WSU Five-Year Program Review
Self-Study

Cover Page

Department/Program: Department of Physics

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Brief Introductory Statement
(Reference: Annual Report – description of contribution to the university as a whole)

The Physics Department at Weber State University is a dynamic department committed to meeting the needs of a growing student body and the regional community. Our strengths fit well with the mission of the university as a whole. We are active scholars in physics and physics education, textbook writers, and active scholars in the profession by hosting and participating in regional and national meetings. Several faculty serve as peer-reviewers for the *American Journal of Physics* and one of our faculty just stepped down as editor to a consulting editor position. We have a commitment to teaching at the general education level and up, a strong history of undergraduate research, and impactful community outreach efforts. Exemplary efforts in the latter two areas include the HARBOR (High Altitude Balloon for Outreach and Research), "Science in the Parks" programs, and the Ott Planetarium. Additionally, our Physics Open House event hosted each fall just had its 12-year anniversary and is still attracting greater than 500 people from the surrounding community each year on a Friday evening.

One prominent change since our last review includes a new science building with new lab space, facilities, and equipment. The new space and equipment provided the impetus to revamp many of our laboratory courses at both the upper and lower course designations. The new building also houses a public observatory to complement our planetarium outreach and a research observatory bringing new undergraduate research and faculty scholarship opportunities to Weber State. Additionally, new instrumentation for our experimental laboratories and computational facilities have provided new pathways for both faculty and student research.

Challenges for the department are similar to those for the university as a whole, including limited faculty time, limited funds, and the wide spectrum of preparation of incoming students. Particular concerns recently include uncertainty in faculty positions. Since the last review, four tenured faculty members have retired (Amiri, Ostlie, Carroll, Galli). In this time period, we have only had one tenure track hire (Rabosky) and one instructor hire (Spirito, whose primary duties are to teach in our introductory lab program). Additionally in that time period, we have seen an increase in teaching needs for our *Physics for Scientists and Engineers* courses, PHYS 2210 and PHYS 2220, which serve other departments and colleges across campus. We have chosen to cut our quarter-time position in the honors program and reduce the number of general education (i.e. PHYS 1010 and ASTR 1040) sections to meet our service and major demands.

The Department is committed to educating all students, including those for whom physics meets a general education requirement, those who take physics in support of another program of study, and of course those students who are working to complete a program of study in our own programs. Although our numbers of graduates each year are very good in comparison to other institutions of similar mission, we are continually working to recruit and retain more. Currently, our recruitment and retention committee works with the entire department to try to increase our numbers and diversity in all our majors and minors, with some special attention being made to meet the demand for qualified physics teaching positions in the region. These efforts have included developing small cohorts of students in the first-year sequence, hosting a Women in Physics group, and writing an NSF grant to support scholarships for teaching students. These efforts are in addition to a healthy rapport between students and faculty, a dedicated learning space ("Physics Majors Room") for our students, a wealth of research opportunities, a student club, opportunities to work within the department, and numerous other features.

Standard A - Mission Statement

The mission of the Department of Physics at Weber State University is to provide high-quality instruction in physics at the undergraduate level. This includes providing courses in the general education area of physical science, pre-professional, science, engineering and pre-engineering courses in physics, and courses and programs for those who want to major or minor in physics.

Further activities of the department include providing opportunities for research and other scholarly activities of both faculty and students, advising the students served by the department, and serving as a resource for the campus and the state of Utah in the areas of physics and astronomy.

Standard B – Curriculum and Standard C -Student Learning Outcomes and Assesment

Note: For the sake of a coherent narrative, we've assembled these two sections together, as the development and justification of our curriculum should braid together with assessment efforts.

Assessment and Curriculum Overview:

The Department charges two working groups, the Assessment Committee and the Curriculum Committee, to consider the outcomes of student learning at all levels as well as how we facilitate the learning through our course offerings. These groups bring issues to the full Department for discussion and approval when necessary. Additionally, a newly formed Department Advisory Committee provides feedback on our programs, though we are currently in the process of more clearly specifying the role and makeup of this Advisory. Simultaneously, individual instructors in the Department are responsible for creating robust and authentic assessments of learning that both inform instruction and facilitate learning, and changes or development of these are highlighted each year in faculty annual reports. Thus, assessment efforts are both individual and collective responsibilities that are ongoing. The Department engages in continual conversations about how to best assess student learning, whether these are around in hallway conversations, facilitated during a seminar (hosting either internal or invited Physics Education experts), or as prompted when the Assessment Committee Chair is compiling individual efforts.

Recently, Department assessment efforts have focused on General Education Physical Science (PS) goals, objectives, and outcomes. Towards this effort, instructors engaged in these courses discussed and planned more systematic measurements than conducted in the past, and these were most recently reported in our General Education renewal for all our PS courses. (The grid that details these efforts in PS courses is contained in Appendix G.)

Currently, instructors of the Department's general education courses are also contemplating and bracing for new general education initiatives to encourage "Signature Assignments" (SA) that address a "Big Question" (BQ) that is central to the course and physical science (see https://www.weber.edu/GenEd/faculty_info.html). Toward this end, some faculty have employed these to lead the way for the Department and the University. These are modeling for other faculty some examples of how a SA can be framed and how the BQ can be incorporated into coursework. The idea that there is such a thing as a central theme of inquiry in a class is easy for us to understand, but it's also a challenge we are working on embracing. Even as we have started these efforts, we have run into new questions for ourselves. For example, Dr. Rabosky, in teaching her *Elementary Physics* course and incorporating these thematic elements, has found that her students don't fully understand the nature of science and what it means to analyze data. This has spurred a research project together with Dr. Johnston and an undergraduate researcher. This is all to point out that we see the next steps in general education reform and assessment as problematic in interesting ways. We anticipate that the very nature of our assessments will look different, though we're not sure exactly how.

Considering curriculum and learning in Physics programs (majors and minors in all variations), we have recently instituted a few notable changes to what we consider to be an already strong program of study. These, like other changes in the past, are instigated by our own analyses of programs and input from the external community. These have included:

1. The development of a new, advanced course in observational astronomy, PHYS/ASTR 3040*, Principles of Observational Astronomy, Advanced*. This course is an upper division offering for students who have advanced in the major but realized they want to develop more understanding and skills in the practice of astrophysics. Previously, they were limited to course offerings at the lower division level. However, these students have advanced skills in thermal and modern physics that are essential for advanced work

in astrophysics. Moreover, these students have mathematical skills for advanced data analysis. This coursework meets a need of these students and builds towards future work, graduate studies, or research projects.

2. Revision and retitling of PHYS 3420, *Data Analysis, Statistics, and Instrumentation*, to incorporate current advances in scientific laboratory techniques and technologies. These changes filled holes in our major program, as well as for other related fields (chemistry, engineering, and technology fields in particular) to give students learning opportunities in advanced data acquisition and the designing of research devices through 3D printing and advanced instrumentation.
3. A department focus group has identified our "capstone" course, Advanced Physics Seminar, as a focal point for future assessment. For this course we need to assess the preparation of our students in physics research, as well as the outcomes in advanced physics and research skills that can be documented in this 1-credit opportunity. (It's correct to say that our assessment efforts are making us rethink our assessment efforts. Such is progress.)

Through the efforts already employed, we've recognized current strengths and weaknesses of our current assessment measures. First, we have drawn from assessments that are natural and authentic components of a course (e.g., see various examples in the curriculum map that follows below). That is, there is a "natural habitat" of each course (conceptual astronomy versus a problem-solving physics course, for example) that provides a rich context for more general outcomes. In a problem solving course for science majors, students solve problems that connect energy transformations within a system in order to predict a specific result; yet in a conceptual course a student may need to narratively describe the source of the Sun's energy during solar system formation. We've determined that there are very specific concepts that match the more general outcomes, and moreover there are very specific tasks that we engage students in different coursework. These all are assessed differently.

At the same time, some assessments are better than others. While we think that most of our assessments are "direct," there are probably different levels of such directness. And, some measures are simply better than others. We know, for example, that a student can solve problems that require an understanding of force at some level, but they may not be able to use that understanding in other contexts. This might seem like a damning evaluation of a particular assessment method, but we see that this is a weakness across the board. All assessments suffer this weakness. Rather than brush it aside, we're embracing it and using this to further our work. That's a much longer process. (The most used research instrument in physics education research, the Force Concept Inventory, has items that have been used for three decades, but the meaning of these is still scrutinized and debated.)

Finally, we're pleased that there are measures here that we think are potential models to build from because they are particularly well aligned with outcomes and simultaneously provide a valid measure of deep learning. For example, we have been able to pull data about student thinking in readings of historical literature in an introductory physics class; we can evaluate student understandings of scientific practices in laboratory environments; we have demonstrated how students compile and evaluate data to construct scientific models (e.g., solar system formation data in astronomy courses); students demonstrate understandings of the nature of science by testing their own scientific explanations and reflecting on the process itself; and many others. These kinds of measures are not simply measures, but part of the curriculum of a given course that helps students to learn science in meaningful ways. This goes in concert with our overall philosophy of assessment and curriculum development: Individual instructors are responsible for demonstrating student learning in diverse but deep ways, and these are shared with one another as we each develop coursework and the overall structure of our programs and assessments.

Learning Outcomes

The Department of Physics has a standing set of learning outcomes determined for students in all classes and programs. These currently include the following, including modes of assessment and brief summaries. (Each description is given a brief name, italicized, for reference in tables.)

