Affordable Materials Grants, Round 21:

Continuous Improvement Grants

(Spring 2022-Spring 2023)

Proposal Form and Narrative

# Applicant and Team Information

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| --- | --- |
| Requested information | Answer |
| Institution(s) | Georgia Gwinnett College |
| Applicant name | Tae Song Lee |
| Applicant email | [tslee@ggc.edu](mailto:tslee@ggc.edu) |
| Applicant position/title | Associate Professor of Physics |
| Submitter name | Helen McDaniel |
| Submitter email | [hmcdanie@ggc.edu](mailto:hmcdanie@ggc.edu) |
| Submitter position/title | Coordinator |

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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| --- | --- | --- |
| Team member | Name | Email address |
| Team member 1 | Tae Song Lee | tslee@ggc.edu |
| Team member 2 | Sairam Tangirala | stangira@ggc.edu |
| Team member 3 |  |  |
| Team member 4 |  |  |
| Team member 5 |  |  |

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

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# Project Information

| Requested information | Answer |
| --- | --- |
| Type of Project | *Creation of OER materials to supplement “Physics of Robotics” course for non-STEM majors* |
| Priority Category / Categories  *Projects in these categories will receive three extra points in the final score for fitting a priority of these particular rounds of Grants. The type of funding for the project is determined by the funding categories criteria above. As of Round 18, projects can be a part of more than one category. Note that the below categories only indicate priority, not which applications qualify for a grant. Select all that apply.* | *Professional support from staff* |
| Requested Amount of Funding  *$10,000 maximum total award per grant* | *$4,000* |
| Course Titles and Course Numbers | Physical Science II, PSCI 1102 |
| Final Semester of Project | Spring 2023 |
| Currently Existing Resource(s) to be Revised/Ancillaries Created  *Please provide a title and web address (URL) to each of the currently existing resources that you are revising, creating new ancillary materials for, or replacing. If replacing, please include a title and web address (URL) to the new OER as well.* | **Optional Resources (Reason for the application serving under Continuous Improvement Grant):**  Practical Electronics for Inventor, 4th ed  Amazon Price: $32.99  Author: Paul Scherz and Simon Monk  Link: ([link](https://www.amazon.com/Practical-Electronics-Inventors-Fourth-Scherz/dp/1259587541))  Electronics for Beginners: A Practical Introduction to Schematics, Circuits, and Microcontrollers  Author: Jonathan Bartlett  Amazon Price: $31.99  Link: ([link](https://www.amazon.com/Electronics-Beginners-Introduction-Schematics-Microcontrollers/dp/1484259785)) |

# Project Goals

**Goal-1: Creation of an open pedagogical resource covering foundational physics concepts responsible for robotics and automation technologies. Currently, such a resource does not exist for non-STEM audience**

Robotic and automation technology is becoming ubiquitous in our everyday lives. The high-tech automation technology has arrived and is here to stay. Its incorporation into the fabric of our lives is only going to accelerate soon. Even though these technologies have begun to affect our daily lives, a significant portion of the world’s population does not recognize nor appreciate the fact that these technological changes arise from advancements made in physical sciences (Brooks, 1994). It is even more important today for all people to understand the importance of science and the close inter-dependent relationship between science and technology, if they are going to be able to make sense of and function effectively as informed citizens. At this time, there are very limited structured pedagogical resources available to educators (of non-STEM students) for teaching direct applications of science to robotics and automation technology (Philip Dixon, 2018 and Walter Banzhaf, 2010). Several of these resources are meant for hobbyists and not for educators and assume a practitioner’s approach which may not be appropriate for non-STEM students. Importantly, there are further limited education materials that build upon high-school science foundations and introduce conceptual science principles that have revolutionized robotics and automation technologies.

**Goal-2: Bringing a heightened awareness of the importance of science in the current economy**

Since the emergence of Covid-19 pandemic, there has been an arguable display of misunderstanding of the scientific way of discovering knowledge. Furthermore, the dynamic and ever-improving nature of “scientific discovery process” has been used as a tool to disregard the importance of science in society. In this pedagogical resource, by providing examples form daily used electronic, and robotic technologies, we plan to highlight the deep and historical connections between theories/concepts proposed by science and later being adopted into technological devices.

