Physics 2020-2021 Assessment Plan

1. Program Mission Statement

The core mission of the Physics program is to train students to think quantitatively about the workings of the physical universe. We provide support at the introductory level for several majors at Wells, as well as our own, and contribute to the general education curriculum with appropriate lab science experiences. And, equally importantly, we seek to provide an as complete as is feasible undergraduate major, both in physical theory (conceptual and mathematical), and in hands-on laboratory work. Students who complete the program may make explicit use of our curriculum in their chosen career path (which is very often as an engineer), or in furthering their education by way of graduate training in physics or engineering.

All students who take one or more courses with us use their physics training to intelligently break down a problem down into its essential components (an implicit objective of our entire curriculum), which will serve them well in nearly any future endeavor. We strive to have our students gain competence in verbal and mathematical expression of the material. Our major is at the heart of STEM fields, and consequently our graduates have significant success in obtaining employment in engineering and the physical sciences. Therefore, because of its intellectual challenge and the ways in which it teaches students how to grapple with complex problems, the major fits very well with Wells's overall mission and recent commitment to a curriculum that can be used in practical (and, we daresay, lucrative) careers.

2. Physics Program Goals

[Goals 1 & 2 are directed at all science students, primarily at the introductory level]

Goal 1: To provide thorough foundational background knowledge in classical physics [addresses Student Learning Goals C1, ES1c, ES2, ES6a, ES6c]
Goal 2: To support the general education curriculum of the College [addresses Student Learning Goals ES1a, ES2, ES3, ES5]

[Goals 3 & 4 are directed primarily but not exclusively toward physics majors]

Goal 3: To enable students to be able to apply quantitative thinking to problems in physics, using appropriate mathematical tools [addresses Student Learning Goals C2, C3ES1b, ES1c, ES4, ES6b, ES6c]
Goal 4: To have students acquire competence and confidence in the physics laboratory [addresses same Student Learning Goals as Goal 3]

[Goals 5 & 6 aim to tie what happens in the major to the college's mission]

Goal 5: To have our students understand how the study of physics can lead to a meaningful and satisfying life/career after Wells [addresses Student Learning Goals C3, ES2, ES6a]
Goal 6: To have our students accurately communicate physical laws and processes in clear natural English, both spoken and written [addresses Student Learning Goals C3, ES1b]

3, 4, 5. Physics Program Objectives, Measurable Learning Outcomes, and Means of Assessment of Outcomes

Goal 1: To provide thorough foundational background knowledge in classical physics

Learning Objective 1.1: Students will possess sufficient ability to use mathematics and to learn physics so as to streamline future learning and comprehension

Learning Outcome and Assessment 1.1.1: Demonstrate mathematical ability using algebraic methods and calculus. Assessed by HS transcript, score(s) on relevant AP and math placement, and individual conversation.

Learning Outcome and Assessment 1.1.2: Assess competence in basic principles of physics and related disciplines at the entry-to-college level. Assessed by HS transcript, score on relevant AP exams, and individual observation and conversation.

Learning Objective 1.2: At the introductory level, to be able to apply physics training to other scientific coursework

Learning Outcome 1.2.1: Demonstrate mastery of the material in our introductory level calculus-based physics. Assessed through quiz scores and a comprehensive final exam, and class and laboratory participation,

Learning Outcome 1.2.2: Possess an understanding of the role physics plays in underpinning all of the sciences. Assessed by successful application of basic physics concepts to examples drawn from other sciences.

Goal 2: To support the general education curriculum of the College

Learning Objective 2.1: In physics courses meant for non-majors, to have students master theoretical and lab-based physics ideas

Learning Outcome 2.1.1: Students demonstrate conceptual, experiential, and quantitative competence in a field of physics that has relevance to the liberal arts. Assessed through examinations, homework responses, lab participation, written work, and class participation.

Learning Outcome 2.1.2: Students gain awareness of how the ways of thinking in physics can deepen insight to any topic in the liberal arts. Assessed through discussion and written work.

Goal 3: To enable students to be able to apply quantitative thinking to problems in physics, using appropriate mathematical tools, including but not limited to algebra, differential and integral calculus in one and higher dimensions, differential equations, and estimation and approximation techniques

Learning Objective 3.1: Master a variety of mathematical techniques for their own sake, irrespective of their applicability to problems in physics, in order to develop critical and analytical thinking

Learning Outcome 3.1.1: Gain competence in college-level mathematics as an abstract body of thought. Assessed through grades in related mathematics classes and examination performance in physics classes.

Learning Outcome 3.1.2: Learn specific mathematical techniques and problem-solving skills, including but not limited to algebra, differential and integral calculus in one and higher dimensions, differential equations, and estimation and approximation techniques. Assessed through proper application on examinations and homework problems of those specific techniques.

Learning Objective 3.2: Successfully apply quantitative thinking to problems and processes that occur in the natural world, be they mechanical, electromagnetic, thermodynamic, or quantum-mechanical, and in fields related to physics

Learning Outcome 3.2.1: By means of assigned problems, examinations based on the material in text and lecture, and one-on-one interactions with faculty, achieve the objective, in each of the topic areas. Assessed through successful completion of upper-level physics courses.

Learning Outcome 3.2.2: Make clear connections in discussion and written work about the ways in which physics operates in providing a mathematical understanding of the processes of the universe. Assessed through discussion and evaluation of written materials.