1. *Major Concepts*: At graduation, physics majors should have a thorough knowledge and comprehension of the core concepts of classical and modern physics, as assessed by: student success in passing the required and elective courses for their physics major; student scores on the GRE Physics Exam (in comparison with nationwide results from the American Institute of Physics and the American Association of Physics Teachers); student acceptance rates for graduate school and/or job placement; a comparison of WSU's physics curriculum with the curricula of 1) physics programs in schools with a comparable student profile, and 2) the best physics programs.
2. *Physics Skills*: At graduation, physics majors should have a set of fundamental skills that can be applied to a variety of situations. These skills should include the following:
    a. *Presentation skills*. Physics majors should be able to express (orally and in writing) their understanding of core physical principles, the results of experiments, and their analysis of physical problems, as assessed by their success in the Physics capstone presentation required of all majors and in other courses which require a written or oral report.
    b. *Laboratory skills*. Physics majors should be competent experimentalists. They should be able to design and set up an experiment, collect and analyze data, identify sources of error, and interpret their result and connect it to related areas of physics, as assessed by student performance in physics laboratory courses and faculty- supervised research projects. Students should have a basic understanding of laboratory safety issues, and follow safe practices in their own laboratories.
    c. *Computer skills*. Physics majors should be competent users of basic software, such as word processing, spreadsheet, and graphing programs, and Mathematica software. Physics majors should have an understanding of computer programming and fundamental numerical algorithms as used for problem solving and visualization in the natural sciences, as assessed by student performance in the computing components of courses in the physics curriculum.
    d. *Problem-solving skills*. Physics majors should be competent problem-solvers. They should be able to identify the essential aspects of a problem and formulate a strategy for solving the problem. They should be able to estimate the solution to a problem, apply appropriate techniques to arrive at a solution, test the correctness of their solution, interpret their result and connect it to related areas of physics, as assessed by student performance in the problem-solving components of courses in the physics curriculum.
3. *Analysis*: Physics majors should be adequately trained to apply their physics experience and knowledge to analyze new situations, as assessed by: student acceptance rates and success in academic and industrial intern positions; post-graduation student success in graduate school, industry, or teaching – in physics or otherwise – as established by questionnaires and interviews of graduates, employers, and graduate faculty. This should include a "long-term" evaluation to obtain feedback from majors of 5 – 10 years ago.
4. *Nature of Science*: All physics students (majors, minors, support, and Gen Ed students) should understand the nature of science, as assessed by exams, questionnaires, interviews, and student focus groups.
5. *General Concepts*: General Education students should understand several core concepts of physics, as assessed by nationally reviewed pre- and post-tests (for example, the Force Concept Inventory and the Mechanics Baseline Test for Newton's laws) and interviews.

NOTE: In addition to these concepts, the Department recognizes and prioritizes the learning objectives designated by the University for Physical Science General Education Breadth requirements. We refer to these learning objectives by their shorthand descriptions: Nature of Science, Integration of Science, Science and Society, Problem Solving, Systems, Matter, Energy, and Forces. (These objectives are described fully at http://www.weber.edu/academicaffairs/natural_sciences.html.) Many of these naturally overlap with other extant Department learning objectives.

6. *Teacher Prep*: Physics Teaching majors and Elementary Teaching majors should have an appropriate knowledge of physics and a variety of teaching strategies to accommodate the multiple learning styles of their students, as assessed by a comparison of the WSU Physics Teaching major with the Utah State Core Curriculum, classroom observation of student teachers, interviews with physics teachers and pre-teachers, and job placement in major teaching field.

Curriculum Map

Coursework:

The department currently offers the following coursework. Courses offering the general education "Physical Science" breadth requirement are annotated with "PS" next to the course number. Courses marked with superscript "*" are crosslisted with the ASTR ("Astronomy") prefix (in addition to the PHYS prefix).

PHYS 1010 PS - Elementary Physics
PHYS 1040 PS - Elementary Astronomy*
PHYS 1360 PS - Principles of Physical Science
HNRS 1500 PS - Perspectives in the Physical Sciences (variable titles)
PHYS 2010 PS - College Physics I
PHYS 2015 - College Physics I Lab
PHYS 2020 - College Physics II
PHYS 2025 - College Physics II Lab
PHYS 2040 PS - Principles of Observational Astronomy*
PHYS 2090 - Environmental Physics - Energy and Power
PHYS 2210 PS - Physics for Scientists and Engineers I
PHYS 2215 - Physics for Scientists and Engineers I Lab
PHYS 2220 - Physics for Scientists and Engineers II
PHYS 2225 - Physics for Scientists and Engineers II Lab
PHYS 2300 - Scientific Computing for Physical Systems
PHYS 2600 - Laboratory Safety
PHYS 2710 - Introductory Modern Physics
PHYS 2800 - Introductory Individual Research Problems*
PHYS 2830 - Introductory Readings in Physics/Astronomy*
PHYS 2890 - Cooperative Work Experience
PHYS 2920 - Short Courses, Workshops, Institutes and Special Programs
PHYS 3040 – Principles of Observational Astronomy, Advanced
PHYS 3160 - Stellar and Planetary Astrophysics*
PHYS 3170 - Galaxies and Cosmology*
PHYS 3180 - Thermal Physics
PHYS 3190 - Applied Optics
PHYS 3300 - Advanced Computational Physics
PHYS 3410 - Electronics for Scientists

PHYS 3420 - Data Analysis, Statistics, and Instrumentation
PHYS 3500 - Analytical Mechanics
PHYS 3510 - Electromagnetic Theory
PHYS 3540 - Mechanical and Electromagnetic Waves
PHYS 3570 - Foundations of Science Education
PHYS 3710 - Nuclear and Particle Physics
PHYS 4200 - The Physics of Materials
PHYS 4400 - Advanced Physics Laboratory
PHYS 4410 - Materials Characterization Laboratory
PHYS 4570 - Secondary School Science Teaching Methods
PHYS 4610 - Quantum Mechanics
PHYS 4620 - Advanced Quantum Mechanics
PHYS 4800 - Individual Research Problems*
PHYS 4830 - Readings in Physics/Astronomy*
PHYS 4890 - Cooperative Work Experience
PHYS 4920 - Short Courses, Workshops, Institutes and Special Programs
PHYS 4970 - Senior Thesis
PHYS 4990 - Seminar in Physics

Program Outcomes:

1) At graduation, Physics majors should have a thorough knowledge and comprehension of the core concepts of classical and modern physics, as assessed by:

a) student success in passing the required and elective courses for their physics major.
Courses: PHYS/ASTR 2040, 2210, 2219, 2220, 2229, 2300, 2600, 2710, 3040, 3160, 3170, 3180, 3190, 3300, 3410, 3420, 3500, 3510, 3540, 4200, 4400, 4410, 4610, 4620, 4800, 4830, 4970, 4990.

b) student scores on the GRE Physics Exam (in comparison with nationwide results from AIP, AAPT).
Extra-curricular experience: GRE Physics Exam.

c) student acceptance rates for graduate school and/or job placement (in comparison with nationwide results from AIP, AAPT).
Extra-curricular experiences: application for graduate school and/or employment.

d) a comparison of WSU's physics curriculum with the curricula of 1) physics programs in schools with a comparable student profile, and 2) the best physics programs.
Courses: PHYS/ASTR 2040, 2210, 2219, 2220, 2229, 2300, 2600, 2710, 3040, 3160, 3170, 3180, 3190, 3300, 3410, 3420, 3500, 3510, 3540, 4200, 4400, 4410, 4610, 4620, 4800, 4830, 4970, 4990.

2) At graduation, physics majors should have a set of fundamental skills that can be applied to a variety of situations. These skills should include the following:

a) Presentation skills. Physics majors should be able to express (orally and in writing) their understanding of core physical principles, the results of experiments, and their analysis of physical problems, as assessed by their success in the Physics capstone presentation required of all majors and in other courses which require a written or oral report.
Courses: PHYS 4400, 4410, 4970, 4990.

b) Laboratory skills. Physics majors should be competent experimentalists. They should be able to design and set up an experiment, collect and analyze data, identify sources of error, and interpret their result and connect it to related areas of physics, as assessed by student performance in physics laboratory courses and faculty-supervised research projects. Students should have a basic understanding of laboratory safety issues, and follow safe practices in their own laboratories.
Courses: PHYS 2040, 2219, 2229, 2600, 3040, 3190, 3410, 3420, 4400, 4410, 4800, 4970.

c) Computer skills. Physics majors should be competent users of basic software, such as word processing, spreadsheet, and graphing programs. They should also have an understanding of the fundamental aspects of a programming and/or computer algebra language (PYTHON, C++, Mathematica, LabView etc), as assessed by student performance in the computing components of courses in the physics curriculum.
Courses: PHYS 2219, 2229, 2300, 3300, 2710, 3510, 4400.

d) Problem-solving skills. Physics majors should be competent problem-solvers. They should be able to identify the essential aspects of a problem and formulate a strategy for solving the problem. They should be able to estimate the solution to a problem, apply appropriate techniques to arrive at a solution, test the correctness of their solution, interpret their result and connect it to related areas of physics, as assessed by student performance in the problem-solving components of courses in the physics curriculum.
Courses: PHYS/ASTR 2040, 2210, 2220, 2710, 3040, 3160, 3170, 3180, 3190, 4200, 3300, 3410, 3420, 3500, 3510, 3540, 3640, 4570, 4610, 4620, 4800, 4830, 4970.

3) Physics majors should be adequately trained to apply their physics experience and knowledge to analyze new situations, as assessed by:

a) student acceptance rates and success in academic and industrial intern positions.
Extra-curricular experiences: application for graduate school and/or employment.

b) post-graduation student success in graduate school, industry, or teaching --- in physics or otherwise -- as established by questionnaires and interviews of graduates, employers, and graduate faculty. This should include a "long-term" evaluation to obtain feedback from majors of 5 - 10 years ago.

