Summer 2019

Principles of Physics II (GA Southern)

William Baird
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Grants Collection

Affordable Learning Georgia Grants Collections are intended to provide faculty with the frameworks to quickly implement or revise the same materials as a Textbook Transformation Grants team, along with the aims and lessons learned from project teams during the implementation process.

Each collection contains the following materials:

- **Linked Syllabus**
  - The syllabus should provide the framework for both direct implementation of the grant team’s selected and created materials and the adaptation/transformation of these materials.
- **Initial Proposal**
  - The initial proposal describes the grant project’s aims in detail.
- **Final Report**
  - The final report describes the outcomes of the project and any lessons learned.

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Initial Proposal
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Application Summary

Competition Details

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Application Information

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Baird, William - #2580 1 of 19
No-or-Low-Cost-to-Students Learning Materials

Course Title(s)
Principles of Physics II

Course Number(s)
PHYS 2212K

Team Member 1 Name
William Baird

Team Member 1 Email
wbaird@georgiasouthern.edu

Team Member 2 Name
Jeffery Secrest

Team Member 2 Email
jsecrest@georgiasouthern.edu

Team Member 3 Name

Team Member 3 Email

Team Member 4 Name

Team Member 4 Email

Additional Team Members (Name and email address for each)

Sponsor Name
Delana Nivens

Sponsor Title
Dean, College of Science and Technology

Sponsor Department
College of Science and Technology

Original Required Commercial Materials (title, author, price)

Average Number of Students per Course Section Affected by Project in One Academic Year
24

Average Number of Sections Affected by Project in One Academic Year
4

Total Number of Students Affected by Project in One Academic Year

Baird, William - #2580
Average Number of Students Affected per Summer Semester
0

Average Number of Students Affected per Fall Semester
48

Average Number of Students Affected per Spring Semester
48

Original Total Cost per Student
$150-$355 (see Statement of Transformation)

Post-Project Cost per Student
$32.50

Post-Project Savings per Student
$117.50-$289 (see Statement of Transformation)

Projected Total Annual Student Savings per Academic Year
$11,280-$27,740 (see Statement of Transformation)

Using OpenStax Textbook?
Yes

Project Goals
We plan to enhance student success and engagement while reducing the financial burden associated with taking a university physics course. We will move from the WebAssign OHS (online homework system, providing randomized problems and computerized grading of homework) and the Halliday & Resnick physics textbook to the new OpenStax University Physics text and the ExpertTA OHS. We will use open source software as well as hardware (i.e., designs/licenses freely available to anyone wanting to produce their own hardware) to provide our student population with skills in programming and data collection that they are likely to use in future classes and in whatever job or graduate school may follow. We hope to see increased learning gains and higher levels of student engagement and satisfaction, as well as lower DFW rates.

Statement of Transformation
Recently, we were awarded a Textbook Transformation Grant, completed in 2018, for PHYS 2211K (introductory mechanics – note that the “K” represents the fact that the lecture and lab portions of the course are now combined into the same time slot so that the division of time between lecture and lab can be altered to match weekly needs and instructor preferences). This grant involved the adoption of the OpenStax textbook and the creation of video homework solutions. We used the newly-available class time to introduce some basic computer programming using VPython (an open-source package built to make illustrating physical concepts easier). We felt that this was an all-around improvement for both faculty and students; faculty did not have to spend an hour a week solving essentially the same problems each semester and stronger students did not have to sit through solutions of problems they had already mastered. Weaker students were also able to watch solutions repeatedly if the process did not “click” for them the first time through.

Replacing our current Halliday & Resnick book with the OpenStax University Physics series will result in a significant cost savings for our students. From the 2017-2018 Georgia Southern Common Data Set *, books and supplies are projected to represent, on average, 15% of the total cost of in-state tuition, fees, and books/supplies. Our numbers indicate that if not for our careful attention to costs, PHYS 2212K would be disproportionately expensive in this regard. We can say that it is difficult to accurately and honestly calculate the effective savings. We have for some years made an effort to reduce student costs by not using the latest edition of a textbook. We find very few substantive changes from edition to edition, but the latest edition of our current book is available at Amazon for an astonishing $267. Used copies start at $195 and even a semester-long rental, which we believe is a truly false economy for a subject which is foundational for many of our students, is over $70. By using the 9th edition instead of the 10th, students can buy a used copy for about $60.

The online homework system (OHS), WebAssign, is almost three times the price of the system we are planning to use if the proposal is funded. To be fair, the WebAssign fee of $90 includes an electronic copy of the textbook, but that copy expires after one semester. For an additional $30, students can use that particular edition on WebAssign forever (as long as the course they are taking uses that edition; it is not transferrable to another edition or to another student). Whether in electronic or physical form, we believe the text will be a reference for at least some of these STEM students for some years to come – we are not interested in the philosophy that treats these materials as something to rent for one semester and then discard.

The larger problem is that old editions will not be available forever, even at Amazon; our bookstore has complained to us many times that they cannot source old editions in quantity. The WebAssign OHS currently provides both the 9th and 10th editions of our current book, but no older editions are usable. The license agreement requires us to certify that we are using a particular text, and we can only choose problems from that text. Therefore, even if we had a large supply of old editions, they would eventually age out of the homework system. If we didn’t care about student expenses at all (and if we wanted to improve the apparent savings figures for this application), we would require the 10th edition.

We administered the attitude survey that was part of our previous ALG grant in Fall 2017 to our 2211K students who were using the Halliday & Resnick book, and we also gave the survey to our Spring 2018 2211K students who used the OpenStax book. When responding to the statement “Buying the textbook was or would have been a significant financial strain”, two thirds of the students in each course (n=28 in Fall 2017, n=26 in Spring 2018) answered “Agree” or “Strongly Agree”. In a more worrying development, there is a section where students can rank the utility of various learning aids from 5 (very useful) down to 2 (not at all useful) and then 1 (did not try to use). We found 36% of the students in the Fall answered “did not try to use” to the question about the textbook. While this does not prove they did not buy the book (and we regret not adding this question specifically), it certainly suggests it. Finally, 21% of the students both reported not using the book and that buying it would have been a financial hardship.