In preparation of the proposed course materials, an interpretation of Say's law of markets will be used. It states that, when it comes to science and technology, supply creates its own demand. The pedagogical material created through this grant will select relevant technological products and use them as hooks to engage non-stem students to ride the physical science vehicle that tours the land of opportunities created for people who make friends with science and technology. We believe that using an economic argument for promoting science among non-STEM students may be a successful way to increase the awareness of the importance of science in the society.

**Goal-3: Improved academic and post-academic career success**

Between STEM and non-STEM students, the knowledge gap pertaining to the awareness of scientific applications in daily lives is getting wider. A goal for this proposal is to create a scientifically informed non-STEM consumer of technology who is aware of the pros and cons of rapid emergence of robotics and automation. There are numerous STEM targeted web sites (e.g., github from Microsoft), books, and journals for engineering and science major students, but there is no dedicated, condensed, and curated educational resource catering to general non-STEM population. One only with a significant effort with many hours of dedicated search can collect these vast amounts of information in technologies and robotics. Beyond the searching for information, understanding of background science (physics) in each technology is one more additional huddle that one needs to overcome. With this imperative matter, we need the bridge that helps non-STEM students to save their valuable time to catch up with and acknowledge the current status of science and technology within a designated semester.

# Action Plan

**Current State of the course**

Dr. Lee has taught this course earlier in Spring 2019. In that course he decided not to require textbooks for this course for several reasons: First, the books on the physics of robotics (Scherz et al.,2016 and Bartlett, 2020) are appropriate for hobbyists and practitioners and not written for non-STEM undergraduate students. Dr. Lee adapted the textbook content and make it suitable for a lower-level Physical Science course by keeping non-science majors in context. Second, these books do not sufficiently cover the fundamental science topics relevant to the PSCI 1102 course. In fact, there are only nine chapters from book (Scherz et al. ,2016) and seven chapters from book (Bartlett, 2020) are of use in this course. Third, an online proposed ALG textbook will be of greater value as a teaching tool since the faculty can regularly update them and can tailor-made to be engaging and relevant for a student. More importantly, the students will be able to use the textbook on the very first day of class and alleviate additional financial burden.

On a separate note, when Dr. Tangirala taught a different course on Introductory Physics-II (Physics 1112K) for STEM majors using the OpenStax College physics textbook, a good number of students appreciated having an online textbook. This motivated both of us to create an OER (e.g. e-textbook) for this course on physics of robotics.

**Getting non-STEM caught up with technological innovations most relevant in robotics**

In this project, we plan to use, create and, curate instructor’s non-licensed instructional materials to serve as an alternative to currently recommended copyright textbooks.

Even PSCI 1102 is not a lab-based science course. A pure lecture on theories of physics in robotics for hours might cause students’ interest to drift away from a class topic. Since student success will be measured in several ways including students’ undivided attention, persistence, and understanding of class contents, we will divide hour lecture hours into three main parts. First, give a lecture on each physics concept in robotics. A firm understanding of the topic is a necessary first step for success. Second, once the course topic has been covered, watching a short documentary or film on robots built by professionals, and having a discussion session among students will help their understanding in real-world examples and how physics theories have been applied to actual robots. Third, this is the most unique part of instruction, hands-on experience using simulation (Tinker CAD Circuit from Autodesk). We call this “Hands-on Lecture.” There are many open-source microcontroller-based computer codes compatible within Tinker CAD Circuit. Tinker CAD Circuit provides a simulated Arduino microcontroller with many input sensors (sonar and IR) and output display options including LED and 7-segment display. This is lively interactive exercise that students can feel a direct physical connection between their fingertips and outside phenomena and realize that their control influences the real world. A second and third parts of lecture with concrete understanding of physics concepts will provide continuous undivided attention from student.

**Creation of novel conceptual science pedagogical content for easy adoption by other instructors**

There are so many books and literature in robotics for science and engineering major students. These students are well or at least moderately trained in understanding math and physics. Even robotics for beginners requires prior knowledge from various parts in math, physics, and engineering. These beginners’ books are not designed for how to educate physics in robotics to non-STEM majors, but how to complete certain robot projects on time. These books are more like step-by-step cookbooks, unknowingly following what authors did. Currently, there is no well-designed textbook for non-STEM students.