Extra-curricular experiences: opportunities for career advancement and promotion.
4) All physics students (majors, minors, support, and Gen Ed students) should understand the nature of science, as assessed by questionnaires, interviews, and student focus groups.
Courses: PHYS/ASTR 1010, 1040, 1360, 2010, 2010L, 2020, 2020L, 2210, 2210L, 2220, 2220L, 2740, 3160, 3170,3180, 3190, 4200, 3300, 3410, 3420, 3500, 3510, 3540, 3640, 4610, 4620, 4800, 4830, 4970, 4990; HNRS 1500

5) General Education students should understand several core concepts of physics, as assessed by nationally reviewed pre- and post-tests (for example, the Hestenes Force Concept Inventory and the Hestenes Mechanics Baseline Test for Newton’s laws) and interviews.
Courses: PHYS/ASTR 1010, 1040, 1360, 2040, 2010, 2210; HNRS 1500

6) Physics Teaching majors and Elementary Teaching majors should have an appropriate knowledge of physics and a variety of teaching strategies to accommodate the multiple learning styles of their students, as assessed by:

a) a comparison of the WSU Physics Teaching major with the Utah State Core Curriculum.
Courses: PHYS/ASTR 1010, 1040, 1360, 2210, 2220, 2600, 2710, 3160, 3170, 3180, 3190, 3200, 3300, 3410, 3420, 4570.

b) classroom observation of student teachers.
Extra-curricular experience: student teaching.

c) interviews with physics teachers and pre-teachers.
Extra-curricular experiences: preparation and employment experiences of teachers and pre-teachers.

d) job placement in major teaching field.
Extra-curricular experience: application for employment with public or private schools.

The learning objectives, assessment instruments, and courses all listed above have multiple intersections, as described in the following summaries, including where in which each learning objective is assessed (e.g., PHYS 2210, or another experience of a student/graduate), as well as what assessment tools are used (e.g., WE for "written exams,") to measure these outcomes. The Department has identified a set of direct measures and a set of indirect measures of these outcomes. These sets are not meant to be exhaustive. Abbreviations for each of these measures are indicated and utilized as follows:

> Direct Measures: WE = written exams (standardized or locally-developed), OE = oral exams, LAB = laboratory activities, REP = reports/writing samples, CAP = capstone projects, IEX = inside examiners, CO = comparisons with external programs or standards, OEX = outside examiners, INT = internship experiences
>
> Indirect Measures: EI = exit interviews, GR = graduate school acceptance, JOB = job placement, PO = participant observation, FG = focus groups, PGS = survey of post-graduation success, JP = reported job performance

Major Concepts:

A. student success in passing the required and elective courses for their physics major. [WE, OE, LAB, REP] *Courses*: PHYS 2210, 2219, 2220, 2229, 2300, 2600, 2710, 2800, 2830, 3040, 3160, 3170, 3180, 3190, 3200, 3300, 3410, 3420, 3500, 3510, 3540, 3640, 3710, 4200, 4400, 4410, 4610, 4620, 4800, 4830, 4970, 4990.
B. student scores on the GRE Physics Exam (in comparison with nationwide results from the American Institute of Physics and the American Association of Physics Teachers). [OEX] *Extra-curricular experience*: GRE Physics Exam.
C. student acceptance rates for graduate school and/or job placement (in comparison with nationwide results from AIP, AAPT). [GR, JOB] *Extra-curricular experiences*: application for graduate school and/or employment.
D. a comparison of WSU's physics curriculum with the curricula of 1) physics programs in schools with a comparable student profile, and 2) the best physics programs. [CO] *Courses*: PHYS 2210, 2219, 2220, 2229, 2300, 2600, 2710, 2800, 2830, 3040, 3160, 3170, 3180, 3190, 3200, 3300, 3410, 3420, 3500, 3510, 3540, 3640, 3710, 4200, 4400, 4410, 4610, 4620, 4800, 4830, 4970, 4990.

Skills:

A. Presentation skills. [CAP, REP] *Courses:* PHYS 3190, 3410, 3570, 3640, 4830, 4970, 4990.

B. Laboratory skills. [LAB, WE, OE, REP, PO] *Courses:* Phys 2219, 2229, 2600, 3040, 3190, 3410, 3420, 3640, 4400, 4410, 4800, 4970.
C. Computer skills. [WE, REP] *Courses:* PHYS 2219, 2229, 2300, 3040, 3160, 3170, 3180, 3300, 3420, 3510, 3640, 4400, 4410, 4610, 4620, 4800, 4830, 4970, 4990.
D. Problem-solving skills. [WE, REP] *Courses:* PHYS 2210, 2219, 2220, 2229, 2300, 2600, 2710, 2800, 2830, 3040, 3160, 3170, 3180, 3190, 3200, 3300, 3410, 3420, 3500, 3510, 3540, 3640, 3710, 4200, 4400, 4410, 4610, 4620, 4800, 4830, 4970, 4990.

Analysis

A. student acceptance rates and success in academic and industrial intern positions. [JP, INT] *Extra-curricular experiences:* application for summer research appointments and intern positions.
B. post-graduation student success in graduate school, industry, or teaching. [PGS, JP]

Nature of Science

A. as assessed by exams, questionnaires, interviews, and student focus groups. [WE, OE, FG, EI, IEX] *Courses:* Phys 1010, 1040, 1360, 2040, 2010, 2019, 2020, 2029, 2210, 2219, 2220, 2229, 2710, 2800, 2830, 3040, 3160, 3170, 3180, 3190, 3200, 3300, 3410, 3420, 3500, 3510, 3540, 3570, 3640, 3710, 4200, 4400, 4410, 4610, 4620, 4800, 4830, 4970, 4990; HNRS 1500

General Concepts

A. as assessed by exams, questionnaires, and interviews [WE, EI, IEX] *Courses:* PHYS 1010, 1040, 1360, 2010, 2019, 2040, 2210, 2219; HNRS 1500

Teacher Prep

A. appropriate content knowledge of physics and teaching strategies to accommodate diverse learners as assessed by a comparison of the WSU Physics Teaching major with the Utah State Core Curriculum. [CO] *Courses:* PHYS 1010, 1040, 1360, 2040, 2210, 2219, 2220, 2229, 2300, 2600, 2710, 2800, 2830, 3040, 3160, 3170, 3180, 3190, 3200, 3300, 3410, 3420, 3500, 3510, 3540, 3570, 3640, 3710, 4200, 4400, 4410, 4570, 4610, 4620, 4800, 4830, 4970, 4990.
B. *Extra-curricular experience:* student teaching and interviews with physics teacher candidates. [EI, PGS, PO]
C. *Extra-curricular experiences:* job placement and experiences in the teaching profession [JOB]

<u>Overall Analysis of Curriculum and Learning:</u>

Several courses offered by the Department fulfill the Physical Science Breadth requirement for General Education. These include PHYS 1010, 1040, 1360, 2010, 2040, 2090, 2210, and HNRS 1500. Instructors have utilized a variety of techniques in these varied courses, as well as a variety of assessment measures that are appropriate for the courses and settings. Additionally, many of these courses have dedicated lab components in which students must engage in scientific practices that model the competencies of the natural sciences (see http://www.weber.edu/academicaffairs/natural_sciences.html); and, even courses without a natural laboratory (e.g., 1010) can engage students in class investigations and research projects that fulfill these criteria in similar ways. In specific sections, instructors have elected to utilize other innovations in curriculum and assessment, such as investigating and discussing the history of science and societal interactions with physics research through book discussions. In all these varied settings, all passing students must demonstrate competency in the Physical Science learning objectives. As reported and approved in 2016, these have been successful even in their wide variety of methods. In the future, however, we recognize that we need to adapt to new general education guidelines, and instructors are currently working to develop Signature Assignments for their individual courses.

For majors/minors in Physics, there is a progression of learning that takes place in which learning in one course is assessed and enhanced in subsequent courses. A student's success in PHYS 2210 isn't just measured by the final exam in this course, but by homework in an upper division course. So, in the above description of assessments, a student in one of our programs is demonstrating competency not just once but in a progression of subsequent, developing understandings. In our majors, the capstone of any student's program is in his/her presentation of research at an advanced level (PHYS 4990). In this course we get to both publicly present a student's multiple understandings and skills. This presents both an opportunity and a challenge.

Notably, the Department and its programs emphasize "high impact" learning opportunities at multiple levels. The most clear demonstration of this may be found in students' individual research projects (often conducted for credit in PHYS 4800 and presented in seminar in PHYS 4990, but not always) that are conducted with mentoring from faculty in the department. Students in PHYS 3410, for example, have explicit assignments to demonstrate electronics concepts to 5th graders in a local school, and preservice teachers in PHYS 4570 must work with students and parents to help mentor science fair projects at another local school. Finally, the Department faculty model service to the community through its annual Open House, which incorporates volunteers from most of our majors. Primarily, this event is meant to build a relationship with the community, but we've learned that it also builds a community within and allows students to demonstrate multiple program learning outcomes in a public venue. Although this and many other activities (research, outreach, service, etc.) of the Department are not formally part of our curriculum, they complement and integrate into the overall development of our students' identities as engaged scientists.

Curriculum & Assessment Summary and Discussion

The Department has made great effort to be clear about its learning outcomes, as well as to be deliberate about their emphasis and assessment. At the same time, we recognize that we will be reevaluating these in the near future. There are several pieces contributing to this expectation:

1. Signature Assignments (SA) in General Education: As we, along with the rest of the campus, grapple with reforms in general education, we will need to support one another in both understanding the reforms and meeting the needs of our learners. Developing SAs will be one task for individual instructors, but we expect that this will be done in a robust collaboration among faculty. Moreover, the outcomes of the SAs will help us to develop assessments across the department. We have questions about how these will complement versus replace existing measures, but our expectation is that we will embrace SAs as a more meaningful way to understand the learning that takes place in our coursework and how to continually revise our practices.

2. Department Advisory: As we redevelop the role and makeup of an Advisory group, the feedback and recommendations of such may help us to determine both future changes in curriculum as well as the nature of our assessments. We don't know what this could look like or even if it will instigate change, but we embrace that possibility.

3. Capstone Assessment: As described above, the Advanced Physics Seminar (4990) represents a capstone to all of our coursework and gives students the opportunity to demonstrate their research skills, physics knowledge, and scientific communication practices. Students (in exit interviews) nominate their

research and seminar as a critical experience in their education, but we need to investigate and document this more clearly. We are considering how this can be done more effectively while still retaining the robustness of the experience. Other means of understanding the total takeaway from a program of study in the Physics Department are welcomed, but using 4990 in parallel with exit interviews of graduating students is a step we think will be fruitful.