Transformative Impact - We would now like to bring our PHYS 2212K (electricity & magnetism, light & optics) into alignment with our transformed PHYS 2211K. We again propose to introduce video solutions of homework problems to recapture class time, but we now plan to move beyond VPython since our students will have already used that in PHYS 2211K. We now want to integrate the Arduino system into our labs. Briefly, Arduinos are microcontroller boards which are open-source hardware and they are programmed in an environment which is also open-source.

This means that anyone can build and sell his/her own Arduino-compatible clone, and this has served to drive the price of the clone hardware down to less than $20 for each basic setup. There is an enormously large ecosystem of Arduino programs already available for download, so it is quite easy to get started. The programming environment shares similarities with Java and C++, but was designed to be friendly to non-STEM users. We plan to implement three lab exercises which will involve experiments similar to those we (and most other universities) already do, but which will be performed in this case with Arduinos rather than multimeters, oscilloscopes, etc.

Because our student population is almost exclusively STEM majors, familiarity with programming and sensors/data collection will allow them to connect the topics discussed in physics with real-world problems. As in the previous ALG grant, the goal is not to turn the introductory physics sequence into a substitute for any computer science course; our aim is merely to show the students how simple it can be to get started, and the commonalities between different
programming environments (since they will have had some experience with VPython by the time they encounter the Arduino).

We have calculated the savings based on our expectations for 2019. We have typically had two 24-person sections of PHYS 2212K, one in the spring and one in the fall. Our projections (reflected in our schedule currently being created for spring) are that we will need twice that many sections in 2019, as we are already seeing an increase in the 2211K population. Since first being announced, the merger has promised many more engineering students on campus, all of whom must take both semesters of calculus-based physics. Chemistry & Biochemistry majors (most of whom formerly took the algebra-based sequence 1111/1112) will now all take 2211/2212. According to the 2016 Armstrong Fact Book *2 (the last one available before consolidation), Chemistry and Biochemistry had a total of 213 majors. This alone, ignoring engineering or any projected growth, would approximately double the 2018 enrollment.

We are also discussing the implementation of our previous ALG grant for 2211K with our new colleagues in Statesboro, and they have so far been receptive. We are planning to submit an application in the next round under the Scaling Up OER category. Our hope is that, should this application be successful, the joint physics faculty will have a cohesive two-semester solution involving the key elements of both proposals and will therefore greatly magnify their effects.

The idea that introductory physics courses are great places to learn programming is not an original one. Even a cursory review of the literature of Physics Education Research (PER) shows that programming has been used to augment introductory physics classes *3 *4 *5 *6 *7 for 50 years or more, from the venerable FORTRAN to the Arduino itself. We introduced programming through Microsoft Excel years ago, but we have moved our focus to open-source offerings such as Python (e.g., the recent ALG grant) and this would further that transition. The added benefit to the students in this case is that if one of our Arduino labs does spark their interest in sensors and data collection, they will be able to acquire their own system for home use and experimentation for $50 or less rather than the multi-thousand-dollar expense associated with some physics lab equipment.


**Transformation Action Plan**

Drs. Baird and Secrest will jointly identify appropriate homework problems from the collection available through ExpertTA. Dr. Baird will record video solutions to all problems to be posted after the due date for each homework. Since Summer 2016, Dr. Baird has recorded over 700 videos solving homework problems (about 175 per course, including 167 with closed captioning for the ongoing Textbook Transformation Grant for 2211K) and has found the time spent doing so is worth the recovered class time. Dr. Secrest will handle the IRB application (which we expect to be judged either exempt or eligible for expedited review as the attitude survey is essentially the only item at issue).

The PIs will work together to identify suitable Arduino-based labs in the literature (viz. Refs. 6 and 7) and/or develop their own. Since PHYS 2212K is focused on electricity and magnetism, including circuits and optics, we already have plans for some exercises but will remain open to better ideas that may already be available. Any instructor who may have an interest will be provided with the lab materials. We especially hope to see our new colleagues adopt some of these activities. The extra class/lab time needed to add these programming assignments will come from the time recovered by the use of video homework solutions.
Quantitative & Qualitative Measures

The materials will be used for PHYS 2212K in Spring 2019. We have long employed a standard assessment instrument known as the Conceptual Survey of Electricity and Magnetism (CSEM), a widely-used 32-question test of concepts discussed in second-semester physics courses. We have (and will) administer this as a pre/post-test. The normalized gain, defined as \((\text{post} - \text{pre})/(32 - \text{pre})\), where \(\text{pre}\) and \(\text{post}\) are the CSEM scores at the beginning and end of the semester, will be calculated. This number is commonly reported in the Physics Educational literature, since it quantifies the student’s prior familiarity with the subject. We will compare this gain with existing CSEM results gathered at GSU-Armstrong in past semesters. Drs. Baird and Secrest offer extra-credit incentives to students based on performance on the final CSEM to ensure that students try to do well on it.

Students will be given a survey about the text (attached) and their use of it, as well as the other course resources available (video homework solutions, online class notes, etc.) and their answers will be compared with data gathered during the previous semester. This will allow us to record student attitudes and opinions about the course materials, as well as providing them the opportunity to mention other resources they found to be helpful. We will investigate any student proposals for these added resources, and adjust our focus on existing materials in response to the multiple-choice questions. Finally, DFW rates will be compared to historical averages.

We have been informed that this will require IRB approval, but we do not foresee any difficulty in obtaining it. The surveys will be anonymous from their creation, and we have always destroyed our assessment test sheets after recording the data from them. We only report class-average normalized gains when discussing student performance in our courses.

