Didactic Press for Remote Experimentation Applied in Spring to Study Hooke's Law

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***Abstract*—This paper describes o development an remote experiment which used an didactic press to study of Hooke's Law in way theoretical-practical. The tests demonstrated that the laboratory has the potential educational, returned as a list of values consistent with Hooke's Law. 40 tests were performed to validate the experiment.**

***Index Terms*—Didactic Press, Hooke's Law, remote experiment, Raspberry Pi.**

I. INTRODUCTION

One of the difficulties of science teaching is the lack of practice and interaction with the phenomenon in study. Often, classes are purely theoretical and expository making the process of understanding and assimilation of knowledge challenging. Because of these difficulties, numerous universities worldwide have been developing remote laboratories and remote experiments, which are environments controlled and manageable to distance, aiming to learning through experimentation [1,2]. These apparatus offer students an insight into the actual process of a system, and can enhance the ability to apply theories learned in the classroom or in books [3]. An important feature is that they stay connected to the World Wide Web at any time, 24 hours a day, 7 days a week [4]. From a pedagogical perspective these technologies promote teaching through observation, the construction of mental models, which are connected to theoretical concepts and principles [5]. These advances are only possible due to advanced technologies and new communication tools, information and automation [1].

A basic knowledge of the manufacturing processes of some products is the phase of elastic material. The knowledge of this property is important for determining the damping capacity or storage of energy in a spring, for instance. The mechanical properties of materials are essential in the design of new products or optimization of existing products [6].

This article describes a remote experiment that seeks to facilitate observation and study of the Hooke's Law in helical springs through a remote didactic press.

A. Objectives

The main objective of this paper is to describe the development of a press didactic Remote Experimentation to perform a compression coil spring car, providing a learning environment of Hooke's Law applied in spring. The Figure 1 shows an overview of experiment components. a) It's the didactic press, b) it's the Raspberry Pi microcomputer, e) It's the control site, d) it's the user side, and c) it's the wide world web for internet access, where interconnects devices a, b, d and e.

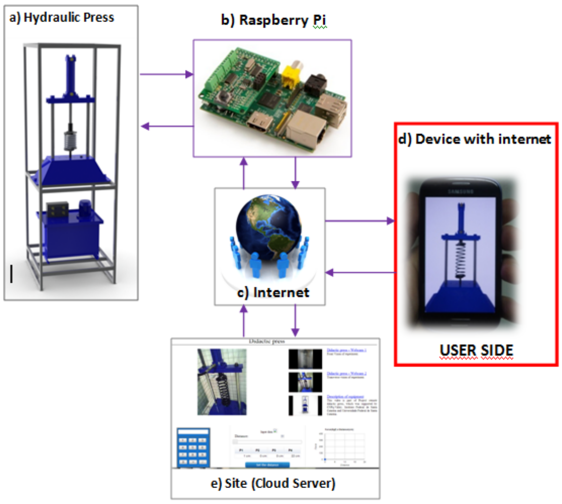

Figure 1–Overview of experiment

II. PARTS OF EXPERIMENT

A. The physical location of experimentation

The didactic press (b) stays in a mechanical structure (a) together of hydraulic unit (d) according Figure 2

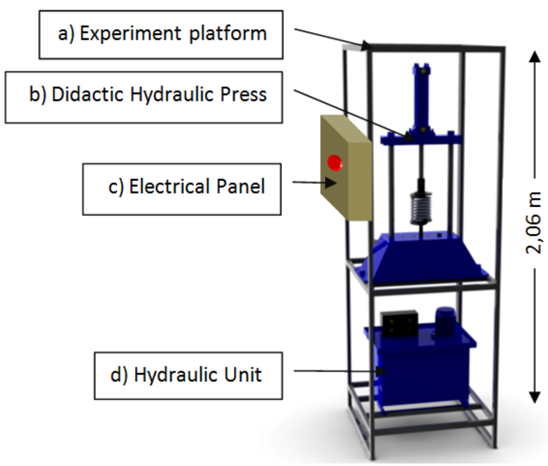

Figure 2. Structure of Experimentation

The hydraulic unit (d) is accountable for provide hydraulic power for the didactic press. The activation of hydraulic unit is done by control panel (c).

B. *The didactic press*

The didactic press (Figure 3) is composed: The hydraulic cylinder (a), the distance sensor (b) the helical spring (c) and the press base (g) are the most important components of the didactic press, because they are responsible for deforming the spring and providing data monitoring. The distance sensor is infrared.

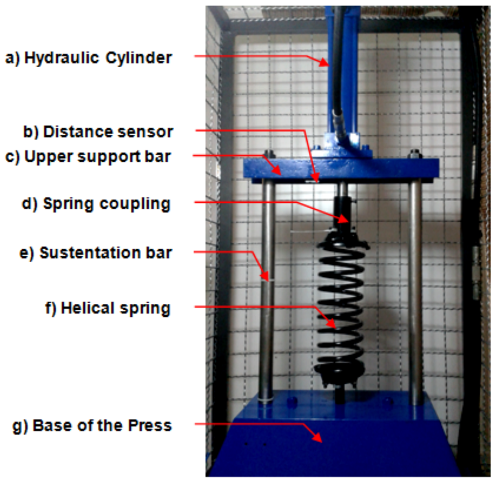

Figure 3. Didactic press

The load cell lays within the base (See details in Figure 4) for measuring the force on the spring.