4. Learning Outcomes: Our current learning outcomes and assessment measures are functional, but they are also largely the same as they have been for several program review cycles. There could be benefit in reconsidering these at some point in the near future, even as we aren't explicitly dissatisfied with them. This would at least be a useful exercise and a good test to see if we are missing anything. The implementation of a new Department Advisory may also aide in this, though previous advisories have not seen any particular omission in our current set of standards and curricula.

At the same time that we have these dimensions of curriculum and assessment that we'd like to continue to develop, we also feel strongly that the curriculum and assessments currently in place are informing our teaching, encouraging ongoing course development and revision, and providing positive environments for student learning and their development as scientists and citizens.

Standard D - Academic Advising

Advising is done primarily by the department chair for the physics and applied physics majors and by Dr. Johnston for the physics teaching major. Advising within the department is done by faculty rather than staff. This is accomplished through an introductory discussion at the time of major declaration and follow-up meetings. There is no mandatory advising policy.

At the beginning of every school year, a “Welcome Back” letter is sent to all physics majors encouraging them to meet with their advisor, and informing those in their final year of the process involved in preparing for their senior seminar. An email list of physics majors has been compiled to notify students of important events and deadline, such as those for scholarship applications and Graduate Record Exams. The list is updated regularly. The Department regularly offers advising seminars on careers and graduate study, typically every year as part of its weekly seminar series.

Along with formal advisement efforts within the Physics Department, the College of Science also has an office for general advisement. Jane Stout and Monica Linford are responsible for advisement regarding general education. The chair of the department meets regularly with the CoS advisors and a CoS advising council to ensure that the general advising office is appropriately informed about our programs and common advising questions can be discussed as a group. The recently acquired STARFISH software enables physics instructors and the CoS advising office to work together to identify students struggling in our courses and get them academic advice promptly.

Effectiveness of Advising

The advising process within the Physics Department is evaluated through data collected via the anonymous exit surveys required of all graduating seniors. One of the questions asked in that survey directly addresses the advising process: “What comments do you have about advisement you received regarding: (a) Course selection and scheduling?, (b) Career goals?, (c) Help in obtaining employment and/or graduate school placement?” The results for (a) indicate that many students have obtained little or no schedule advising simply because they have not sought it. (One student answered, “I didn’t receive much advisement, nor did I look for much, but when I did it was there.”) As noted above, students are provided with a sound introduction to the department when they sign up as physics majors, and many students feel they do not need additional help with their scheduling, despite the yearly invitation in the “Welcome Back” letter to visit their advisor. The results for (b) indicate that as students near graduation, they rely on the faculty with whom they have worked for help and advice on their post-graduation plans. The results for (c) demonstrate the need for additional resources for career employment and graduate school advisement, both within the Department and through Greg Nielson’s office in Career Services.

We have recently begun to contact alumni and collect survey data from alumni in a systematic way. These data will be used to update our advising (both academic and career).

Standard E – Faculty

Faculty Demographic Information

For the 2018-19 academic year, the Physics Department has 8 tenured faculty members, 1 tenure-track faculty member and one full time (non-tenure-track) instructor. One of the tenured faculty (Dr. Walther Spjeldvik) is on ½ time appointment. These total 9.5 FTE positions, a significant reduction from the previous program review of 12.25 FTE in these same categories.

The Physics Department faculty have had numerous special reappointments within the Department, College of Science and external to the university. At present, these include the Department Chair (Dr. Colin Inglefield) with a 0.5 FTE reassignment for administrative duties, the Planetarium Director (Dr. Stacy Palen) with a 0.25 FTE reassignment. One faculty member (Dr. John Armstrong) is on sabbatical for the full 2018-19 AY, a 1.0 FTE leave. Dr. Johnston, as a physics education specialist, is regularly assigned to teach courses that are crosslisted across multiple departments, or completely bought out to teach courses for inservice teachers.

The Department of Physics has a strong group of faculty with a broad range of backgrounds in physics and astronomy. These diverse academic backgrounds complement one another and provide excellent opportunities for our undergraduate majors and minors to explore a variety of specialty areas. Areas of expertise represented by the faculty include astrophysics, astrobiology, high energy and particle physics, condensed matter and materials physics, optics, nuclear medical physics, space physics, electronics, physics education, nuclear physics, and computational physics. Along with the various specialty areas, the Department has endeavored to provide an appropriate mixture of theoretical, computational, and experimental opportunities for our students. The curriculum vitae of the current departmental faculty are made available as supplementary material.

The Department also employed two adjunct faculty members (Jacob Albretson and Orest Gogosha) on a regular basis to teach evening courses and is currently searching for another for additional evening or summer sections. Other adjunct faculty teach lower-division labs: William Dowell, James Child, Cristine Jennings.

Programmatic/Departmental Teaching Standards

Contract faculty perform the vast majority of all instruction within the Physics Department. When adjunct faculty are employed, great care is given to hire faculty who are fully qualified to teach physics at the university level as evidenced by their educational backgrounds. In addition, these faculty are also screened through an interview process to insure that they are good classroom teachers. Specifically, potential adjunct faculty are required to go through an interview process with multiple experienced faculty. The Department does not employ applicants who do not meet these rigorous standards. Students evaluate the performance of adjunct faculty in every class they teach, and the Chair periodically reviews their teaching materials. If it is determined that currently employed adjunct faculty are not meeting the rigorous standards of the Department, they are not assigned to additional courses in the future.

Due to the existence of a fairly uniform curriculum, physics programs across the nation tend to establish similar expectations and standards for undergraduate education, particularly as they apply to core major and minor coursework. A small number of standard textbooks exist in each of these core topic areas, and within these texts, problems have been developed that are challenging but appropriate to the level of the course.

Along with the standardization that naturally occurs due to the common curriculum and textbooks, other factors also help to insure that appropriate teaching standards are established throughout the Department. For example, within the Department of Physics, no faculty member "owns" an individual course. Faculty are often rotated through courses on a periodic basis, allowing them to remain fresh and excited about the material being presented. In addition, faculty within the Department routinely share ideas and pedagogies in an informal way, so that individual faculty members are aware of the expectations of other faculty teaching the same or similar courses.

In multiple-section general education and service courses, faculty are encouraged to discuss textbook selection with the other faculty teaching the same course. Although academic freedom demands that textbook selection is ultimately up to individual instructors, the Department attempts as much as possible to reach a common consensus of the text(s) to be used for a specific course. This commonality of textbook selection also encourages high academic standards among the faculty of the Department.

Following a process that has been in place for a number of years, teaching schedules and service workloads are established in the Physics Department by first requesting that faculty indicate their preferences for courses and service activities. Based on the requests, the Chair then constructs teaching schedules that reflect faculty interests, expertise, and abilities to interact with specific student populations (general education, service, majors/minors). With an average load of 12 TCHs per semester, care is taken to insure an even balance across faculty assignments. The entire department is then given an opportunity to review and comment on the assignments established by the Chair. In most cases minor adjustments can be and have been made to satisfy specific concerns that arise. Typical concerns have included courses scheduled too close together or multiple sections of courses assigned on alternate day sequences (MWF or TTh). Over the period of time considered in this program review, this process of establishing faculty workloads appears to satisfy all concerned.

Faculty in the Department of Physics generally use traditional lecture settings for their teaching. Exceptions to this are laboratories taught in 30-student introductory lab settings, 20-student upper-division lab settings for Electronics, Advanced/Optics Labs, Materials Labs, and Instrumentations labs. We have a computer lab classroom that we share primarily with the Department of Earth and Environmental Sciences. Two courses, Elementary Physics and Astronomy, are regularly offered online, and online/face-to-face hybrid courses have been offered on occasion. Regardless of the spaces, many faculty employ a variety of active-learning teaching models: group work, project-based learning, in-class experiments, flipped classes, etc..

Many faculty with the Department of Physics at Weber State University are actively involved in research and innovation in instructional pedagogy. For example, many faculty in the Department are members of, and actively involved in, the American Association of Physics Teachers (AAPT) and the American Physical Society (APS). As such they routinely participate in regional meetings of, for example, the Idaho/Utah section of the AAPT and the Four Corners section of the APS. They also participate in national meetings of those organizations, where they and their students have presented numerous papers. In addition, members of the Weber State Physics faculty have also been actively involved in the leadership of the regional division of the AAPT (Drs. Daniel Schroeder and John Sohl). One member of the Department (Dr. Daniel Schroeder) serves as an Consulting Editor of the *American Journal of Physics*, a publication of the AAPT.

Along with active involvement in the AAPT, one member of the faculty (Dr. Adam Johnston) has specific research interests in physics education and is well recognized for his contributions in that area. His work has resulted in several publications in journals such as *The Journal of Research in Science Teaching* and *The American Education Research Journal*.

Along with providing a wide range of educational and research opportunities for our majors and minors, the faculty are also carefully selected to be excellent teachers. As documented in the section on "Evidence of Effective Instruction" below, many of our faculty have already received formal recognition for their strengths in teaching and physics education.

Faculty Qualifications

Department faculty all hold Ph.D.s in physics, applied physics, astronomy, or physics education and are highly qualified to provide a first-rate education for our undergraduate students. Faculty in the Department of Physics are also able to serve as examples of faculty who are engaged and excited about their chosen field of study.

Adjunct faculty all hold degrees in physics or a related field, and undergo screening for teaching abilities during the hiring process as described in the "Teaching Standards" section above.

When opportunities arise to hire new faculty in the Department, great attention is given to selecting candidates who can enhance the Department's ability to provide the highest possible level of undergraduate education. In the future, supporting new programs and contributing to the economic development of the region may become more prominent considerations. Serving as a strong guide in this process are the formal objectives and goals that have been established by the Physics Department, and are reviewed on a regular basis.