Timeline

October 1, 2018 – As soon as notification of the award is received, the PIs will begin to identify homework problems and laboratory exercises. Dr. Secrest will prepare the IRB paperwork for submission for both Fall 2018 PHYS 2212K and Spring 2019 PHYS 2212K so that we may gather survey data before and after the transformation.

October 15, 2018 – We expect to have chosen most, if not all, of the homework problems at this point and Dr. Baird will begin recording video solutions while Dr. Secrest starts planning the particular activities to be performed in each lab and orders necessary supplies.

November 15, 2018 – We estimate Dr. Baird will have recorded one half to two thirds of the homework solutions by this point. These are more time-consuming than might otherwise be expected due to the necessity to add closed captioning to the videos. While YouTube does some of this automatically, there is a great deal of editing required when going over equations and other concepts from physics problems that don’t typically appear in YouTube dialog. Dr. Secrest will have two of the three labs finalized at this point.

November 30, 2018 - Last day of classes. Dr. Baird will administer the CSEM as a post-test and the Student Survey of Course Resources (SSCR).

December 15, 2018 – By this time, the homework solutions should be finished as well as the lab exercises. We expect to be ready for the Spring semester, but this timeline will give us an additional month before classes actually start in case there are unforeseen difficulties.

January 14, 2019 – Classes begin at GSU-Armstrong. Dr. Baird will administer the CSEM pre-test during the first PHYS 2212K class.

Spring Semester, 2019 – The PIs will meet regularly to discuss the progress of the course and any issues with labs or homework videos. If needed, adjustments will be made to these materials.

May 3, 2019 – Last day of classes. Dr. Baird will administer the CSEM as a post-test and the Student Survey of Course Resources (SSCR).

Summer 2019 – The PIs will assemble the data from the DFW rates, the CSEM tests, and the SSCR surveys. We will perform tests of statistical validity on our data and prepare the final report.

Budget
We request $5,000 salary for each PI. We also request $800 to be used for supplies and travel. The supplies are expected to consist of Arduino boards and sensors, while the travel funds would be used for registration, mileage, and hotel expenses for events such as the required kick-off meeting and/or conferences where the results of this work may find an audience (e.g., SACS-AAPT, etc.).

Salary, Dr. Baird - $5,000  
Salary, Dr. Secrest - $5,000  
Travel and Supplies - $800  
Total - $10,800

**Sustainability Plan**

We believe the sustainability is the easiest part of this process. When we talk to faculty, it seems the largest hurdle to overcome in a course transformation is inertia; if things are already working well, change for the sake of change or for minimal benefit will not be received warmly. To be clear, the content provided in the current Halliday & Resnick book is excellent, as are the homework problems found there. If price were not a factor, we would not consider a change.

Our sole objection to the text we use now is financial: when a new book is approaching the $300 mark, and the difference from one edition to the next would be hard to see without a careful dissection, it begins to gnaw at the conscience to require it. On a more practical level, we know that a sizable fraction of the students will just not buy a book that expensive. Perhaps there are some disciplines where everything in the text can be fully covered in classroom lectures, but physics is certainly not one of them. We’re shocked at the prices of the books, but in their defense, they do exceed 1200 pages!

While the OpenStax book may not quite be at the level of Halliday and Resnick yet, it is in our opinion more than good enough to justify the trade. Once we have changed over all of our homework assignments and video solutions, and we know we are saving the students quite a bit of money, it is frankly hard to imagine what could motivate a switch back to an expensive book.

As our department is in the process of expanding, we expect to receive permission to conduct a search for a tenure-track position to replace a retired colleague this year. When the new physicist arrives on campus and has at least two classes for which to prepare, we believe that providing him or her with our fully developed course package of textbook, homework, video solutions, and labs will prove to be a strong incentive to continue what we are doing.

Of course, we expect some evolution of the course with time, but it is much easier to decide to replace 10 or 20 of the homework problems with new ones (and new solutions) than to create nearly 200 of them from scratch. All of our materials will be available to our new colleagues in Statesboro. We plan to present our work at one of their weekly colloquia. Even if only one or two of them made this transformation, the number of students affected would climb dramatically.

**Acknowledgment**

**Grant Acceptance**

[Acknowledged] I understand and acknowledge that acceptance of Affordable Learning Georgia grant funding constitutes a commitment to comply with the required activities listed in the RFP and that my submitted proposal will serve as the statement of work that must be completed by my project team. I further understand and acknowledge that failure to complete the deliverables in the statement of work may result in termination of the agreement and funding.
August 28, 2018

Affordable Learning Georgia
Textbook Transformation Grant Review Committee

Dear Review Committee,

I am pleased to provide my highest support for Affordable Learning Georgia Textbook Transformation grant proposal submitted by Dr. William Baird and Dr. Jeffery Secrest of the Department of Physics at Georgia Southern’s Armstrong Campus. Their proposal, entitled "Electrical and Electronic Experiments in Physics (EEEP)", to extend the current use of OpenStax University Physics digital textbook in PHYS 2211K to PHYS 2212K. In addition, the team will record additional videos of homework solutions (they have recorded approximately 700 videos thus far for Physics courses) to accompany the OpenStax. Finally, they will integrate Arduino microcontroller systems into the labs to allow for open-source programming and the implementation of low cost lab materials (similar to the previous PHYS 2211 ALG project that used VPython).

Professors Baird and Secrest have been previously funded to use open-source materials and VPython in PHYS 2211K. Funding this second phase of the project will assure that no STEM majors, whose program requires a full year of physics, will have to purchase a textbook (especially a textbook that they would only use for one semester). This amounts to significant savings for students. The grant requests funding to support the creative portion of the project, which is the time and cost heavy part. Once created, however, the materials will be easy to revise and maintain so that it will be a sustainable resource for several academic cycles. The team is experienced with ALG grants and their assessment, and I have confidence that they will deliver on their stated goals.

