1. **Detailed description of the project:**

My proposed project is to research the efficacy of the Physics Department's new 5-credit PHY 123/124 courses. These courses parallel the General Physics I/II sequence (PHY 113/114) but also include a dedicated hour for developing student skills in problem solving. I also plan to develop an instructional guide for professors who teach it. If results are positive, additional sections of the course could be opened, and it could potentially become the standard method of instruction for teaching General Physics courses.

The PHY 123 course is scheduled to be offered for the first time during the Fall 2025 semester, followed by PHY 124 in Spring 2026. Thus, the scope of this proposal focuses on the PHY 123 course. That said, much of the work would also benefit the PHY 124 course in the following semester.

The PHY 123/124 courses provide an additional hour of problem solving as a fifth credit - an extension of the 4-credit General Physics I-II courses (PHY 113/114). The goal is to provide additional problem solving support for students who may need it. Through WFU's Office of Institutional Research, we have found that students who receive repeatable grades (C- or lower) in PHY 113/114 are frequently first generation students or students who scored a B or lower in calculus (MTH 111). Thus, the development of the PHY 123/124 course is a step toward making our physics program more equitable. At WFU, this could have significant impact on keeping students "in the pipeline" for majors in physics or for other STEM fields than include physics as a requirement. This could impact not just first generation students, but all underrepresented groups who may want to major in physics or another STEM field.

Data from the American Physical Society (APS) and Integrated Postsecondary Education Data System (IPEDS) indicates that in recent years, marginalized ethnic groups (defined by APS to include Black and African Americans, Hispanic and Latino Americans, American Indians, Alaska Natives, Native Hawaiians, and other Pacific Islanders) graduate with a smaller fraction of physics degrees than expected. Despite making up approximately 35% of the bachelor's degrees awarded from colleges nationwide, students from marginalized groups account for only approximately 15% of physics majors.

Our PHY 113/114 courses have 150 minutes per week in lecture (three 50-minute periods or two 75-minute periods) plus a 110-minute laboratory. This is a common way to teach the course; William and Mary and University of Virginia are two examples of many that also follow this model. But there are courses at several other institutions that teach a similar schedule but provide an additional hour of problem solving work. Anecdotally, this has been successful at those schools. One example is Carleton College, which is ranked #8 in National Liberal Arts Colleges by US News and World Report.

Other modifications to the WFU model include using a "recitation section" where a graduate teaching assistant teaches an additional hour of homework-directed instruction. Johns Hopkins is one example.

There does not appear to be a standard way of assessing the impact of an additional hour of problem solving work in an introductory physics course; my study could add to the literature in that area.

My project has the following four goals:

1. Assess whether PHY 123 is serving groups of students that need support and develop a system to attract those students to the course. In other words, are we effectively serving our target audience?
2. Create an instructor's guide for teaching the PHY 123 course.
3. Assess the effectiveness of PHY 123 in developing student problem solving skills.
4. Present this work at a section or national American Association of Physics Teachers meeting. (Spring or Summer 2026)

To assess whether we are serving the groups that traditionally have higher D/F/W rates in physics courses, we will need to obtain and analyze institutional demographic data about who has taken the course. We will also need that data for students in the parallel PHY 113/114 courses to see how many students the 123/124 courses may "miss". We may also need to survey the students regarding how they made the choice to take the course they selected, why they chose to drop the course, and/or what their prior background in physics courses was. In addition, I would need to learn how to proactively locate students who may benefit from the PHY 123 course, such as building partnerships with campus initiatives like First in the Forest. Other departments such as Chemistry and Mathematics have tried to target potentially underprepared students, and we may be able to adopt elements of their processes. Educational literature may also suggest some answers.

