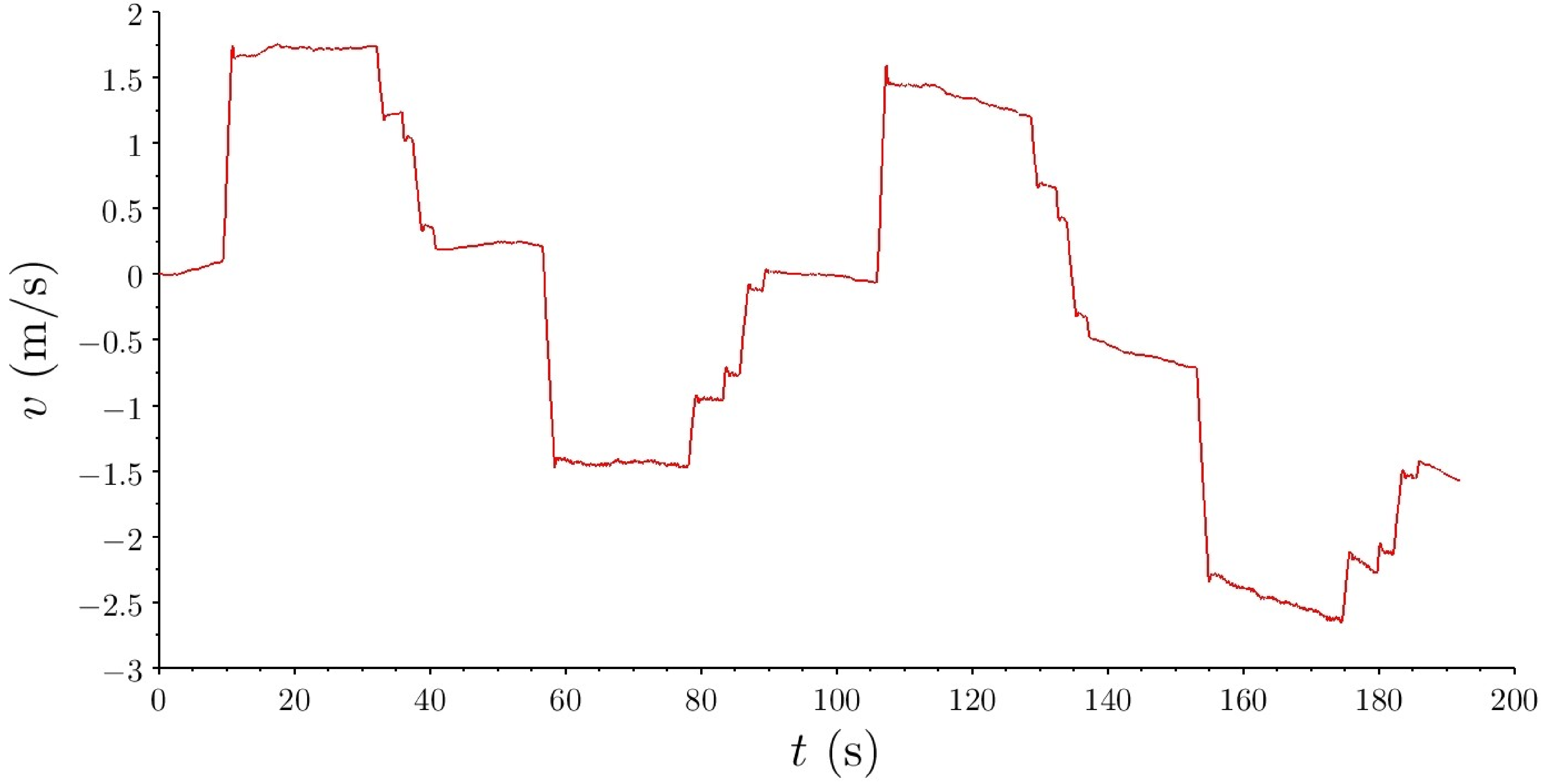
Strolling the elevators