The College of Science and Mathematics recognizes the importance of engaging our students in the STEM disciplines and the proposed project will further this objective, by utilizing modern technology to assist student learning in this challenging area. I am pleased to wholeheartedly support this project.

Thank you for your consideration,

[Signature]

Delana A. Gajdosik-Nivens
Dean
College of Science and Mathematics
Notes

- The proposal form and narrative .docx file is for offline drafting and review. Submitters must use the InfoReady Review online form for proposal submission.
- The only way to submit the official proposal is through the online form in Georgia Tech’s InfoReady Review. The link to the online application is on the Round 12 RFP Page.
- The italic text we provide is meant for clarifications and can be deleted.

Applicant, Team, and Sponsor Information

The applicant is the proposed Project Lead for the grant project. The submitter is the person submitting the application (which may be a Grants Officer or Administrator). The submitter will often be the applicant – if so, leave the submitter fields blank.

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<th>Georgia Southern University (Armstrong Campus)</th>
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<td>Professor of Physics</td>
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Please provide the first/last names and email addresses of all team members within the proposed project. Include the applicant (Project Lead) in this list. Do not include prefixes or suffixes such as Ms., Dr., Ph.D., etc.

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If you have any more team members to add, please enter their names and email addresses in the text box below.

Baird, William - #2580
Please provide the sponsor's name, title, department, and institution. The sponsor is the provider of your Letter of Support.

Delana Nivens, Dean of the College of Science and Mathematics, Georgia Southern University

Project Information and Impact Data

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Narrative Section
1. Project Goals
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2. Statement of Transformation
Recently, we were awarded a Textbook Transformation Grant, completed in 2018, for PHYS 2211K (introductory mechanics – note that the “K" represents the fact that the lecture and lab portions of the course are now combined into the same time slot so that the division of time between lecture and lab can be altered to match weekly needs and instructor preferences). This grant involved the adoption of the OpenStax textbook and the creation of video homework solutions. We used the newly-available class time to introduce some basic computer programming using VPython (an open-source package built to make illustrating physical concepts easier). We felt that this was an all-around improvement for both faculty and students; faculty did not have to spend an hour a week solving essentially the same problems each semester and stronger students did not have to sit through solutions of problems they had already mastered. Weaker students were also able to watch solutions repeatedly if the process did not "click" for them the first time through.

Replacing our current Halliday & Resnick book with the OpenStax University Physics series will result in a significant cost savings for our students. From the 2017-2018 Georgia Southern Common Data Set\(^1\), books and supplies are projected to represent, on average, 15% of the total cost of in-state tuition, fees, and books/supplies. Our numbers indicate that if not for our careful attention to costs, PHYS 2212K would be disproportionately expensive in this regard. We can say that it is difficult to accurately and honestly calculate the effective savings. We have for some years made an effort to reduce student costs by not using the latest edition of a textbook. We find very few substantive changes from edition to edition, but the latest edition of our current book is available at Amazon for an astonishing $267. Used copies start at $195 and even a semester-long rental, which we believe is a truly false economy for a subject which is foundational for many of our students, is over $70. By using the 9\(^{th}\) edition instead of the 10\(^{th}\), students can buy a used copy for about $60.

The current online homework system (OHS), WebAssign, is almost three times the price of the system we are planning to use if the proposal is funded. To be fair, the WebAssign fee of $90 includes an electronic copy of the textbook, but that copy expires after one semester. For an additional $30, students can use that particular edition on WebAssign forever (as long as the

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course they are taking uses that edition; it is not transferrable to another edition or to another student). Whether in electronic or physical form, we believe the text will be a reference for at least some of these STEM students for some years to come – we are not interested in the philosophy that treats these materials as something to rent for one semester and then discard.

The larger problem is that old editions will not be available forever, even at Amazon; our bookstore has complained to us many times that they cannot source old editions in quantity. The WebAssign OHS currently provides both the 9th and 10th editions of our current book, but no older editions are usable. The license agreement requires us to certify that we are using a particular text, and we can only choose problems from that text. Therefore, even if we had a large supply of old editions, they would eventually age out of the homework system. If we didn’t care about student expenses at all (and if we wanted to improve the apparent savings figures for this application), we would require the 10th edition.

We administered the attitude survey that was part of our previous ALG grant in Fall 2017 to our 2211K students who were using the Halliday & Resnick book, and we also gave the survey to our Spring 2018 2211K students who used the OpenStax book. When responding to the statement “Buying the textbook was or would have been a significant financial strain”, two thirds of the students in each course (n=28 in Fall 2017, n=26 in Spring 2018) answered “Agree” or “Strongly Agree”. In a more worrying development, there is a section where students can rank the utility of various learning aids from 5 (very useful) down to 2 (not at all useful) and then 1 (did not try to use). We found 36% of the students in the Fall answered “did not try to use” to the question about the textbook. While this does not prove they did not buy the book (and we regret not adding this question specifically), it certainly suggests it. Finally, 21% of the students both reported not using the book and that buying it would have been a financial hardship.

**Transformative Impact** - We would now like to bring our PHYS 2212K (electricity & magnetism, light & optics) into alignment with our transformed PHYS 2211K. We again propose to introduce video solutions of homework problems to recapture class time, but we now plan to move beyond VPython since our students will have already used that in PHYS 2211K. We now want to integrate the Arduino system into our labs. Briefly, Arduinos are microcontroller boards which are open-source hardware and they are programmed in an environment which is also open-source.