To create a useful instructor's guide, the physics education literature and curricula must be extensively reviewed, and physics departments from other schools will be consulted. This has proved to be successful at places like Carleton College, and those faculty have indicated they are interested in sharing what they have learned to make our process more efficient. Appropriate materials need to be selected, field-tested, and provided to faculty with instructions on their use. Physics education research literature has a lot of effective ideas, and the goal is to turn those ideas into effective implementation of curriculum and problem solving instruction at WFU.

To develop and assess the effectiveness of the fifth hour of problem solving instruction, I would need to create and/or utilize written and online surveys to identify students understanding of physics and problem solving, ideally given at the start and end of the semester. A more robust understanding could also be gained from in-person student interviews after course instruction is completed. Data on student course grades would also be collected. This is one aspect of the work that may need to be extended beyond the term of the course reduction due to the need to collect and analyze data after the submission of grades. In addition, data from other institutions would be gathered about their fifth hour courses, particularly for programs whose fifth hour is taught by faculty instead of teaching assistants. This allows our department to put our WFU data in context.

I seek to combine the data I gather from our PHY 123/124 courses with data from departments who have tried similar approaches. Common themes and publication-worthy results can then be discovered on the impact of our fifth hour of instruction.

2. **How will this project enhance WFU teaching and learning?**

   This project has two major impacts. First, it aims to discover and convey useful strategies for teaching problem solving. I expect to gain expertise in this area through my review of the physics education literature and corresponding curricula and instructional techniques. I will convey that to fellow faculty at WFU through the creation of a guide for teaching problem solving in the PHY 123 class. This benefits all instructors who teach the class as well as their students. Also, a successful implementation could become the standard method of instruction for all our General Physics I/II courses (113/114 as well as 123/124). The course may also serve as a model for other physics departments to follow.

   Second, it aims to find out how to more effectively reach out to groups who are underprepared for college physics, with the intention of increasing the diversity of students who continue in physics. I expect to develop partnerships with WFU programs such as First in the Forest to help identify students who would benefit from the additional problem solving instruction. This targeted problem solving may also impact underrepresented groups who often leave physics before graduation.

3. Detailed Timeline for project

- Spring 2025 (prior to semester of course reduction)
    - Request and analyze demographic data from Institutional Research on students registering for PHY 113/123
    - Review literature on best practices for teaching problem solving and identify useful techniques and curricula that could be used for the PHY 123 course. Begin development of an instructional guide.
    - Identify students who would benefit from the PHY 123 course and encourage them to register. This would involve building partnerships with university offices such as First in the Forest as well as other departments at WFU who have tried to address this equity gap in their introductory courses.
    - Identify which other universities have implemented 5-credit courses or courses with an additional problem-solving hour. Initial work has been done on this via a physics department chairs' listserv. Carleton and Stony Brook are two such institutions that have a recitation/fifth hour taught by faculty.
- Fall 2025
    - Review demographic data for students, keeping track of additions and drops of the PHY 113/123 courses
    - Continue development of instructional guide with additional resources.
    - Assess the effectiveness of instructional techniques using surveys and/or in-class observations. This involves both the administration of pre-existing surveys/interviews/etc. as well as creation of new protocols specific to the PHY 123 course.
    - Gather data from other universities that use an additional problem-solving period / fifth hour in their courses.
- Spring/Summer 2026 (following the semester of course reduction)
    - Post-course data collection (interviews with students, online surveys)
    - Presentation of results at an American Association of Physics Teachers meeting

4. Project length beyond the semester of course reduction?

The length of this project will continue past the Fall 2025 semester into Spring/Summer 2026. Post-instruction data collection from the Fall 2025 PHY 123 can only be completed once the students finish their course and receive course grades. Some post-instruction interviews may also be conducted after the semester ends. Analysis of this data and subsequent presentation of the project at a national physics teaching conference would be completed during the Spring/Summer 2026 semesters.

5. Additional funding

Additional sources of funding for this project are desirable, but they are not critical to the completion of the project. I would seek to use any available funding to develop curricula, obtain teaching materials, conduct interviews with students, and visit institutions who already implement an additional hour of problem solving instruction.