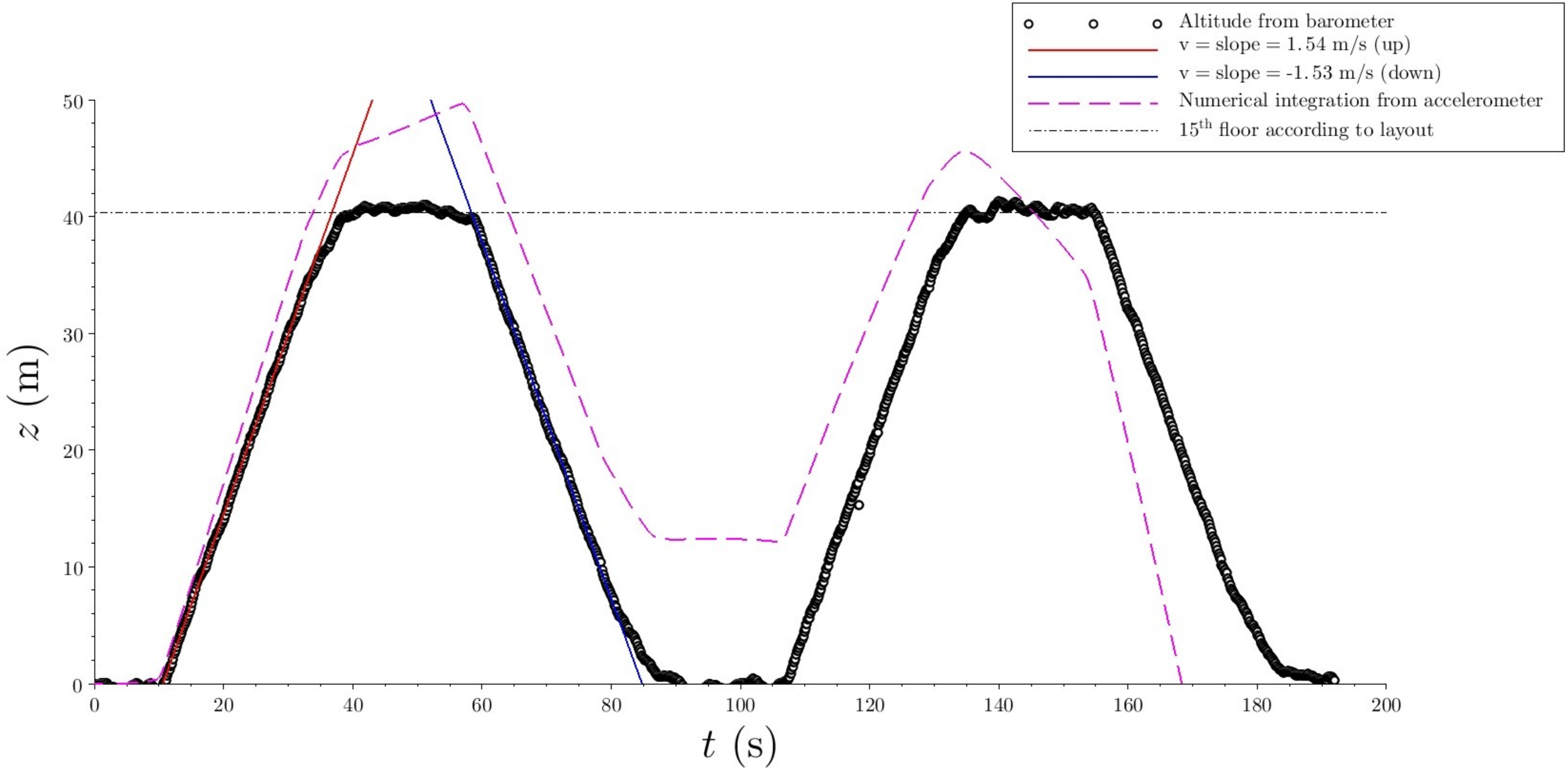
Could we get the **speed** from the **accelerometer**?