The textbook will have two major parts, physics concepts in robotics and Hands-on Lecture. There will be about eight to ten chapters, starting with “What are robots? and where can we find them?” to bring students’ everyday connections to the devices that use concepts from a robot. On the second chapter, we will introduce actual world of physics and how it has been applied to the real world. The third chapter will be dedicated to the introduction of Tinker CAD Circuit with simple demonstration and Hands-on lecture. From chapter four, we will start to work on basic robotic components such as an LED (conceptual understanding in quantum physics), temperature sensor (concept in heat), sonar sensor (concept in sound wave and velocity), IR (Infrared) sensor (concept in electromagnetic wave). Surely, a Boolean algebra will be covered to understand logic circuit concept (7-segment display). As soon as sensors are done, electric actuators (e.g., DC and servo motors) will be covered to understand the concepts of electromagnetic force. Each chapter will start with a PowerPoint interactive lecture (with demonstration and animation) in physics concepts used in sensors and actuators. After the lecture, Students work on Hands-on workbook. As we stated already, these Hands-on workbook exercises utilize Tinker CAD Circuit from Autodesk. A student can get access to Tinker CAD Circuit by simply creating an account with Autodesk. It is a free account and comes with many electronic parts including Arduino microcontroller. Since it is completely simulation based, students do not need to pay for any hardware, and any electronic connection mistake (electric short) can be fixed without any harm to students.

1. **The roles of each team member:**

For last five years at Georgia Gwinnett College, Dr. Tangirala and Dr. Lee have been working on robotic research with undergraduate students in various majors. Both of us have engaged with undergraduate students while working on design and development of a robotics and automation projects like: rocker-bogie rover, a chess playing robot arm, a 3D printed humanoid arm, and a vision-based smart parking lot. Additionally, both have been research mentors to two GGC student-teams that competed in nationally in the NASA-MINDS challenge in 2021 and 2022.

Both will work independently to create pedagogical content relating to

* chapter-1: “What is physical science”
* chapter-2: “Building blocks of robotics”
* chapter-3: “Concepts in electricity”
* chapter-5: “Electronic components in a typical robot”
* Both of us are planning to collect and analyze the collected e-text related assessment data from students

Dr. Lee will concentrate his work on

* chapter-4: “Tinker CAD circuits”
* chapter-6: “Display systems”
* chapter-8: “Connection between electricity and magnetism

Dr. Lee will take approximately 190 hours to complete the tasks assigned to him for the duration of the project.

Dr. Tangirala will work towards the creation of materials and activities pertaining to

* chapter-7: “Sensors”
* chapter-8: “Connection between electricity and magnetism”
* project’s assessment and evaluation plan

Dr. Tangirala will take approximately 190 hours to complete the tasks assigned to him for the duration of the project.

1. **Review of existing open, no-cost/or low-cost course materials:**

The team will be utilizing OER and free online resources such as found in MERLOT and Galileo. The team will work with the Librarian assigned to the School in order to search for resources. Some examples are found in [8, 9]

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| **Existing books versus Proposed Transformed Textbook** | |
| **Existing books** | **Proposed Transformed Textbook** |
| **Practical Electronics for Inventor, 4th ed by Paul Scherz and Simon Monk:**   1. Introduction to Electronics 2. Theory 3. Basic Electronic Circuit components 4. Semiconductors: Diode, Transistor 5. Sensors 6. Power supplies 7. Displays 8. Microcontrollers 9. Motors: DC, servo, stepper   **Electronics for Beginners: Jonathan Bartlett:**   1. What is Electricity? 2. First Circuit 3. Understanding Power 4. Logic circuit 5. Microcontrollers 6. Concepts in electricity 7. Semiconductors: Diode, Transistor | **Proposed Equivalent Curriculum Material:**  1. What is a physical science  2. Building blocks of robotics? (overview)  3. Concepts in electricity  4. Tinker CAD circuit ([link](https://www.tinkercad.com/learn/circuits))  5. Electronic components in a typical robot   * 1. Display system   2. Sensors   6. Display Systems   1. Light Emitting Diode (LED) 2. 7-segment display 3. Liquid Crystal display (LCD) 4. Capacitive touchscreens   7. Sensors   1. Temperature sensors 2. Sound waves and Sonar sensor (HC-SR04 sensor) 3. Light waves and Infrared (IR) sensor   8. Connection between electricity and magnetism   1. Motors    * 1. DC motor      2. Servo motor      3. Stepper motor   9. [Sample Existing Resources](https://drive.google.com/drive/folders/1_0YjwUs53u0FyU3b5otj_uyDxHYbQQJ7?usp=sharing) Links  The above link provides sample materials listed below   1. Sample lecture ppt 2. Sample tests 3. Sample homework |