Evidence of Effective Instruction

i. Regular Faculty

In general, faculty in the Physics Department at Weber State University have been on the cutting edge of developing and using effective pedagogical strategies in their courses. This is evidenced by the number of faculty in the Department who have been awarded or nominated for various teaching awards while at Weber State, including the Best of State University Professor, College of Science Seager Award, Lowe Innovative Teaching Award, Honors Nye-Cortez Professor, Honors Program New Professor Award, Honors Eccles Fellowship, Crystal Crest Teacher of the Year, and John S. Hinckley Award. Three of our current faculty and one retired faculty (who still teaches on an adjunct basis) have been named WSU Brady Distinguished Professors, the highest honor the University bestows on faculty.

On a more systematic level, faculty within the Physics Department, and faculty across Weber State University are required to have student evaluations performed in at least two courses each year. The selection of the two courses is to be determined through consultation with the Department Chair (PPM 8-11.II.B). Copies of the student evaluations are submitted to the Chair for his/her review and evaluation, and those copies are kept in confidence in faculty files in the Chair's office. In addition, faculty within the College of Science meet with the Department Chair on an annual basis (beyond the requirement of PPM 8-11.II.A) to discuss performance issues in general, and teaching effectiveness in particular. Copies of those Annual Faculty Reviews are also kept on file in the office of the Chair. Additionally the Annual Reviews, together with student evaluations of at least two courses per year are shared with the Dean of the College of Science.

ii. Adjunct Faculty

Although adjunct faculty do not meet formally with the Department Chair on a systematic basis, they are required to have their teaching effectiveness evaluated through the same student evaluation process as the contract faculty. Every course taught by adjunct faculty is evaluated, and the Chair periodically reviews the teaching materials used by adjuncts.

Mentoring Activities

Given that turnover within the Department is relatively infrequent, the Department has been able to work with faculty and staff on a case-by-case basis. This informal process involves ongoing conversations with the Department Chair and with other faculty within the Department.

A formal process of orientation has been instituted at the University-wide level for new faculty. Annually a New Faculty Retreat has been held to provide valuable information about the institution, as well as teaching strategies that more seasoned faculty have found useful.

Diversity of Faculty

Physics and astronomy have struggled to attract underrepresented populations into the discipline. Unfortunately this problem has been and continues to be more severe in physics and astronomy than in any other field of science.

According to recent statistics from the American Institute of Physics (AIP 2013 Report on Women among Physics & Astronomy Faculty) as of 2010 only 17% of faculty positions in undergraduate-only departments were held by women (12% at PhD granting institutions). The WSU Physics Department currently has 4 full-time faculty members that are women (out of 9.5 FTE positions), significantly outpacing the national trend. In at least one recent semester, half of physics courses at WSU were taught by women. Hence, we have an established track-record of attracting highly-qualified female applicants in recent hiring processes, and of retaining those faculty members. While our major numbers do not reflect this level of near gender parity, data suggest that our student demographics are better than some of our "competing" departments. This last observation is based on data provided to the department on "stop-in" and "stop-out", meaning what major programs we regularly exchange students with.

Ongoing Review and Professional Development

Ongoing training and development opportunities exist at several levels. There are many in-house opportunities for faculty, such as the Teaching and Learning Forum and the Hemingway New Faculty grants. Workshops on various aspects of WSU faculty life may be scheduled on eWeber's Training Tracker. All faculty are encouraged to participate in regional and national meetings in their various areas of expertise. The faculty are also encouraged to actively engage in research and scholarship activities as a means of remaining current in the rapidly progressing and evolving disciplines of physics and astronomy.

The Department Chair reviews all contract faculty and classified/professional staff on an annual basis. The annual review of contract faculty is conducted in a systematic fashion within each department in the College of Science. During the Spring Semester, each faculty member is required to complete an Annual Faculty Review of his/her activities in the areas of teaching, research and scholarship, and service. Each faculty member is also required to attach at least two summaries of student evaluations conducted during the past year. The Annual Review is then discussed during a meeting with the Chair. The Chair also evaluates progress made toward goals set the previous year, and works with the faculty member to establish goals for the coming year. The Chair summarizes his/her evaluation of the faculty member on the Annual Review document, provides a copy to the faculty member, keeps a copy for departmental files, and shares a copy with the Dean of the College of Science.

In addition to annual reviews, tenure-track faculty and tenured faculty below the rank of full professor are also extensively evaluated through a university-wide procedure for progress toward tenure and/or advancement in rank. The candidate is evaluated by the Chair near the end of his/her second year of service to the institution. In the third and sixth years, and at the time of application to the rank of full Professor, the candidate is also evaluated by a peer review committee (which examines the candidate's teaching materials), a departmental rank and tenure committee, a College of Science rank and tenure committee, and the Dean of the College. All candidates are evaluated in the areas of teaching, scholarship, and service, using the evidence developed by the peer review committee and contained in the candidate's professional file. In cases of dispute over evaluations at various levels of the process, the Provost will also participate in the review process. An additional University-wide committee may also evaluate certain petitioned cases. Full details of the University's tenure and promotion process are available in the Policy and Procedures Manual, Section 8.

The formal process of annual faculty reviews also seems to be quite successful. These important checkpoints help to identify potential areas of concern for faculty in tenure-track positions and also provide opportunities to discuss current and anticipated future activities with tenured faculty. These annual conversations also provide the Chair with important feedback on the health of the Department by providing faculty with a systematic way to address concerns that they might have about such issues as how the Department is managed. Overall, the peer-review and annual evaluation processes continue to provide evidence of a highly-engaged and exceptional faculty.

Standard F – Program Support
Support Staff, Administration, Facilities, Equipment, and Library

Adequacy of Staff

In support of its academic programs, the Physics Department employs an administrative specialist (Nereyda Hesterberg, classified staff). The Department also employs a laboratory manager (Rick Schroeder, professional staff). The department currently has one additional staff member, an engineer (Jeff Page), whose position is funded extramurally through a grant for the HARBOR (High-Altitiude-Balloon) program. Details can be found in Appendix C.

Classified and professional staff are also reviewed on an annual basis. As with the departmental and college Annual Faculty Reviews, the staff are asked to establish goals for the coming year in consultation with the Chair.

The Department's support staff is barely adequate in both quantity and background to support the needs of the physics program. In particular, it is difficult to support the needs of large lecture courses in the morning while maintaining lab equipment being used throughout the day while equipment in both areas is tidy and accessible. Consequences include disruptions to lectures and broken or missing equipment causing delays in lab. With a new science building, lectures and laboratories are further separated in space, exacerbating the problem. Additionally, with the new science building our department received several new pieces of major research instrumentation. These new instruments have increased the maintenance load on faculty for broken or malfunctioning equipment taking time away from their primary research objectives. These new instruments have also increased the demand on our lab manager's time/training to help fix issues as they arise.

i. Ongoing Staff Development

The administrative specialist continually develops and enhances the necessary skills for her position by learning about new office software tools (word processing, spread sheets, scanners, and web authoring tools). Our admin specialist also strives to maintain her proficiency by receiving training for updates in administrative software systems, specifically Banner. On-campus and on-line workshops are available to aid in this process.

The laboratory manager must remain up-to-date in new laboratory technologies, which has been especially pertinent with the move to a new building; and he must be prepared to help set up and repair lab and research equipment as needed.

Adequacy of Administrative Support

The Administration is generally appropriately supportive of the physics program. The department's budget is adequate, but only barely so to maintain the physics program at its present level of operation. Recent decisions to not replace retiring faculty Dr. Carroll and Dr. Galli were, of course, disappointing to the department. There could have been better communication with respect to those decisions throughout the process.

The Office of Sponsored Projects has the responsibility of assisting faculty across the institution with obtaining and managing external grant programs. Generally, the relationship between OSP and the department is good one, and they have been supportive of our efforts in obtaining grants. We would like more support after a grant has been obtained in terms of management, which can become a burden to the department because of limited staffing.

There have been difficulties coordinating efforts between the Physics Department and Purchasing, but our relationships have been improving as we learn to better understand the needs of both entities with respect to unique, one-of-a-kind purchases of research-related equipment.

Along with funding for software and equipment to support educational and research projects, the Physics Department has been fortunate to receive generous donations from private sources and through University tuition waivers to provide financial support for many of our majors as they progress through their undergraduate careers. To date, the Department is able to provide support through the following scholarship, fellowship, and tuition waiver programs:

- Jim Bateman Scholarship
- College of Science Beishline Computer Application Fellowship
- The Pope M. & Grace C. Burkhart Undergraduate Research Fellowship
- Mary Margaret Clarke Scholarship
- J. Ronald and Cheryl M. Galli Scholarship
- H. Paul Huish Scholarship
- Questar Corporation Scholarships
- Physics Department Activity Fellowship
- Planetarium Activity Fellowships
- Paul and Carolyn Thompson Research Fellowship
- WSU Undergraduate Research Fellowship

Additional scholarships and fellowships are also available through the College of Science and the University.

The Physics Department supplements its lower-division laboratory budgets (a portion of the current expense budget) through laboratory fees of $25 per semester. This source of revenue is vital to maintaining current laboratory programs, and has provided the opportunity for future upgrades. Equipment for general education courses (PHYS 1010 and 1040) are supplemented by $10 lab fees per student.

Adequacy of Facilities and Equipment

There have been dramatic changes to Facilities and Equipment since our last program review, concomitant with our move to the Tracy Hall Science Center for Fall 2016. Notably all of our laboratory spaces are more visible, as part of the "Science on Display" theme of the building. We have two large introductory laboratory rooms where we teach sections of 30 students in groups of 3 for both the first (mechanics, thermodynamics) and second (electricity, magnetism, optics) semesters of the introductory physics sequences. With the preparatory space in between these two labs, we can relatively smoothly accommodate the hundreds of students that use these spaces every semester. Our upper-division teaching labs were consolidated as part of the move, notably combining the advanced-lab space and the optics lab into one reconfigurable room following a cut to the space allotment for physics as part of the planning process. The upper-division teaching labs have their own preparation space.