Speed from numerical integration of the acceleration



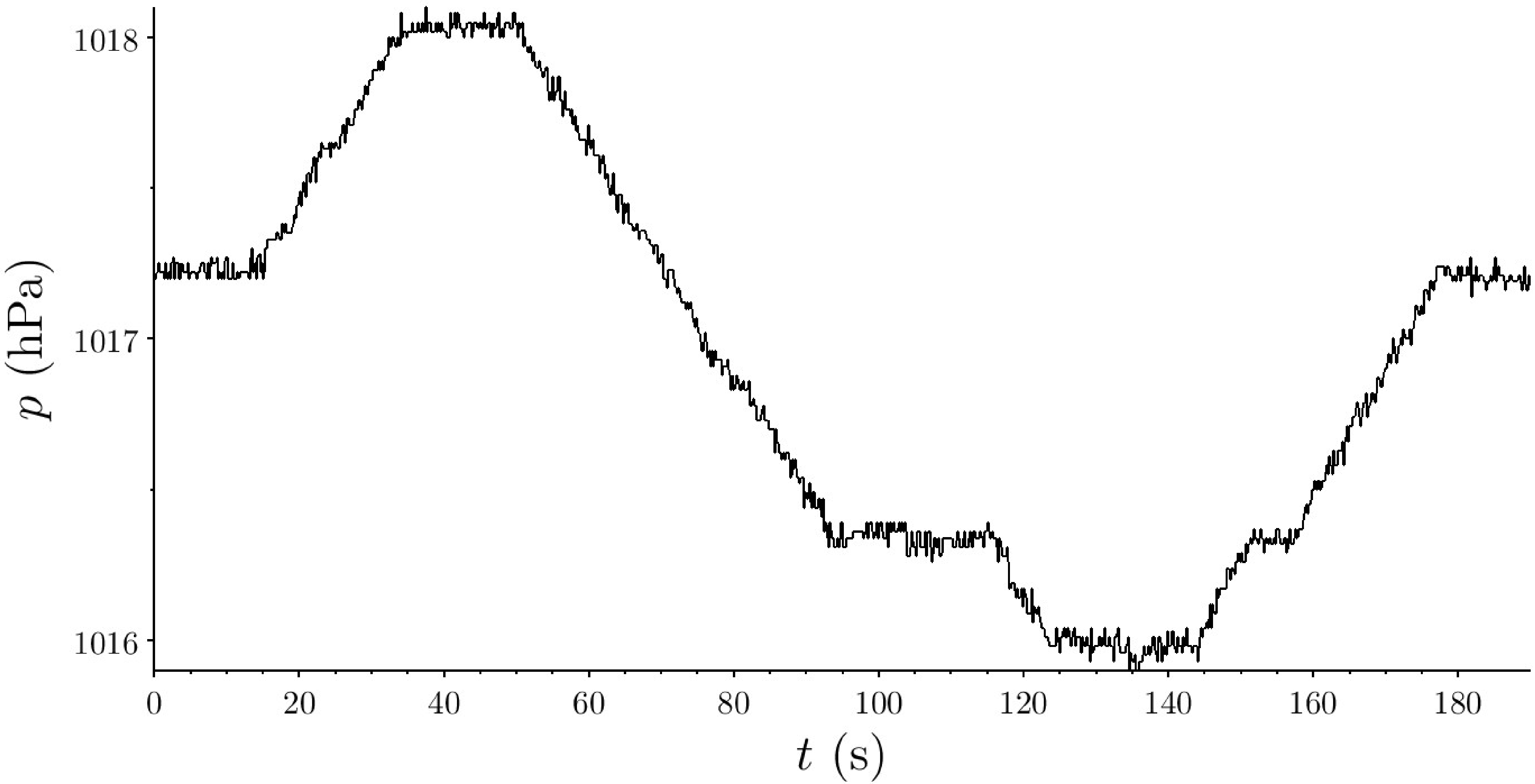
Comparison of both sensors and the architectural layout



What if I have vertigo to the elevators?