1. **Plan for redesigning course:**

We propose to adapt some content from two commercially available books (Scherz et al.,2016 and Bartlett, 2020) and add additional resources to develop a feasible content for non-STEM majors. Since these books were not written as a physical science textbook for non-STEM students, the transformed textbook materials need to be focused not too much on technical contents but more on conceptual physical science connections to robotics.

1. **Plan for providing open access and ADA compliance:**

After the OER materials are developed by us, they will be uploaded under CC-BY licensing at ALG’s manifold platform (<https://alg.manifoldapp.org/>). The textbook contents can be downed under free open access from the ALG repository, OpenALG. The course materials for GGC students may be accessed via Brightspace (D2L) learning management system. Dr. Tangirala has experience in working with the Manifoldapp platform while working on his earlier ALG grants.

The proposed e-text in this project may look like his existing projects at:

<https://alg.manifoldapp.org/projects/science-of-everyday-materials>

The team will work with GGC staff person, Ms. Chris Robinson, Technical Writer, to do a final check of 508/ADA compliance.

# Budget

*Please enter your project’s budget below. Include personnel and projected expenses, keeping in mind that this grant funds the estimated time in your Action Plan. The maximum amounts for the award are as follows:*

**A. PERSONAL INDIVIDUAL AWARDS:**

**Total amount requested: $4,000**

Dr. Lee (PI) requests $2,000 to cover his pay, fringe benefits, and future academic travel expenses. He will oversee the project and be responsible for preparing the textbook chapters assigned to him including chapter notes and assignments.

Pay: $1,569.12

Fringe Benefit: $430.88

Total Request: $2,000.00

Dr. Tangirala (Co-PI) requests $2,000 to cover his pay, fringe benefits, and future academic travel expenses. He will be responsible for preparing the textbook chapters assigned to him including chapter notes and assignments.

Pay: $1,711.01

Fringe Benefit: $$288.99

Total Request: $2,000.00

Ms. Chris Robinson will provide support to the project as a service to the institution.

# Creative Commons Terms

The grant team understands that any new materials or revisions created with Affordable Learning Georgia funding will, by default, be made available to the public under a Creative Commons Attribution License (CC-BY), with exceptions for modifications of pre-existing resources with a more restrictive license.

# Accessibility Terms

*I understand that any new materials or revisions created with Affordable Learning Georgia funding must be developed in compliance with the specific accessibility standards defined in the Request for Proposals.*

All materials generated (worksheets and PowerPoints) will be 508 compliant to ensure accessibility for all students and faculty.

# Letter of Support

*The Department Chair from the corresponding project, or the Department Chair’s direct report such as the Dean or Provost, must provide a signed Letter of Support for the project. This letter should acknowledge the following:*

* *The department will provide support for fund disbursement in correspondence with the Grants/Business Office.*
* *The department approves of the work on the proposal by the applicant(s).*
* *The department acknowledges the sustainability of these affordable resources after the grant work is complete.*

*In the case of multi-institutional affiliations, all participants’ institutions must provide a letter of support.*

*Please provide the name and title of the department chair (or other administrator) who provided you with the Letter of Support.*

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| *Dr. Chavonda Mills, Dean of School of Science and Technology, Georgia Gwinnett College* |

# Grants or Business Office Acknowledgment Form

*Institutional Grants/Business Offices will be responsible for fund disbursement, often in correspondence with the Department Chair, including expense and travel reimbursement. All applicants will need to provide a signed Acknowledgement Form, the template for which is linked on the RFP page, stating that the Grants/Business Office knows about the applicant’s intent to apply for an Affordable Materials Grant. Either the Department Chair or the Project Lead can work with the Grants/Business Office to get this signed form.*

*In the case of multi-institutional affiliations, all participants’ institutions must provide this form.*

*Please provide the name and title of the grants or business office representative who provided you with the acknowledgement form.*

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