**Affordable Learning Georgia Affordable Materials Grants  
Continuous Improvement Grants Final Report**

*(or Mini-Grants, for R17 and earlier)*

# General Information

Date: 12/10/2022

Grant Round: Round 20

Grant Number: M174

Institution Name(s): Clayton State University

Team Members (Name, Title, Department, Institutions if different, and email address for each):

Dmitriy Beznosko, assistant professor, Dept. of Chemistry and Physics, [dmitriybeznosko@clayton.edu](mailto:dmitriybeznosko@clayton.edu)

Tatiana Krivosheev, professor, Dept. of Chemistry and Physics, [tatianakrivosheev@clayton.edu](mailto:tatianakrivosheev@clayton.edu)

Project Lead: Dmitriy Beznosko

Course Name(s) and Course Numbers:

PHYS 2211L (Principles of Physics I Laboratory)

PHYS 2211L (Principles of Physics II Laboratory)

Final Semester of Project:

Fall 2022

***If applicable to your project:***

Average Number of Students Per Course Section:

For PHYS 2211L: 24

For PHYS 2212: 15

Number of Course Sections Affected by Implementation of Revised Resources:

4 per year, 2 sections of 2211L and 2 sections of 2212L

Total Number of Students Affected by Implementation of Revised Resources: 78

# Project Narrative

*Describe the course of your revision or ancillary creation project, including*

* *A summary of your project’s purpose, plan, and timeline.*
* *The original works which were revised or added to, with links. For example, if you revised an open textbook, give the title, author, and link.*
* *A narrative description of how the project’s plan was carried out.*
* *Lessons learned, including anything you would do differently next time.*

The idea behind this improvement project was to re-think the entire introductory labs sequence. Note that at CSU the PHYS 2211-2212 sequence is typically taken by students in their sophomore or even junior year, thus a slight adaptation to your circumstances may be needed. The same manuals can be used for PHYS 1111L and 1112L algebra-based courses, and manuals indicate with parts are not suitable for the lower-level intro courses, such as avoiding the use of derivatives and reducing number of derivations, etc. However, these manuals are not designed to support the pre-med and bio students specifically and are generic by design.

In our vision, the intro lab sequence should not only support the lecture material but provide to students the important lab skills and tools and can be used in subsequence courses (such as advanced labs in PHYS, CHEM and others) or outside of the classroom in everyday life. To achieve this goal, and to provide lab delivery format flexibility, the following features were introduced:

Use of Tracker software (<https://physlets.org/tracker/>) to analyze videos and data, do plotting and fitting with different function at higher-then-spreadsheet level. This gives the flexibility for the video of the experiment to be taken during the lab session, at home if needed as during a pandemic, or can be provided to students.

Use of simple statistical and mathematical instruments such as: measurement errors and sources, data window selection effect on the mean and standard deviation, error bars plotting, , error propagation, plot of residuals and area under the curve is introduced throughout the experiments.

Introduction of the lab format that is following the science paper.

As well as the updated and exciting experiment ideas, such as the deviation from the linearity of Ohm’s law, the direct measurement of the equality, the pendulum period depends on the initial angle and others.

The following materials were created towards this goal: video tutorials for Excel and Tracker, lab manuals for each experiment, supplemental materials such as templates for the students and videos for the offline analysis.

The materials after creation were tested in the real lab setting (2211L in Summer and Fall semesters, 2212L only in the Fall), all noted typos and mistakes, etc., were corrected. Clarifications were added following students’ questions and common mistakes in the reports.

These materials will be updated as needed for their continuous use at CSU.

# Materials Description

*Describe all the materials you have created or revised as part of this project. These descriptions may be used in the* [OpenALG](https://alg.manifoldapp.org/) *repository description field. Include the* [*open license your materials will be shared under*](https://creativecommons.org/share-your-work/)*—for most materials, this will be an Attribution 4.0 License (CC BY) as required in the Grants Request for Proposals.*

Two tutorial videos were created and placed on YouTube for the students to watch. One video shows how to use Excel for the specific needs of the labs (such as plotting error bars and doing simple fits and linear regressions). The other video is a Tracker tutorial that covers all needed parts for the labs – import and analysis of the video as well as the import and analysis of the data from the csv file.

A total of 24 lab manuals were written from scratch (12 for each semester). The lab manuals follow the science paper format as well. For the clarity, each lab lists the new skills that it introduces following the lab title.

Three presentations that introduce the notion of mean, standard deviation, confidence interval, as well as the partial derivative and error propagation.

A number of video materials, images and data files that are used in experiments.

# Materials Links

*If you are hosting your materials in places other than OpenALG, please provide these links in this section. Otherwise, leave blank. Note: we cannot access D2L or Canvas links.*

A playlist of YouTube materials (to both videos): <https://www.youtube.com/playlist?list=PLra9sbnMdYHMAmAMSn3SePo3jl2avmk1y>

A direct link to Excel tutorial video: <https://www.youtube.com/watch?v=gyvmuZIzwnk>

A direct link to Tracker tutorial video: <https://www.youtube.com/watch?v=IrD10scYpsA>

A link to two archive zip files that contain all other materials for PHYS2211L and PHYS2212L separately.

<https://drive.google.com/drive/folders/1DCCyWRPaEJjGtecfNbQbj9d259gcCMht?usp=sharing>

# Future Plans

* *Describe any planned or actual papers, presentations, publications, or other professional activities that you expect to produce that reflect your work on this project.*
* *Describe any plans to revise or add to these materials in the future.*

CURRENT PUBLICATIONS AND PRESENTATIONS:

The intermediate results (PHYS2211L only) from this project were presented at Teaching matters 2022 conference at Gordon college, SACS-AAPT Meeting in Fall 2022 as well as at ICHEP2022 International Conference. The latter presentation also resulted in the publication:

<https://pos.sissa.it/414/368/pdf>

D. Beznosko, T. Krivosheev and A. Iakovlev. “Innovations in teaching of the Physics laboratories”, PoS(ICHEP2022)368 pdf, 2022

FUTURE PLANS:

Present the completed results from this project in the Outreach and Education section of ICRC2023 International conference (<https://www.icrc2023.org/> ), or TAUP2023 International conference (<https://indico.cern.ch/event/1199289/program> ) or a similar conference. Subject to COVID, political situation and other global factors.

The future improvement plans include writing separate manuals for the PHYS 1111L – 1112L, as these courses are taken by Biology and pre-med students, thus making labs tuned towards these subjects will be a great idea and an interesting challenge.