This means that anyone can build and sell his/her own Arduino-compatible clone, and this has served to drive the price of the clone hardware down to less than $20 for each basic setup. There is an enormously large ecosystem of Arduino programs already available for download, so it is quite easy to get started. The programming environment shares similarities with Java and C++, but was designed to be friendly to non-STEM users. We plan to implement three lab exercises which will involve experiments similar to those we (and most other universities) already do, but which will be performed in this case with Arduinos rather than multimeters, oscilloscopes, etc.

Because our student population is almost exclusively STEM majors, familiarity with programming and sensors/data collection will allow them to connect the topics discussed in
physics with real-world problems. As in the previous ALG grant, the goal is not to turn the
introductory physics sequence into a substitute for any computer science course; our aim is
merely to show the students how simple it can be to get started, and the commonalities
between different programming environments (since they will have had some experience with
VPython by the time they encounter the Arduino).

We have calculated the savings based on our expectations for 2019. We have typically had two
24-person sections of PHYS 2212K, one in the spring and one in the fall. Our projections
(reflected in our schedule currently being created for spring) are that we will need twice that
many sections in 2019, as we are already seeing an increase in the 2211K population. Since first
being announced, the merger has promised many more engineering students on campus, all of
whom must take both semesters of calculus-based physics. Chemistry & Biochemistry majors
(most of whom formerly took the algebra-based sequence 1111/1112) will now all take
2211/2212. According to the 2016 Armstrong Fact Book\(^2\) (the last one available before
consolidation), Chemistry and Biochemistry had a total of 213 majors. This alone, ignoring
engineering or any projected growth, would approximately double the 2018 enrollment.

We are also discussing the implementation of our previous ALG grant for 2211K with our new
colleagues in Statesboro, and they have so far been receptive. We are planning to submit an
application in the next round under the Scaling Up OER category. Our hope is that, should this
application be successful, the joint physics faculty will have a cohesive two-semester solution
involving the key elements of both proposals and will therefore greatly magnify their effects.

The idea that introductory physics courses are great places to learn programming is not an
original one. Even a cursory review of the literature of Physics Education Research (PER) shows
that programming has been used to augment introductory physics classes\(^1, \, ii, \, iii, \, iv, \, v\) for 50 years or
more, from the venerable FORTRAN to the Arduino itself. We introduced programming through
Microsoft Excel years ago, but we have moved our focus to open-source offerings such as
Python (e.g., the recent ALG grant) and this would further that transition. The added benefit to
the students in this case is that if one of our Arduino labs does spark their interest in sensors
and data collection, they will be able to acquire their own system for home use and
experimentation for $50 or less rather than the multi-thousand-dollar expense associated with
some physics lab equipment.

3. Transformation Action Plan
Drs. Baird and Secrest will jointly identify appropriate homework problems from the collection
available through ExpertTA. Dr. Baird will record video solutions to all problems to be posted
after the due date for each homework. Since Summer 2016, Dr. Baird has recorded over 700
videos solving homework problems (about 175 per course, including 167 with closed captioning
for the ongoing Textbook Transformation Grant for 2211K) and has found the time spent doing
so is worth the recovered class time. Dr. Secrest will handle the IRB application (which we

expect to be judged either exempt or eligible for expedited review as the attitude survey is essentially the only item at issue).

The PIs will work together to identify suitable Arduino-based labs in the literature (viz. Refs. 4 and 5) and/or develop their own. Since PHYS 2212K is focused on electricity and magnetism, including circuits and optics, we already have plans for some exercises but will remain open to better ideas that may already be available. Any instructor who may have an interest will be provided with the lab materials. We especially hope to see our new colleagues adopt some of these activities. The extra class/lab time needed to add these programming assignments will come from the time recovered by the use of video homework solutions.

4. Quantitative and Qualitative Measures

The materials will be used for PHYS 2212K in Spring 2019. We have long employed a standard assessment instrument known as the Conceptual Survey of Electricity and Magnetism (CSEM), a widely-used 32-question test of concepts discussed in second-semester physics courses. We have (and will) administer this as a pre/post-test. The normalized gain, defined as \((\text{post-pre})/(32-\text{pre})\), where pre and post are the CSEM scores at the beginning and end of the semester, will be calculated. This number is commonly reported in the Physics Educational literature, since it quantifies the student’s prior familiarity with the subject. We will compare this gain with existing CSEM results gathered at GSU-Armstrong in past semesters. Drs. Baird and Secrest offer extra-credit incentives to students based on performance on the final CSEM to ensure that students try to do well on it.

Students will be given a survey about the text (attached) and their use of it, as well as the other course resources available (video homework solutions, online class notes, etc.) and their answers will be compared with data gathered during the previous semester. This will allow us to record student attitudes and opinions about the course materials, as well as providing them the opportunity to mention other resources they found to be helpful. We will investigate any student proposals for these added resources, and adjust our focus on existing materials in response to the multiple-choice questions. Finally, DFW rates will be compared to historical averages.

We have been informed that this will require IRB approval, but we do not foresee any difficulty in obtaining it. The surveys will be anonymous from their creation, and we have always destroyed our assessment test sheets after recording the data from them. We only report class-average normalized gains when discussing student performance in our courses.

5. Timeline

October 1, 2018 – As soon as notification of the award is received, the PIs will begin to identify homework problems and laboratory exercises. Dr. Secrest will prepare the IRB paperwork for submission for both Fall 2018 PHYS 2212K and Spring 2019 PHYS 2212K so that we may gather survey data before and after the transformation.
October 15, 2018 – We expect to have chosen most, if not all, of the homework problems at this point and Dr. Baird will begin recording video solutions while Dr. Secrest starts planning the particular activities to be performed in each lab and orders necessary supplies.

November 15, 2018 – We estimate Dr. Baird will have recorded one half to two thirds of the homework solutions by this point. These are more time-consuming than might otherwise be expected due to the necessity to add closed captioning to the videos. While YouTube does some of this automatically, there is a great deal of editing required when going over equations and other concepts from physics problems that don’t typically appear in YouTube dialog. Dr. Secrest will have two of the three labs finalized at this point.