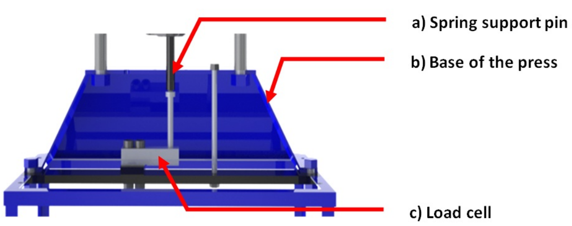

Figure 4. Base of didactic press

C. *Processing central*

In processing central is the Raspberry Pi microcomputer, the switched source (5V+, 12V+), 4 relays and amplifier of load cell.

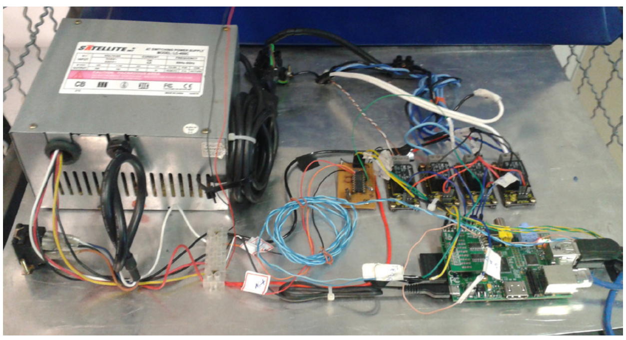

Figure 5. Processing central

The switched source energizes Raspberry Pi (Figure 6), amplifier load cell and solenoids of directional valves.

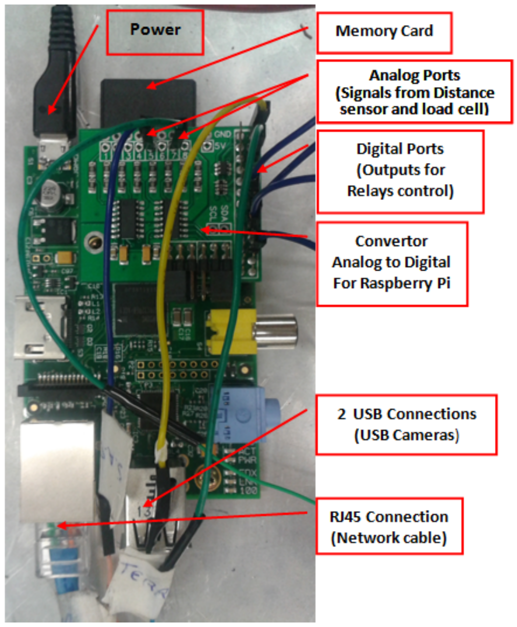

Figure 6. Raspberry Pi

To connect analog sensors of displacement and force (load cell) the Raspberry needs an analog to digital signal converter (ADC) according shown in Figure 7

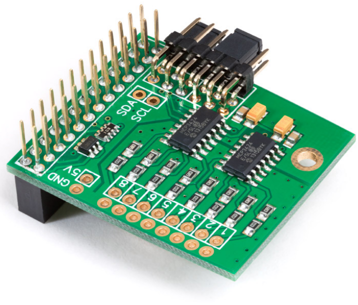

Figure 7. Analog to Digital signal converter

This converter was essential because the raspberry Pi has no analog inputs, has digital inputs only.

D. *The Hooke's Law and the Experiment*

The objective of the experiment is to instigate students to observing and understanding one of the most known material properties, called elastic phase. Robert Hook studied this subject better, what resulted in the elaboration of Hooke's Law that establishes that the deformation of a mechanical spring is proportional to the applied force. In (1) is demonstrated the basic equation of Hook's Law, which students will use for data analysis of experimentation.

$$F = -k.x \tag{1}$$

Where, F is spring force (kgf), x is size variation of spring (cm) and k is spring constant (kgf/cm).

E. Experimentation management

The management and access to experiment is completely done by the Moodle Learning Management System (LMS) (http://www.labtel.com.br) (Figure 8). Beyond content and information, part this environment is responsible for testing, controlling and real-time experiment monitoring. This environment can also be accessed by mobile devices.

F. Performing the Experiment

In order to perform the experiment, students must access the http://www.labtel.com.br site, logging-in and accessing the experiment screen. Before experimentation the user must insert deformation values into the parameters table on the left side of the screen and after clicking the button "Start the experiment". The "Force x Deformation" graphic, created during real time experimentation, is located in the lower right corner of the screen. During this moment, the parameter table is filled in with the respective force for each deformation value, according to that the user configured on the "deformation field" before starting experimentation (to see Figure 8).

Figure 8. Remote experiment website

III. CONSIDERATIONS

The test of experiment done with 40 experimentations (using different points of stop) showed that results have the expected features accordance with Hooke's law.

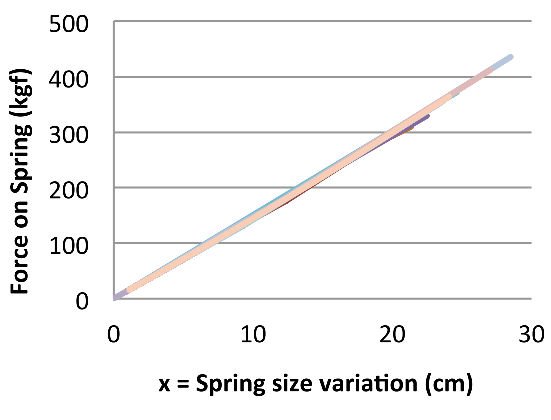

Figure 9. Results of tests in same coordinate axis

Moreover, a visualizing the all graphics plotted in an same coordinate axis, demonstrates that the experiment has an repeatability in its results (see Figure 9).

This provides subsidies to argue that the phenomenon of Hooke's law can be understood through this experiment.

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