Our research lab spaces are the most improved spaces since the last review. Spaces are larger, better equipped (compressed air, fume hoods, electrical power, lighting, etc.) than their counterparts in the older Science Lab building. As part of the space upgrade, funds were made available for equipment upgrades as well, and particularly notable are our facilities for Materials Science research and teaching. These include a new commercial sputtering deposition system, an environmental Scanning Electron Microscope, a new (2018) Atomic Force Microscope and Atomic Layer Deposition system.

We did not acquire new classroom spaces as part of the move, as we now share classroom spaces in Tracy Hall with other departments. In at least one case, the computational lab/classroom, this has resulted in a compromise of design that is not particularly well suited to the collaborative lab format that we would like to use to teach our computational courses. Other rooms are set up in a way that make use of physics demonstration equipment difficult, and many don't allow the projector screens and boards to be used at the same time, which would help with problem-solving activities.

Hence, overall, our ability to do research and teach undergraduate majors in up to date laboratories in a way that is highly visible to visitors and other university students has dramatically improved, while our ability to control and tailor classroom spaces to fit our needs has suffered. The department continues to work with the college and other departments with which we share spaces to make the best use possible of our space.

Some ongoing infrastructure issues remain despite the newness and modernity of the new building. These include a lack of departmental and personnel directories in the new building, and unreliable elevators, plumbing (e.g., hot water in labs), and classroom audio-visual equipment.

Adequacy of Library Resources

Weber State no longer has access to some key American Institute of Physics (AIP) journals (Journal of Applied Physics, Applied Physics Letters, Review of Scientific Instruments, Journal of Chemical Physics, etc.). Still, the Physics Department appears to be adequately, if not optimally, supported for its primary mission of teaching. The library is working with faculty to identify and attempt to restore access to key journals to support teaching and research efforts. The Department is allotted an adequate budget for buying new books, and the library's interlibrary loan program works very well, providing any book or journal article needed within a matter of days. Miranda Kispert, the Science Librarian, works effectively to keep the faculty up to date on new library technologies and opportunities. She has attended a department faculty meeting and is enthusiastic about working with our faculty and students.

Standard G - Relationships with External Communities

The physics department has a group of alumni and external stakeholders that we keep in regular contact with, both formally and informally. We've been particularly active in inviting alumni to present at our weekly seminar series. At the beginning of academic year 17/18, we had a day-long meeting with an advisory group of:

Dr. Janica Cheney, PhD (WSU Alumnus and Director Test and Research Operations for Propulsion Systems at Orbital ATK)

William Cruff (Chemistry Teacher and Department Chair, Weber High, Summer Research Assistant in our Martials Laboratory)

Dr. Vikram Deshpande (University of Utah Physics Department Graduate Admissions)

The most important outcome of the meeting was a short list of challenges facing the department that have served to direct our strategic planning moving forward (in no particular order):

1. A need from local employers for graduates with more computing experience.

2. An image problem where students who are interested in science (especially physics) at the high school level are advised to attend the University of Utah or another school rather than WSU.

3. Difficulty meeting increased demand for our service courses with available resources.

4. A lack of theoretical perspective in our upper-division courses based on faculty expertise and background

5. Less expertise in astronomy/astrophysics compared to historical levels in our department, despite the fact that that area is the most often identified primary area of interest for new majors.

I'll address the concerns in order describing strategies that are underway or nascent to address each concern.

1. This is seen primarily as an advising issue as we already have in the catalog a computational emphasis within our physics major. This emphasis includes specialized coursework (PHYS 3300, *Advanced Computational Physics*) and electives in the Computer Science department. Part of the standard new major advising for Physics majors includes an overview of career options including the current uptick in demand for students with more computational skills and experience.

2. We've chosen to address this by attempting to build stronger relationships with local high school physics and science teachers, whom science-oriented high school students frequently go to for advice. William Cruff has been instrumental in this process because of his status in the Weber School District and his ongoing relationship with our department. With him, we held an afternoon meeting in the Tracy Hall Science Center with several teachers from Weber and Davis school districts, along with alumni from those districts who are currently in our programs. The day included a facility tour for the teachers and a lengthy discussion regarding how the high school curriculum dovetails to ours, how Advanced Placement courses work for physics majors, concurrent enrolment, and a variety of other topics. We plan to continue these meetings, coordinated by our

departmental Recruitment and Retention committee and Mr. Cruff or another contact in secondary education in the area.

3. This problem has been partially addressed internally as Dr. Schroeder has returned to our department on a full-time basis and we were allowed to offer Ms. Kiley Spirito (M.S. Physics) at least a two-year position as a full-time instructor in the department with primary duties in our introductory lab program. Our primary goal in the department is to hire an additional tenure-track faculty member and any new hire within the department must have demonstrated interest in teaching physics at the level of our high-demand service courses.

4. and 5. The department will continue to make the case for additional tenure-track faculty members to address these issues, which trace back to our previous program review.

<u>Ongoing Discussion Regarding Advisory Groups</u>

The department has received feedback that the administration would like us to have a larger and more formal Advisory Board. It turns out there was not a College Consensus on the roles and responsibilities of Advisory Boards and the College Administrative Team (Dean and Chairs) is having an ongoing discussion about this issue. We expect to continue this discussion. We have also started an exercise internally to try to build consensus on the role of an advisory board for our department

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An extensive list on external contacts and collaborations for individual faculty is included in Appendix E.

Standard H – Program Summary
Results of Previous Program Reviews

Problem Identified	Progress
Issue 1: Insist that the plans for the new science building be revised to ensure that the department will have adequate space to meet its current and anticipated future needs.	Additional research space has been given to the physics department in the new Tracy Hall Science Center although this space was still less than the recommended level. New studio classrooms were not included as very little classroom space is available in the new building. No classroom space was allotted to the physics department in the new building and already classroom space is at a premium. Yet, we do have access to shared classrooms that work well for our small upper-division classes and our weekly seminar series. The Tracy Hall science center did include a substantial upgrade to our research laboratory spaces.
Issue 2: Develop a 5-10 year strategic hiring plan to expand the depth, breadth, diversity, and expertise of the faculty...	A new experimentalist, Kristin Rabosky, was hired to expand the breadth of our Materials Physics program. A lab instructor, Kiley Spirito, was hired, to help with our service mission. We have established a written plan for what areas of expertise our next two faculty hires should be. Areas of immediate need are theoretical physics, computation, and astrophysics. A new search has recently begun for an environmental (climate) science position that could possibly be housed in the department. Our current position is that five departures/retirements of tenured faculty (Amiri, Carroll, Galli, Larson, Ostlie) have been replaced with one tenure-track (Rabosky) and one full-time instructor (Spirito) hire. Further position cuts would be devastating to the core mission of the department.
Issue 3: Initiate a search next year, then replace retiring faculty immediately.	The department has submitted requests for new tenure track faculty positions for several years and all requests have been denied.

Issue 4: Develop an agreed-upon definition of the term “research” that the department and college can use for planning purposes...	This task was taken up at the College level with a revision of the tenure document. Adam Johnston represented us on this committee. The process stalled at the level of the Dean, but is being reanimated.
Issue 5: Develop and implement a long-term assessment plan for program-level assessment...	We have followed new guidelines and reporting requirement from the Office of Institutional Effectiveness. Our General Education courses all went through an extensive review process and were renewed.
Issue 6: Increase the number of faculty attending meetings and workshops to remain current...	The department has continued doing an excellent, relative to the university, job of attending meetings for research and professional development. Faculty have been making use of University RSPG funds for travel as well our newly implemented Koldewyn Physics Research Grant to supplement the funds available through the department.
Issue 7: Expand the department’s recruiting effort to improve diversity and the number of calculus- ready students...	To help increase the diversity of students attracted to and retained in our program, we are sponsoring a Women in Physics club managed by Kristin Rabosky. Additionally, we have met with high school science teachers in the Ogden City, Davis County, and Weber County school districts to brainstorm ways to attract more students from the surrounding local area. In 2018, a branch of the Northern Utah Academy for Math, Engineering, and Science (NUAMES) charter school for grades 10-12 has opened on our campus providing a new pipeline for calculus-ready students to our department.
Issue 8: Increase recognition of faculty who supervise undergraduates within a research setting.	We have increased participation in our on-campus opportunities (annual research symposium) and continued our participation in off campus conferences (e.g. APS 4-corners). The current system is that we can count each student research hour as 0.25 TCH. This issue is also being addressed in the CoS tenure document revision.

Issue 9: Encourage students to apply for summer research programs such as NSF's REU ...	We have had several of our students who have had outside REU opportunities and summer/after-school internships with local industry give seminars for our department. Traditionally, we have one seminar a semester where we ask each faculty to outline potential research opportunities within the department and have expanded that seminar to educate students about other opportunities external to the department including REUs, national lab programs, and industrial internships.
Issue 10: Form an advisory committee composed of representatives from local industries who have interests in a physics-educated workforce.	We formed an initial advisory committee of three members representing our local stakeholders (graduate school professor, high school teacher, industry representative) and held a meeting to make suggestions for improving the long-term plans of the department. One of our faculty, Stacy Palen, has been tasked with leading our initiative to expand the membership and define the goals and tasks of the committee.