November 30, 2018 - Last day of classes. Dr. Baird will administer the CSEM as a post-test and the Student Survey of Course Resources (SSCR).

December 15, 2018 – By this time, the homework solutions should be finished as well as the lab exercises. We expect to be ready for the Spring semester, but this timeline will give us an additional month before classes actually start in case there are unforeseen difficulties.

January 14, 2019 – Classes begin at GSU-Armstrong. Dr. Baird will administer the CSEM pre-test during the first PHYS 2212K class.

Spring Semester, 2019 – The PIs will meet regularly to discuss the progress of the course and any issues with labs or homework videos. If needed, adjustments will be made to these materials.

May 3, 2019 – Last day of classes. Dr. Baird will administer the CSEM as a post-test and the Student Survey of Course Resources (SSCR).

Summer 2019 – The PIs will assemble the data from the DFW rates, the CSEM tests, and the SSCR surveys. We will perform tests of statistical validity on our data and prepare the final report.

6. Budget
We request $5,000 salary for each PI. We also request $800 to be used for supplies and travel. The supplies are expected to consist of Arduino boards and sensors, while the travel funds would be used for registration, mileage, and hotel expenses for events such as the required kick-off meeting and/or conferences where the results of this work may find an audience (e.g., SACS-AAPT, etc.).

Salary, Dr. Baird - $5,000
Salary, Dr. Secrest - $5,000
Travel and Supplies - $800
Total - $10,800
7. Sustainability Plan
We believe the sustainability is the easiest part of this process. When we talk to faculty, it seems the largest hurdle to overcome in a course transformation is inertia; if things are already working well, change for the sake of change or for minimal benefit will not be received warmly. To be clear, the content provided in the current Halliday & Resnick book is excellent, as are the homework problems found there. If price were not a factor, we would not consider a change.

Our sole objection to the text we use now is financial: when a new book is approaching the $300 mark, and the difference from one edition to the next would be hard to see without a careful dissection, it begins to gnaw at the conscience to require it. On a more practical level, we know that a sizable fraction of the students will just not buy a book that expensive. Perhaps there are some disciplines where everything in the text can be fully covered in classroom lectures, but physics is certainly not one of them. We're shocked at the prices of the books, but in their defense, they do exceed 1200 pages!

While the OpenStax book may not quite be at the level of Halliday and Resnick yet, it is in our opinion more than good enough to justify the trade. Once we have changed over all of our homework assignments and video solutions, and we know we are saving the students quite a bit of money, it is frankly hard to imagine what could motivate a switch back to an expensive book.

As our department is in the process of expanding, we expect to receive permission to conduct a search for a tenure-track position to replace a retired colleague this year. When the new physicist arrives on campus and has at least two classes for which to prepare, we believe that providing him or her with our fully developed course package of textbook, homework, video solutions, and labs will prove to be a strong incentive to continue what we are doing.

Of course, we expect some evolution of the course with time, but it is much easier to decide to replace 10 or 20 of the homework problems with new ones (and new solutions) than to create nearly 200 of them from scratch. All of our materials will be available to our new colleagues in Statesboro. We plan to present our work at one of their weekly colloquia. Even if only one or two of them made this transformation, the number of students affected would climb dramatically.

Note: Letter of Support
Attached

Additional: Survey

Student Survey of Course Resources – Fall 2018

I identify as Male Female Other Prefer not to answer

Major_____________________________________________

My current status is
Buying a textbook would have been a significant financial strain

Did you actually purchase the book (not including the WebAssign associated copy)  

Hours/week I used the OpenStax book:  

If the cost for each were the same, I would prefer a physical (i.e., paper) book to a PDF or an e-book

Please rank the following resources in order of their importance to your success in this course (5 = very useful, 4 = somewhat useful, 3 = not very useful  2= not at all useful, 1 = did not try to use)

What are your thoughts about the required text for this course?

For the items above you listed as most/least useful, can you explain why?

What do you think could have been useful to you for this course?


Our schedule for the semester is to cover chapters 5-16 in the second volume and the first six chapters of the third volume by covering approximately one chapter per week. This is a large amount of material, and you should spend at least 12 hours per week working problems, reading the book and the online notes, and reviewing your own notes. The expected learning outcomes for this course are: familiarity with and ability to solve problems involving Coulomb’s law, Gauss’ law, electric fields and potentials, Ohm’s law, both AC and DC circuits including resistors, capacitors, and inductors, magnetic fields, induction, geometric optics, wave optics, and relativity. The grade reported to the academic early alert system will consist solely of your score on the first test.

Homework

You are free to work in groups on your homework assignments, but you should be careful not to use the group as a crutch. When you’re taking a quiz or test, there won’t be anyone there to help, and you’ll have to rely on your own understanding. Homework will be assigned and graded via ExpertTA. You will need to purchase a key online at www.theexpertta.com or at the bookstore. Your name and student email has been used to register you in this class at the web site. You should go to the web site and try to log on as soon as possible. There is a free trial period, and after that the cost is about $35.

You should print a copy of your homework while you are solving it. If you have waited until the last minute before the homework is due and your internet connection goes down, you can still work the problems on your printed copy and bring them to class that morning for a grade (this should happen once or less in a semester!). Otherwise, you will get no credit for the assignment.

Working problems is extremely important in any physics class. Although the online homework would make it possible, I’m not going to assign a huge volume of problems. You are advised to work as many problems as you can – you’ll soon see that there can be a big difference between following along in class and being able to do problems on your own (during a test). **There will be no extensions or makeups for homework.**

Once the deadline has passed for a homework assignment, video solutions will be posted online (you will be given or emailed the location later). You should watch the solution for any problem you did not solve or were not sure about. I can solve the problems in class, but doing it this way will allow you to avoid sitting through solutions you already know, and to replay difficult ones. We are going to devote some of the time gained by doing this to the use of the Arduino microcontroller. The environment will be installed on the lab computers and we’ll have some labs where we gather data with it.

