PROCEEDINGS OF SCIENCE

Promoting usable skills and analysis methods via introductory physics labs

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Science students encounter multiple challenges with employment or upper-level courses thus teaching them solid lab skills and analysis provide needed solid foundation. The lab for intro-level Physics I and II must provide students with practical experience and laboratory skills that would be further developed by upper-level courses. A new approach was instituted to provide meaningful lab experience to students. This article will highlight the innovative methodology using open-source tracker software and the online access to advanced data analysis accessible to students.

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1. Introduction

Science students face many challenges after graduation, thus teaching them useful lab skills is a step to provided needed support. The laboratory sections of Physics I and II courses must provide a student with the practical experience and initial laboratory skills that would be further honed by upper-level courses such as data analysis.

2.Experimental Lab Design

We present the updated experiments and the innovative methodology that were introduced with the use of the open-source Tracker software (https://physlets.org/tracker/) with additional details available in [1]. This new methodology expanded the number of possible lab experiments, and gives students tools to conduct advanced video analysis and data collection using any PC.

With that approach, the labs are now a progression that introduces skills in a sequence to students, such as use of software for simple analysis, error analysis, making of a presentation and others. The detailed table of the labs and skills they emphasize is provided in [2].

3. Data Analysis Tools

The data analysis starts using spreadsheet software (typically Excel) as it's the most available one. For the first few experiments, it is always possible to choose the variable that has the error much larger over the other and plot it on y-axis. Then, using simple equations [2], get the value of the χ^2/ndf. However, most experiments, specifically those that require high precision (such as showing that Ohm's law is not linear as the resistive wire heats up during measurement), are deeply dependent on both x and y error bars, and proper analysis to be conducted. Also, simple equations from [2] work only for the linear fit and are not very useful in all the experiments such as capacitor charging and discharging. A reader might say that the data can be linearized – yes, it can, and we do that. With the use of the tool that can fit properly the simple exponential and custom function data, such fits can be compared, and the limitations and specifics of the data linearization can be illustrated to students.

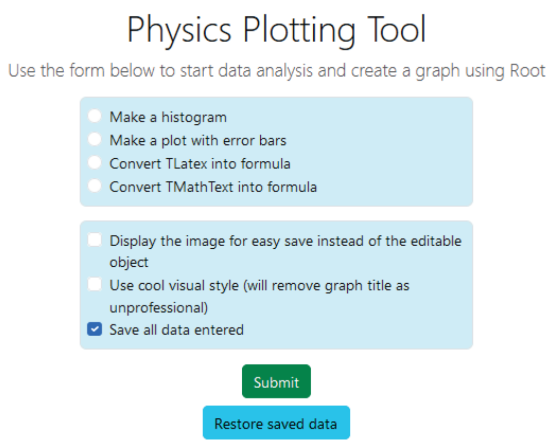

Figure 1. Selection page for the Physics Plotting Tool.

For this purpose, the Physics Plotting Tool, a web-based simple interface to ROOT [3] has been developed and made available to the public (https://sos.clayton.edu/physics/chi2). The website engine is written in python using pyRoot, and the viewer for the produced file is using

JSRoot (https://root.cern.ch/js/). An effort has been made to make the tool resilient to common mistakes that student make in the data entry. The use of this tool can go beyond the intro physics courses and be used in actual research such as [4] or [5] to reduce the time needed for the students to start working with ROOT.

4. Physics Plotting Tool Description

Figure 1 shows the selection page of the Tool. The available options are to make a histogram or a plot, and to convert equation written in LaTeX or MathText into image. A user is encouraged to create the account so that the current session will be remembered and restored at the next login.

For the histogram and plot options, there are fields to enter the data and the field to choose the fitting function (Figure 2). A familiar ROOT syntax is used here.

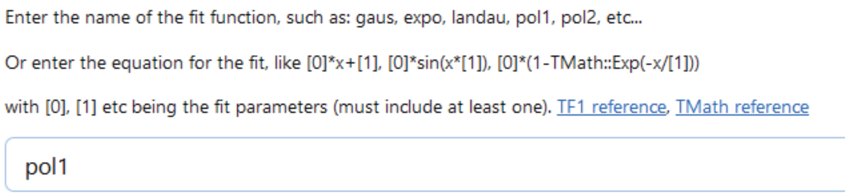

Figure 2. Fitting function specification for the Physics Plotting Tool.

5.Conclusion and Future Plans

The Physics Plotting Tool has been a high success with students both in the introductory physics labs as well as when starting research projects. Further development of the tool is planned.

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