APPENDICES

Appendix A: Student and Faculty Statistical Summary
(*Note*: Data provided by Institutional Effectiveness. This is an extract from the Program Review Dashboard and shows what will be sent to the Boards of Trustees and Regents)

	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
Student Credit Hours Total	7682	7014	7577	7085	7551
Student FTE Total	256	234	253	236	252
Student Majors (3rd Week Fall)	86	96	77	88	76
Program Graduates	10	13	9	12	6
Student Demographic Profile (Majors)					
Female	14	18	16	20	17
Male	72	78	61	68	59
Faculty FTE Total	12.09	11.87	12.04	11.76	n/a
Adjunct FTE	2.76	2.51	2.56	1.38	n/a
Contract FTE	9.33	9.36	9.48	10.38	n/a
Student/Faculty Ratio	21.18	19.70	20.98	20.08	n/a

Appendix B:

Faculty (current academic year)

	Tenure and tenure-track	**Contract**	**Adjunct**
Number of faculty with Doctoral degrees	9		
Number of faculty with Master's degrees		1	3
Number of faculty with Bachelor's degrees			1
Other Faculty			
Total			

Contract/Adjunct Faculty Profile

Name	Rank	Tenure Status	Highest Degree	Years of Teaching	Areas of Expertise
Armstrong, John	Professor	Tenured	PhD	14	Astrobiology
Arnold, Michelle	Associate	Tenured	PhD	17	Nuclear Medical
Inglefield, Colin	Professor	Tenured	PhD	20	Materials
Johnston, Adam	Professor	Tenured	PhD	21	Education
Palen, Stacy	Professor	Tenured	PhD	17	Astrophysics
Rabosky, Kristin	Assistant	Tenure-Track	PhD	4	Materials
Schroeder, Daniel	Professor	Tenured	PhD	26	Theoretical
Sohl, John	Professor	Tenured	PhD	28	Applied
Spjeldvik	Professor	Tenured	PhD	34	Atmospheric/Space
Spirito, Kiley	Instructor	Non-Tenure Track	MS	4	Spectroscopy/Labs
Albretsen, Jacob	Adjunct	Non-Tenure Track	MS	10	Astronomy
Gogosha, Orest	Adjunct	Non-Tenure Track	MS	8	Engineering

Jennings, Cristine	Adjunct	Non-Tenure Track		20	Labs
Dowell, William	Adjunct	Non-Tenure Track		8	Labs
Child, James	Adjunct	Non-Tenure Track		1	Labs

Appendix C: Staff Profile

Name	Job Title	Years of Employment	Areas of Expertise
Hesterberg, Nereyda	Admin. Spec.	14	Office
Schroeder, Rick	Lab Manager	15	Technician
Page, Jeff	Engineer (HARBOR)	2	Instrumentation

Summary Information (as needed)

Ms. Hesterberg and Mr. Schroeder's positions are long-term positions within the department. Mr. Page's position is a temporary one dependent upon extramural funding.

Appendix D: Financial Analysis Summary
(This information is provided by the Provost's Office)

Program Name					
Funding	**13-14**	**14-15**	**15-16**	**16-17**	**17-18**
Appropriated Fund	1305378	1154871	1155823	1294278	1122200
Other:					
Special Legislative Appropriation	172859	112645	257734	170167	66993
Grants or Contracts	21944	13003	28766	30772	8207
Special Fees/Differential Tuition	48520	45215	41460	32200	57730
Total	$1548701	$1325734	$1483783	$1527417	$1255130

Total FTE:	256	234	253	236	251
Cost per FTE:	$6048	$5670	$5875	$6468	$4987

Appendix E: External Community Involvement Names and Organizations

Faculty	External Collaborations
Dan Schroeder	worked with leaders at AAPT and is the consulting editor of AJP
John Armstrong	The Virtual Planetary Laboratory and NExSS - This award is part of a $5 million Co-operative agreement with NASA as a member of the Astrobiology Institute.
	• Sean Raymond, University of Colorado, Boulder, Extrasolar Planet Stability
	• Rory Barnes, University of Washington, Extrasolar Planet Stability
	• Vikki Meadows, University of Washington, Virtual Planetary Laboratory
	• Tim Titus, United States Geological Survey, Mars Data Analysis
	• Robert Haberle, NASA Ames Research Center, Mars General Circulation Models
	• David Crisp, Jet Propulsion Laboratory, Virtual Planetary Laboratory
	• Michael Hernandez, Stacy Palen, Brian Rague - The Scientific Analysis and Visualization Initiative
Kiley Spirito	n/a
Stacy Palen	Audio-Visual Imagineering (Orlando, FL): Dr. Stacy Palen works with Audio-Visual Imagineering to distribute planetarium content around the country.
	Dr. Palen and her staff collaborate closely with planetariums all over the country, teaching workshops, on-site classes and tutorials, creating unique visualizations, formatting shows, and trading or selling content. These relationships encompass planetariums in 29 states and 17 countries.
	Dr. Palen collaborates with astronomy and astronomy-related colleagues around Utah on the Committee for Dark Sky Studies; she is on the Science Committee for this organization.
Walther Spjeldvik	·Los Alamos National Laboratory: Dr. Walther Spjeldvik has worked with the Space Research Section of LANL.
	·Boston University: Dr. Walther Spjeldvik has collaborated with colleagues at Boston University's Astronomy Department regarding Earthspace science.
	·Caltech: Dr. Walther Spjeldvik has collaborated with Caltech's Downs Laboratory on the project SAMPEX spacecraft to detect positrons in space.
	·Caltech, Dr. Walther Spjeldvik has used Caltech's heavy ion accelerator to calibrate time-of-flight ion detection instrumentation for the NASA ISEE-1 spacecraft.
	·NASA Goddard Space Flight Center, Dr. Walther Spjeldvik has used the GSFC's Tandem Van de Graaf accelerator to calibrate proton and

	ion instrumentation for the USAF SCATHA spacecraft and the magnetic spectrometer nuclear counter for the ISEE-1 spacecraft.
	·NASA's Caltech/Jet Propulsion Laboratory: Dr. Walther Spjeldvik has collaborated with the JPL's Division of Planetary Sciences for future Solar System planetary and cometary missions.
	·NASA's Caltech/Jet Propulsion Laboratory: Dr. Walther Spjeldvik has collaborated with the JPL's Quality Assurance Division by predicting expected proton and heavy ion radiation in the Earth's space Environment.
	·NASA's Caltech/Jet Propulsion Laboratory: Dr. Walther Spjeldvik has served as JPL Senior Scientist assigned to NASA Headquarters, Washington, DC.
	·RIKEN (Tokyo, JP): Dr. Walther Spjeldvik has worked with RIKEN's Cosmic High-Energy Physics Laboratory regarding the Japanese ADEOS spacecraft..
	·Lawrence Livermore National Laboratory: Dr. Walther Spjeldvik has collaborated with the Space-Radiation Monitoring Section of LLNL.
	·ONERA-DESP-CERT (Toulouse, FR): Dr. Walther Spjeldvik has collaborated with the Space Research Laboratory, part of the Department of Defense of France regarding modeling of heavy ions in space.
	·University of Campinas (Campinas, Brazil): Dr. Walther Spjeldvik has worked with colleagues in the Physics Department at UniCamp regarding space plasma modeling.
	·Space Research Institute of the Russian Academy of Sciences (Moscow, RU): Dr. Walther Spjeldvik has collaborated with colleagues at the Institute for Cosmic Investigations (IKI).
	·University of Campinas, Physics Department, Campinas, Brazil, Dr. Walther Spjeldvik has collaborated with Professor Inacio Martin's Earth and Space Physics group.
	·NASA Headquarters: Dr. Walther Spjeldvik has worked with the Division of Magnetospheric Physics, serving as National Discipline Scientist for Space Physics.
	·Instituto Nacional de Pesquisas Espasiais (Sao Jose Dos Campos, Brazil): Dr. Walther Spjeldvik has worked with the Brazilian Space Research Institute.
	· Belgian Institute of Space Aeronomy (Brussels-Uccles, Belgium): Dr. Walther Spjeldvik has worked on electromagnetic wave investigations with BISA.
	·Charles Stark Draper Laboratory (Cambridge, Mass): Dr. Walther Spjeldvik has collaborated with the Antimatter Research Section of the laboratory.
	·NASA Institute of Advanced Concepts: Dr. Walther Spjeldvik has worked with NIAC as research & Development subcontractor under Draper Lab contract.

	· Moscow State University, Moscow, Russia; Dr. Walther Spjeldvik has lectured at the Nuclear Physics Institute and collaborated with the MSU space nuclear science group; ongoing activity.
	·US Defense Department (Pentagon), Dr. Walther Spjeldvik has served as assessor/referee on graduate student projects in engineering and computer science.
	·University of Bergen, Norway, Dr. Walther Spjeldvik has collaborated with faculty colleagues in the Cosmic Physics division of the UiB Physics Institute.
	·Science Journals International: Dr. Walther Spjeldvik is a member of the editorial board of Physical Sciences, an electronic journal.
	·American Geophysical Union, Dr. Walther Spjeldvik has served as editorial referee on research papers in AGU journals.
	·NASA Headquarters, Dr. Walther Spjeldvik has repeatedly served as proposal assessor under various NASA funding sections.
Kristin Rabosky	Council on Undergraduate Research, Councilor for Physics and Astronomy Division
	MVSystems, Inc in Golden, CO
	Sean Shaheen at University of Colorado, Boulder
	Brandon Burnett in Chemistry WSU
	Craig Taylor at Colorado School of Mines
	Spencer Peterson in Electrical Engineering, WSU
	John Colton at Brigham Young University
	Michael Scarpulla at University of Utah
John Sohl	Randal Martin, Utah State University (Logan)
	Munkhbayar Baasandorj, University of Utah
	Steven Brown, NOAA ESRL
	John Horel, University of Utah
	Sebastian Hoch, University of Utah
	Erik Crosman, University of Utah
	Ryan Bares, University of Utah
	John Lin, University of Utah
	Kerry Kelly, University of Utah
	Jaron Hansen, BYU
	Christopher Pennell, Utah Division of Air Quality (UDAQ)
	Seth Lyman, Utah State University (Vernal)
	Hugo Valle, Computer Science
	Fon Brown, Electronics Engineering
	Taylor Foss, Manufacturing Engineering Technology
	Mary Foss, Manufacturing Engineering Technology
	Carie Frantz, WSU Geosciences

Michelle Arnold	Brandon Burnett, WSU Chemistry
	David Chettle, McMaster University (Canada), Radiation Science Program
	David Fleming, Mount Allison University (Canada), Physics Department
Adam Johnston	John Settlage, University of Connecticut
	Erik Stern, Weber State University, Department of Performing Arts
	Rachel Bachman, Weber State University, Department of Mathematics
	Brett Moulding, Partnership for Effective Science Teaching and Learning
Colin Inglefield	Matt Domek, Microbiology
	Marek Matyjasik, Geosciences
	Brandon Burnett, Chemistry
	Marcus Newton, University of Southampton, UK
	P. Craig Taylor, Colorado School of Mines

Appendix F: Site Visit Team (both internal and external members)

Name	Position	Affiliation
Tim Herzog	Professor	WSU, Chemistry
Kirk Hagen	Professor/Chair	WSU, Engineering
Eric Toberer	Professor	Colorado School of Mines, Physics

Appendix G:
Evidence of Learning Courses within the Major
See narrative, parts B & C.