Take the stairs!!!!

Going up and down the stairs of ORT University



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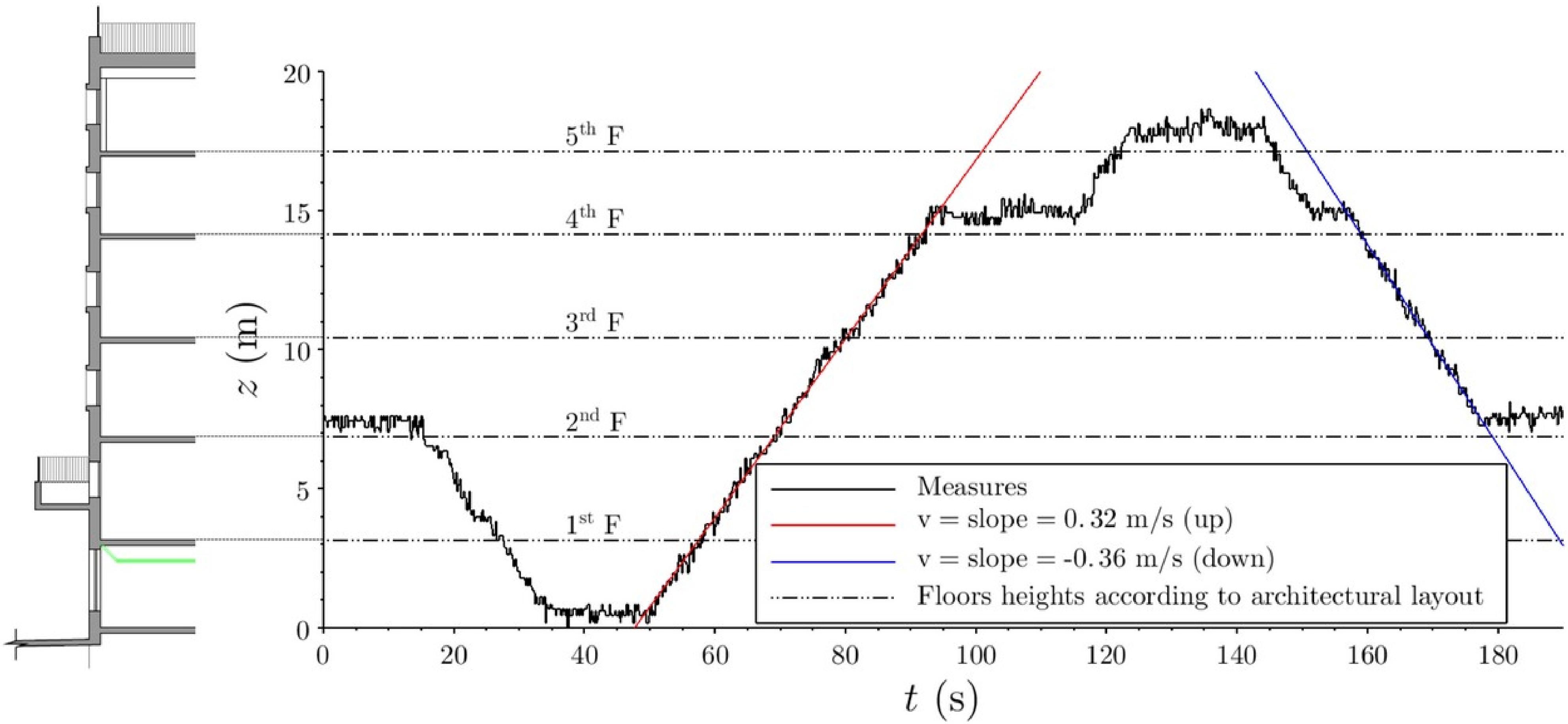
Results