Attendance

When you arrive, please turn off your cell phones, computers and all other electronics, and put newspapers, etc. away. **I do not want to see your phone during class – no texting, calling, etc.** You should bring an ordinary scientific calculator to class and especially to the tests. I will clear the memory of all programmable calculators before each test. If your calculator is programmable and not a TI of some kind, **sometime before the first test**, make sure you have brought it to me so I’ll know how to clear it and you’ll be able to use it during your test.

The lecture and lab portions of the course are blended together in an effort to have a smoother integration between these parts. This means that we will probably not have a solid schedule of what lab or activity
we’ll be doing every day this semester. I can give you estimates of when things will happen, but there’s going to be uncertainty attached to those estimates. For that reason, I would advise you to attend each class. One lab exercise will be dropped, but beyond that, they will start adversely affecting your grade. You should expect to be in class the entire time every day; if we happen to finish early, that’s a bonus. When we are doing a lab, anyone leaving early (even with permission from his/her fellow group members) should expect a disproportionately large penalty on his/her portion of that lab.

Labs will typically occur at the beginning of a given class period. Because arriving late is both inconsiderate and unfair to the rest of your group members, you will lose 1 point (out of a possible grade of 10) if you are less than 10 minutes late. From 10-19 minutes late, you will lose two points, three from 20-29, etc.

Honor Code

The Student Conduct Policy (found at https://students.georgiasouthern.edu/conduct/files/2018-2019-Code-of-Student-Conduct-FINAL-1.pdf) will be strictly upheld. Any violations will become part of the student’s permanent educational record and will receive the harshest punishment allowed, including but not limited to a grade of F for the course. Plagiarism, which is defined as using someone else’s words or ideas (i.e., paraphrasing) without proper attribution, is an honor code violation. DO NOT try this! It is assumed that anything in your lab report that is not credited was written by you and/or your group members whose names appear on the front page. This applies to information from the Internet as well as all other sources. Submitting a report for which you have already received a grade (e.g., in a previous semester, etc.) is also not allowed.

Tests and Grading

As of this writing, there will be three tests, the lowest of which will be dropped (others worth 20% each), a final exam worth 25%, in-class exercises and lab reports for 25%, and an undetermined number of homework assignments for the remaining 10%. The tests will be approximately evenly spaced throughout the semester. If you must miss a test, you must contact me as soon as possible to schedule a makeup exam. While you aren’t required to attend class, your excuse must cover the time from the original exam date until you return to class ready to take the makeup. Keep in mind that the make-up test will almost certainly be harder than the original test; I tend to put the most straightforward questions possible on the main test, and the ones on make-up tests are therefore usually more complicated.

For the reports associated with lab exercises, you can get an idea of what is expected from the information available on my web site under “Lab Report Guidelines”. You should rotate the report-writing and make sure that each group member has a copy of all data as well as a copy of the finished report. Error analysis is a large part of the report.

This syllabus is subject to modifications (which will be announced in class) during the semester.
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Final Report
Affordable Learning Georgia Textbook Transformation Grants

Final Report

To submit your Final Report, go to the Final Report submission page on the ALG website: http://affordablelearninggeorgia.org/site/final_report_submission

Final report submission requires four files:

- This completed narrative document
- Syllabus or syllabi
  - (if multiple files, compress into one .zip folder)
- Qualitative/Quantitative Measures data files
  - (if multiple files, compress into one .zip folder)
- Photo of your team or a class of your students w/ at least one team member, minimum resolution 800x600px
  - (nearly all smartphones take photos larger than this size by default)

Follow the instructions on the webpage for uploading your documents. Based on receipt of this report, ALG will process the final payment for your grant. ALG will follow up in the future with post-project grantees surveys and may also request your participation in a publication, presentation, or other event.

General Information

Date: 8/13/19

Grant Round: 12

Grant Number: 382

Institution Name(s): Georgia Southern - Armstrong

Project Lead: William Baird

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

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Jeffery Secrest, Associate Professor of Physics, Georgia Southern University, jsecrest@georgiasouthern.edu
1. Narrative

Our plan for this grant was to complete the process of switching the calculus-based physics sequence (PHYS 2211K and PHYS 2212K) from the Halliday, Resnick and Walker text to the OpenStax University physics book. We previously made this switch for the first semester course. To continue with the open-source theme, we wanted to develop three labs appropriate for the use of open-source hardware; i.e., the Arduino microcontroller platform. As our student population is overwhelmingly engineers, we felt that adding a few programming assignments would be a useful follow-on to the Python programming we used in the first grant.

To make time for this without compromising the presentation of the core material, we used video homework solutions rather than spending roughly one hour per week of class/lab time to solve each homework problem. This allowed students who were stuck to see the solution more than once, at their own convenience, and also meant we didn’t have to bore students who did understand the problem with a solution in class. We created a total of 134 video homework solutions for this course.

Because we already had created homework videos for the Halliday, Resnick & Walker book, evaluating new problems and recording video solutions (including closed captioning) was by far the largest portion of the effort. Creating three new labs that were level-appropriate, interesting (we hope), and illustrative of relevant physical principles was the second major challenge.