Learning Outcome 3.2.3: Succeed in connecting what is learned in the physics program to the meaning and value of a full liberal arts education. Assessed through discussion and the capstone experience.

Learning Outcome 3.2.4: By selecting courses in fields that are allied to physics, from across STEM fields both within the MPS program or in other sciences, gain a real understanding of the relationships of physics to other technological and scientific endeavors. Assessed through thoughtful academic advising.

Goal 4: To have students acquire competence and confidence in the physics laboratory

Learning Objective 4.1 Gain competence in application of theoretical physics concepts to observation of actual physical phenomena

Learning Outcome 4.1.1: To be able to explain the theoretical basis of experimental work, at all levels. Assessed through submitted lab write-ups and classroom observation.

Learning Objective 4.2: Learn to set up and operate physical equipment, and to successfully obtain accurate and reliable experimental data, and to understand the how measurements may be made with precision and confidence

Learning Outcome 4.2.1: At the introductory level, show patience, leadership, and skill in the physics laboratory, both in operating equipment clearly presenting results. Assessed through submitted lab write-ups and classroom observation.

Learning Outcome 4.2.2: At the upper level, exhibit mature experimental problem-solving skills on a variety of kinds of physics equipment, which will require that the students learns the accompanying theory independently by reading and understanding manufacturer's literature as well as online resources. Assessed through observation and submitted formal lab write-ups.

Goal 5: To have our students understand how the study of physics can lead to a meaningful and satisfying life/career after Wells

Learning Objective 5.1: Through internships and other kinds of hands-on activity, develop the kind of critical thinking and problem-analysis skills physicists use

Learning Outcome 5.1.1: Working with Wells's career services support, obtain meaningful STEM-based internship experiences. Assessed through successful completion of internships, which usually require a journal and a poster presentation.

Learning Outcome 5.1.2: Obtain whenever feasible research experience in REU (Research Experiences for Undergraduates) and similar programs at other institutions. Assessment is difficult in this case.

Learning Objective 5.2: Wherever appropriate, to have our declared majors function as mentors to their fellow students, in order to reinforce learning and communication skills

Learning Outcome 5.2.1: Through informal presentations and in-class conversation, participate in class shared activities that engage the physics material

Learning Outcome 5.2.2: Through TA opportunities, have our upper-class students help beginning students to master important subject areas. Assessed through informal feedback from beginning students.

Learning Objective 5.3: At every opportunity, to support increased diversity of all kinds in the practitioners of the physical sciences

Learning Outcome 5.3.1: To foster in our students a welcoming atmosphere toward others, regardless of gender, ethnicity, and innate quantitative facility, and to make all feel welcome in our classes. Assessment is difficult in this case.

Goal 6: To have our students accurately communicate physical laws and processes in clear natural English, both spoken and written

Learning Objective 6.1: In addition to proper and appropriate use of mathematical language, emphasis is placed on verbal explanations, both written and oral

Learning Outcome 6.1.1: When solving physics problems, accompany the mathematical analysis with clear explanations of what is being done. Assessed by analysis of written work.

Learning Outcome 6.1.2: In the laboratory, provide clear verbal explanations of the experiment and its results. Assessed through written 'formal' lab write-ups and written responses to lab handout questions.

Learning Objective 6.2: To complete a senior capstone thesis

Learning Outcome 5.2.1: Engage in the process of developing an appropriate project topic in physics, through literature research and brainstorming, including various kinds of written work and in-class discussion. Assessed through successful completion of the first part of MPS402.

Learning Outcome 5.2.2: Complete a thesis that contains both well-crafted communication and discussion of the topic and its ideas, using coherent and consistent notation, which is supportive of the technical content. Assessed through successful completion of the thesis project (written document and presentation preparation) for the final part of MPS402..

6. How Assessment Data Will Be Utilized

In courses meant for Physics majors, apart from the heavily quantitative information on student performance that is gleaned from graded homework and examinations, which indeed does provide the student with clear and meaningful feedback about subject areas where improvement is needed, there is ample opportunity for faculty to observe students as they pursue their learning. This qualitative data is equally valuable for student success. Written comments on homework and exams guide the student toward clearer comprehension of the ideas. One-on-one interaction in lab courses with the instructor and with fellow lab team members serves as an extremely timely way to become aware of misconceptions and to mitigate them.

In the introductory courses, as mentioned in the Report, we have moved to a different model for testing and feedback. Shorter, more numerous quizzes, with rapid grading and review, show much promise in improving the student experience and the depth of their understanding, compared to the earlier method of fewer, longer examination. There has been an increasing need in recent years to more closely monitor student progress, and this new model facilitates that.

In the advanced courses, we continue to assess student performance through regularly assigned homework sets, which are graded as expeditiously as possible, and two or three examinations during the course of the semester. Often, a course's instructor will reserve time to cover conceptual issues that arise in solving homework problems and will provide guided assistance to students.

In the capstone experience, on-going give and take between faculty and students as the project takes shape is ideally integral to the process of student intellectual growth; feedback provided after rehearsed verbal presentations should demonstrably improve the final product; we will continue to use written rubrics as assessment tools for students in this pair of courses, to help shape the students' grasp of the important content and style considerations for a successful thesis.

As a department, we continue to be challenged by the limitations of some of our students' abilities. As well, we see significant downsides to the increasingly common practice of 'double majoring' in Physics and another MPS area, when the students who are allowed to do a double major should really focus on a single major and strive to achieve competence there.