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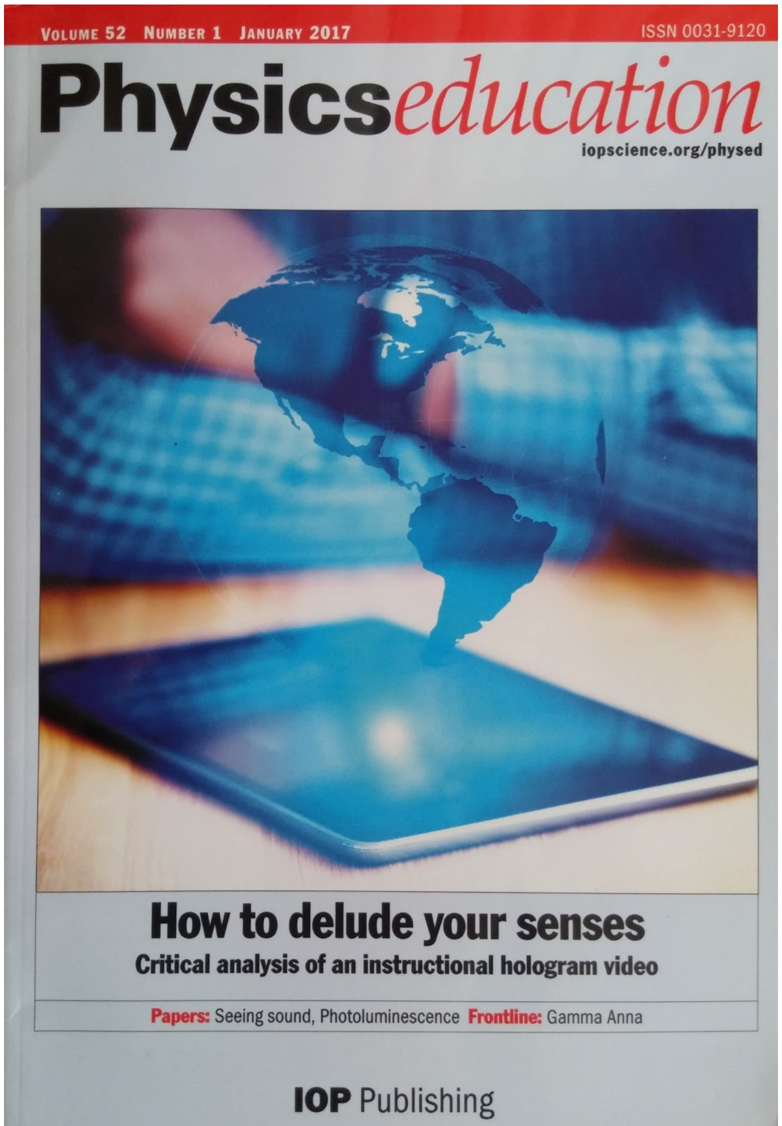
Conclusions

- Barometer: a versatile tool
- Outdoor → exploring atmosphere
- Indoor → elevations and velocities
- Outperforms the accelerometer (or complements)

Martín Monteiro and Arturo C Martí (2017)
"Using smartphone pressure sensors to measure vertical velocities of elevators, stairways, and drones"
Physics Education, 52(1), 015010



PAPER
Phys. Educ. 52 (2017) 015010 (11pp) iopscience.org/ped

Using smartphone pressure sensors to measure vertical velocities of elevators, stairways, and drones