Our primary concern with this grant (and the previous one) was that the academic content of the course not be compromised in an effort to save student funds on the textbook. In our experience, there is not a large substantive difference between the “classic” high-cost textbooks that we and most other departments have traditionally used. The OpenStax book is approaching that level, but we were unsure if it would prove to be a mature enough resource. We did not find a statistically significant difference between the free book and the over $200 book we had been using.
An error made by one of us (WHB) in the survey verbiage is our main regret; because of the similarity between this grant and our similar grant which addressed PHYS 2211K, those surveys were used as the starting template for the surveys in this grant. One of our more important questions was going to be “How many hours per week did you use the assigned textbook?” As we were comparing Spring 2019 (OpenStax) to Fall 2018 (Halliday, Resnick & Walker), I had planned to name the book in each survey. Unfortunately, the Fall 2018 survey asked how many hours per week the student used the (unassigned) OpenStax book rather than the book they were actually supposed to use. To our surprise, there was no statistically significant difference in the answers to these questions from semester to semester.

2. Quotes
“A physical copy would have been nice, but I would have used it about the same as an online textbook”

“I think it was appropriate. It was a little confusing when we jumped texts in the middle of the course.” (Note: This is apparently in reference to the fact that the material for our two-semester course is spread across three volumes of the OpenStax course, meaning we needed both volumes 2 and 3)

“I liked the online book. If I didn’t understand something in class, the book was my go to.”

3. Quantitative and Qualitative Measures
3a. Uniform Measurements Questions

Student Opinion of Materials

Was the overall student opinion about the materials used in the course positive, neutral, or negative?

Total number of students affected in this project: ___26____

- Positive: __50___ % of ___14____ number of respondents
- Neutral: __29___ % of ___14____ number of respondents
- Negative: __21___ % of ___14____ number of respondents

(Note: These numbers are for the OpenStax textbook. A variety of materials were used in the course, such as online notes, video homework solutions, online homework problems, etc. Data about them can be found in the spreadsheet)
Student Learning Outcomes and Grades

Was the overall comparative impact on student performance in terms of learning outcomes and grades in the semester(s) of implementation over previous semesters positive, neutral, or negative?

Choose One:
- ___  Positive: Higher performance outcomes measured over previous semester(s)
- _X_  Neutral: Same performance outcomes over previous semester(s)
- ___  Negative: Lower performance outcomes over previous semester(s)

Student Drop/Fail/Withdraw (DFW) Rates

Was the overall comparative impact on Drop/Fail/Withdraw (DFW) rates in the semester(s) of implementation over previous semesters positive, neutral, or negative?

Drop/Fail/Withdraw Rate:

29% of students, out of a total 17 students affected, dropped after attending the first class or received a grade of D, F, or W in this course in the final semester of implementation.

Choose One:
- ___  Positive: This is a lower percentage of students with D/F/W than previous semester(s)
- _X_  Neutral: This is the same percentage of students with D/F/W than previous semester(s)
- ___  Negative: This is a higher percentage of students with D/F/W than previous semester(s)

3b. Measures Narrative

In this section, summarize the supporting impact data that you are submitting, including all quantitative and qualitative measures of impact on student success and experience. Include all measures as described in your proposal, along with any measures developed after the proposal submission.

The two classes we surveyed (Fall 2018, for-profit book, and Spring 2019, OpenStax) were quite similar in most respects. Probably the largest difference was class size (reported here based on those responding to the survey). We had a class of 21 students (12 male, 9 female) in the fall and 14 (10 male, 4 female) in the spring. The percentage of students declaring an engineering major of some form was almost identical (62% to 64%).
For the DFW percentage, we look at students who were signed up on the first day of class and then dropped the course, withdrew after drop/add, or earned either a D or F. The reason is that most programs requiring this course require a grade of C or better. Our Fall 2018 DFW rate was 27%, and the Spring 2019 rate was 29%.

We administered the Conceptual Survey of Electricity and Magnetism (CSEM), a widely-used standard which is to be given on the first and last days of the course to attempt to measure the learning gains made by students. The normalized gain, defined as \((\text{final score} - \text{initial score})/(\text{perfect score} - \text{initial score})\), is used to control for the fact that students come in with a wide range of pre-existing physics knowledge. We performed a two-tailed t-test and found that, using \(p<0.05\) as the standard of significance, the two classes were not different in initial CSEM score, final CSEM score, or normalized gain.

The final grades for the two courses were again not different by a statistically significant amount.

While disappointment might be a common reaction to a course transformation showing no difference before and after the treatment, we are pleased that we have significantly altered the cost of our course without sacrificing quality. In our experience, students sometimes react negatively when a course is different (in whatever way) from what their peers experienced. We saw no evidence of that, and we view that as a positive.

There was a reduction in the number of students anticipated to be enrolled, which we attribute to the continuing effects of the system-mandated merger of Armstrong and Georgia Southern. However, we have been told by our new President that enrollment is now trending upward, and we believe that going forward, we will still realize impressive financial savings for our students.

4. Sustainability Plan
As we prepare for the start of Fall 2019 classes next week, both sections of PHYS 2212K offered on this campus will be using the OpenStax text and the lower-cost online homework. We have shared labs and will be sharing homework assignments and videos with the new limited-term faculty member who has been hired to teach the other section of the course. As the semester progresses, we will meet periodically and discuss potential revisions to the homework sets, videos, and labs. We believe that the overwhelming majority of the effort was to switch books and homework platforms in the first place. Continuing with what we now have is, in fact, the “path of least resistance”. We cannot think of an incentive to switch away from the OpenStax book unless no online homework support was available for it, and that seems unlikely to say the least.

5. Future Plans
Both of us have continued to move towards low-cost or no-cost textbooks and learning materials. In addition to repeating the treatment described here in another section of PHYS 2212K, the PI will be teaching the Advanced Laboratory I course in the fall, and the required readings will be from instructor notes and notes available online from other universities. The Co-PI taught a summer Astronomy course
and employed the OpenStax text. To be sure, there will be some courses in the upper division which cannot reasonably be moved away from traditional textbooks, at least at this point in time. However, we do have a heightened awareness to the total cost of a course as a result of our investigations in support of this grant.

6. Description of Photograph

Drs. Secrest (left) and Baird (right), co-PI and PI.