Introduction of the multipurpose instrument Meter ZD1301A

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Abstract. The Meter ZD1301A is an affordable multipurpose instrument designed for classroom demonstrations and basic experiments. The device can function as a stopwatch, event counter, RPM meter, digital frequency meter and gamma counter. External components such as photogates, TTL cable for frequency measurements and a Geiger tube can be connected to the device. By introducing our instrument, we hope to encourage physics teachers and students to design and build their own simple laboratory devices.

Introduction

Multipurpose instruments are very practical classroom devises. The Meter ZD1301A [1] was developed to provide a cost-effective option for conducting a variety of accurate high school and undergraduate experiments. The ATmega328P [2] microcontroller-based device (Figure 1.) can be used as a stopwatch, event counter, RPM meter, digital frequency meter and gamma counter. Externally, we can connect eight photogates, TTL cable for frequency measurements and an STS-5 Geiger tube. The architecture of the device allows us to make software modifications and connect additional external sensors.

Our ultimate goal is to inspire students and science teachers to create their own instruments for conducting simple experiments and demonstrations. Here, we will briefly describe a rod pendulum and a fidget spinner experiment in which we used the Meter ZD1303A and highly precise sensors.

Fig. 1. Multipurpose Meter ZD1301A device with a connected Geiger tube.

Experiments

A physical pendulum in the form of a uniform rod suspended by its end has period (T) given by the formula:

$$T = 2\pi\sqrt{\frac{1/3ml^2}{mgx_c}} = 2\pi\sqrt{\frac{l^2}{3gx_c}},$$

where l is the length of the pendulum, x_c is the position of the centre of mass relative to the pivot point, m is the mass of pendulum and g is the acceleration due to gravity. The period is independent of the mass of the rod. To investigate this, we constructed a variable-length pendulum using Lego segments. The pendulum was placed on a platform made from Lego bricks (Figure 2.) and the period of small oscillations was measured using a Meter ZD1301A as an event counter. By plotting the square of the periods versus the length of the pendulum and applying linear regression analysis, we determined the position of the centre of mass from the suspension point to be $x_c = 0.503\ l$.

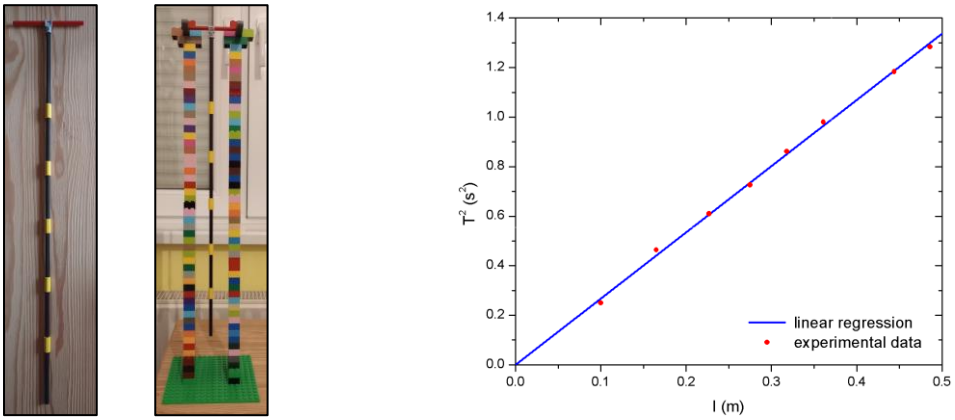

Fig. 2. The rod pendulum made from Lego segments and the pendulum installed on the platform (on the left), and the plot of square of periods versus length of pendulum (on the right).

Fidget spinners are handheld toys designed to be spun between the fingers. Due to their flat structure and low friction between the parts, spinners can rotate at high speeds around the central axis when hit them by an impulsive force. This allows cheap toys to be transformed into fascinating experimental devices. The Meter ZD1301A was employed as RPM meter to study the effects of drag force, dry and viscous dissipative forces. The fidget spinner's central bearing was attached to a fixed vertical axis. An air compressor was used to generate an impulsive force (see Figure 3.). While the air compressor is on, the angular velocity increases, but then declines over time due to frictional forces. The revolution per minute of the spinner versus time is also shown in Figure 3.

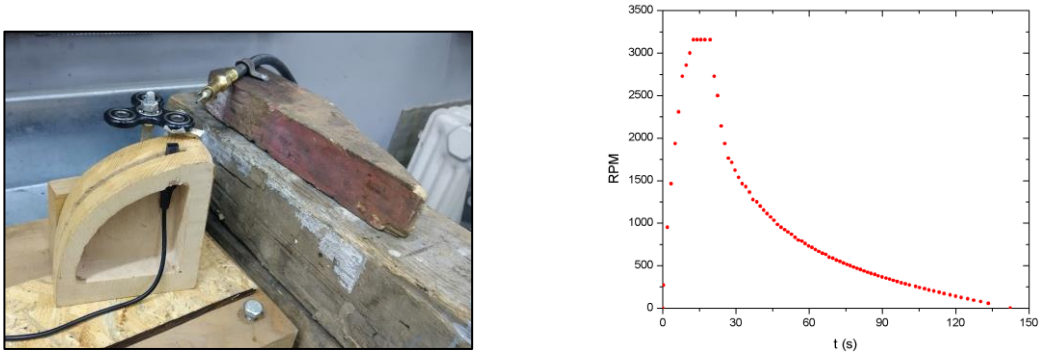

Fig. 3. The fidget spinner, photogate and air compressor's valve in our laboratory (left). The revolution per minute (RPM) of the spinner as a function of time (right).

References

[1] https://drive.google.com/file/d/16pMX9o8qLTQ5CmgxiazOGHirhLKMe4kJ/view?usp=sharing
[2] https://en.wikipedia.org/wiki/ATmega328