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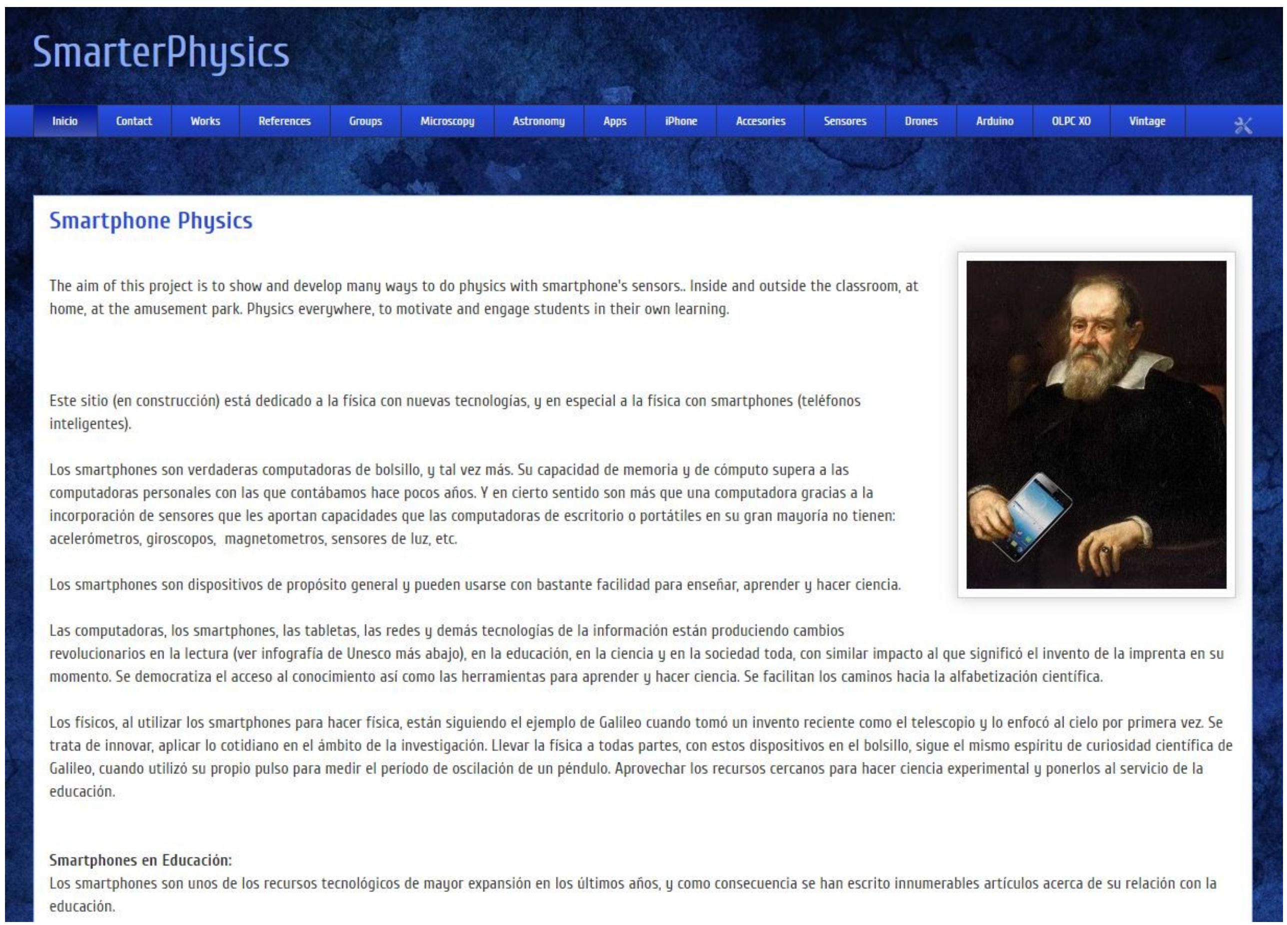
Abstract
We measure the vertical velocities of elevators, pedestrians climbing stairs, and drones (flying unmanned aerial vehicles), by means of smartphone pressure sensors. The barometric pressure obtained with the smartphone is related to the altitude of the device via the hydrostatic approximation. From the altitude values, vertical velocities are derived. The approximation considered is valid in the first hundred meters of the inner layers of the atmosphere. In addition to pressure, acceleration values were also recorded using the built-in accelerometer. Numerical integration was performed, obtaining both vertical velocity and altitude. We show that data obtained using the pressure sensor is significantly less noisy than that obtained using the accelerometer. Error accumulation is also evident in the numerical integration of the acceleration values. In the proposed experiments, the pressure sensor also outperforms GPS, because this sensor does not receive satellite signals indoors and, in general, the operating frequency is considerably lower than that of the pressure sensor. In the cases in which it is possible, comparison with reference values taken from the architectural plans of buildings validates the results obtained using the pressure sensor. This proposal is ideally performed as an external or outreach activity with students to gain insight about fundamental questions in mechanics, fluids, and thermodynamics.

1. Introduction

Smartphone use in physics courses has expanded considerably in recent years. Because of the availability of several sensors in these modern devices (accelerometers, gyroscopes, magnetometer, etc), several experiments can be implemented in laboratories (see past volumes from this journal or ... proposed experiments span a wide range of topics including mechanics [1–7], oscillations [8], waves [9, 10], electricity [11], magnetism [12, 13], and modern physics [14]. The most important advantages of using smartphones are both increasing availability among young people and the decreasing cost (in comparison with other sensors which ...

More information, links, references, papers & projects:

http://smarterphysics.blogspot.com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Inicio | Contact | Works | References | Groups | Microscopy | Astronomy | Apps | iPhone | Accesories | Sensores | Drones | Arduino | OLPC XO | Vintage

Smartphone Physics

The aim of this project is to show and develop many ways to do physics with smartphone's sensors.. Inside and outside the classroom, at home, at the amusement park. Physics everywhere, to motivate and engage students in their own learning.

Este sitio (en construcción) está dedicado a la física con nuevas tecnologías, y en especial a la física con smartphones (teléfonos inteligentes).

Los smartphones son verdaderas computadoras de bolsillo, y tal vez más. Su capacidad de memoria y de cómputo supera a las computadoras personales con las que contábamos hace pocos años. Y en cierto sentido son más que una computadora gracias a la incorporación de sensores que les aportan capacidades que las computadoras de escritorio o portátiles en su gran mayoría no tienen: acelerómetros, giroscopos, magnetometros, sensores de luz, etc.

Los smartphones son dispositivos de propósito general y pueden usarse con bastante facilidad para enseñar, aprender y hacer ciencia.

Las computadoras, los smartphones, las tabletas, las redes y demás tecnologías de la información están produciendo cambios revolucionarios en la lectura (ver infografía de Unesco más abajo), en la educación, en la ciencia y en la sociedad toda, con similar impacto al que significó el invento de la imprenta en su momento. Se democratiza el acceso al conocimiento así como las herramientas para aprender y hacer ciencia. Se facilitan los caminos hacia la alfabetización científica.

Los físicos, al utilizar los smartphones para hacer física, están siguiendo el ejemplo de Galileo cuando tomó un invento reciente como el telescopio y lo enfocó al cielo por primera vez. Se trata de innovar, aplicar lo cotidiano en el ámbito de la investigación. Llevar la física a todas partes, con estos dispositivos en el bolsillo, sigue el mismo espíritu de curiosidad científica de Galileo, cuando utilizó su propio pulso para medir el período de oscilación de un péndulo. Aprovechar los recursos cercanos para hacer ciencia experimental y ponerlos al servicio de la educación.

Smartphones en Educación:
Los smartphones son unos de los recursos tecnológicos de mayor expansión en los últimos años, y como consecuencia se han escrito innumerables artículos acerca de su relación con la educación.