Evidence of Learning: General Education Courses
As referenced in narrative, parts B & C, the following grid describes specific measures of student learning to match PS outcomes.

Elementary Physics, PHYS 1010 (Spring 2016)

Gen Ed Learning Goal Students will demonstrate understanding of:	**Measurable Learning Outcome** Students will demonstrate their understanding by:	**Method of Measurement** Direct and Indirect Measures*	**Threshold**	**Findings Linked to Learning Outcomes**	**Interpretation of Findings**	**Action Plan/Use of Results**
Nature of Science. Scientific knowledge is based on evidence that is repeatedly examined, and can change with new information. Scientific explanations differ fundamentally from those that are not scientific.	Students will identify features of a testable scientific claim and provide examples of how scientific knowledge changes.	First HW and Quiz 1 questions	On quizzes/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Most students (66/85) are "proficient," and almost all students are "mostly proficient" (82/85).	Students are meeting this learning outcome.	No action plan.
Integration of Science All natural phenomena are interrelated and share basic organizational principles. Scientific explanations obtained from different disciplines should be cohesive and integrated.	Students will relate gravitational forces of "earth-bound" to astronomical systems.	First HW and Quiz 1 questions	On quizzes/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Most students (66/85) are "proficient," and almost all students are "mostly proficient" (82/85).	Students are meeting this learning outcome.	No action plan.

Gen Ed Learning Goal Students will demonstrate understanding of:	**Measurable Learning Outcome** Students will demonstrate their understanding by:	**Method of Measurement** Direct and Indirect Measures*	**Threshold**	**Findings Linked to Learning Outcomes**	**Interpretation of Findings**	**Action Plan/Use of Results**
Science and Society The study of science provides explanations that have significant impact on society, including technological advancements, improvement of human life, and better understanding of human and other influences on the earth's environment.	Students will analyze the historical and societal implications of scientific work as presented in biographical/historical reading and case study.	Reading, discussion, and quiz on Oppenheimer biographical text.	On quizzes/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	49/78 students were proficient.	Students are meeting this outcome.	No action plan.
Problem Solving & Data Analysis Science relies on empirical data, and such data must be analyzed, interpreted, and generalized in a rigorous manner.	Students will examine and analyze data to make a prediction or solve a problem.	Multiple, especially including heat energy question and calculation.	On quizzes/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	34/67 students were proficient; 55/67 students were mostly proficient.	Students are meeting this outcome with less frequency on this outcome than on others and some improvements could be made.	Incorporate more "real data" examples in the course and student work.
Organization of systems The universe is scientifically understandable in terms of interconnected systems. The systems evolve over time according to basic physical laws.	Students will analyze data to determine general rules that define a physical system.	Multiple throughout the course, and the basis of the entirety of Exam 1.	On quizzes/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	50/80 students were proficient; 71/80 students were mostly proficient.	Students are meeting this outcome.	No specific action plan, but departmental conversations continue to take place around developing teaching and assessment tools for this outcome.

Gen Ed Learning Goal Students will demonstrate understanding of:	**Measurable Learning Outcome** Students will demonstrate their understanding by:	**Method of Measurement** Direct and Indirect Measures*	**Threshold**	**Findings Linked to Learning Outcomes**	**Interpretation of Findings**	**Action Plan/Use of Results**
Matter Matter comprises an important component of the universe, and has physical properties that can be described over a range of scales.	Students must identify are considering basic properties of matter, such as mass and its effect on changes in motion.	Multiple throughout the course, and the basis of the entirety of Exam 1.	On quizzes/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	50/80 students were proficient; 71/80 students were mostly proficient.	Students are meeting this outcome.	No specific action plan, but departmental conversations continue to take place around developing teaching and assessment tools for this outcome.
Energy Interactions within the universe can be described in terms of energy exchange and conservation.	Students must identify transformations of energy in physical systems, and predict outcomes of such energy exchanges.	Multiple throughout the course, and the basis of the entirety of Exam 1.	On quizzes/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	50/80 students were proficient; 71/80 students were mostly proficient.	Students are meeting this outcome.	No specific action plan, but departmental conversations continue to take place around developing teaching and assessment tools for this outcome.
Forces Equilibrium and change are determined by forces acting at all organizational levels.	Students will identify the forces contributing to equilibrium and/or predict changes in motion resulting from unbalanced forces.	Multiple throughout the course, and the basis of the entirety of Exam 1.	On quizzes/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	50/80 students were proficient; 71/80 students were mostly proficient.	Students are meeting this outcome.	No specific action plan, but departmental conversations continue to take place around developing teaching and assessment tools for this outcome.

Elementary Astronomy, PHYS 1040 (Spring 2016)

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
Nature of Science. Scientific knowledge is based on evidence that is repeatedly examined, and can change with new information. Scientific explanations differ fundamentally from those that are not scientific.	Students will examine data and form and test hypothesis based on these data.	"51 Pegasi: The Discovery of a New Planet" assignment. Students must demonstrate understanding of testable hypothesis and appropriately analyze relevant data.	On assignments, 60% correlates to a "basic but developing" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Most students are proficient, with an average score of 76%.	Students are meeting this learning outcome.	No action plan.
Integration of Science All natural phenomena are interrelated and share basic organizational principles. Scientific explanations obtained from different disciplines should be cohesive and integrated.	Students will apply physics of "earth-bound" systems to novel astronomical systems.	"Measuring the Mass of Earth" hands-on assignment requires students to apply Newton's Universal Law of Gravitation to a falling object to calculate the mass of Earth.	On assignments, 60% correlates to a "basic but developing" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	All students are proficient, with an average score of 98%.	Students are meeting this learning outcome.	No action plan.
Science and Society The study of science provides explanations that have significant impact on society, including technological advancements,	Students will analyze the historical implications of an astronomical discovery and evaluate the societal value of future scientific work.	"Habitable Worlds" in-class assignment requires students to explore the implications of discovering life elsewhere in the galaxy and craft a defendable	On assignments, 60% correlates to a "basic but developing" understanding of the learning outcome; 75% correlates to a	The average score on the assignment was 67%.	While there is formative in-class assessment that suggests there's better understanding, we generally observe that students need more explicit	Develop more assignments to explicitly draw this society connection as related to the search for life in the universe.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
improvement of human life, and better understanding of human and other influences on the earth's environment.		argument for such research.	"proficient" understanding.		experiences in connecting science and technology to societal implications.	
Problem Solving & Data Analysis Science relies on empirical data, and such data must be analyzed, interpreted, and generalized in a rigorous manner.	Students will examine data and form and test hypothesis based on these data.	"51 Pegasi: The Discovery of a New Planet" assignment. Students must demonstrate a mathematical analysis, application, and graphical representation of empirical data.	On assignments, 60% correlates to a "basic but developing" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Most students are proficient, with an average score of 76%.	Students are meeting this outcome.	No action plan.
Organization of systems The universe is scientifically understandable in terms of interconnected systems. The systems evolve over time according to basic physical laws.	Astronomy is, at its heart, an an analysis of systems that are described by physical law. Students will analyze data to determine general rules that define a physical system.	"Hubble Law" lab: students analyze real empirical data that provide evidence of universal expansion when time is played "in reverse", which prompts them for an argument for Big Bang.	On assignments, 60% correlates to a "basic but developing" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Most students are proficient, obtaining an average of 80% on the Hubble Law lab.	Students are meeting this outcome.	No action plan.
Matter Matter comprises an important	Students must identify are considering basic	Planet Formation Activity assignment: students must apply	On assignments, 60% correlates to a "basic but	Most students are proficient, obtaining an	Students are meeting this outcome.	No action plan.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
component of the universe, and has physical properties that can be described over a range of scales.	properties of matter, such as mass and density, and must be able to distinguish astronomical scales.	physical law to argue how matter organizes from large scale clouds of dust and gas into stars and planets.	developing" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	average of 80%on the assignment.		
Energy Interactions within the universe can be described in terms of energy exchange and conservation.	Students must identify transformations of energy in physical systems, and predict outcomes of such energy exchanges.	Indirect: In-class formative assessment of students ideas about sources of stellar energy. Direct: "Spectroscopy" assignment requires students to identify and characterize the transformation of collisional energy to radiative energy in order to complete the task.	On assignments, 60% correlates to a "basic but developing" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Most students are proficient, obtaining an average of 81%	Students are meeting this outcome.	No action plan.
Forces Equilibrium and change are determined by forces acting at all organizational levels.	Students will identify the forces contributing to equilibrium in astronomical systems.	"51 Pegasi: The Discovery of a New Planet" and "Mass of Jupiter" assignments. Students must identify gravitational forces and their relation to planetary motion in	On assignments, 60% correlates to a "basic but developing" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	All students successfully complete these labs and most students demonstrate proficiency of all concepts with an average score of 76%.	Students are meeting this outcome.	No action plan.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
		order to complete the assignment.				

Principles of Physical Science, PHYS/CHEM 1360 (Fall 2015)

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
Nature of Science. Scientific knowledge is based on evidence that is repeatedly examined, and can change with new information. Scientific explanations differ fundamentally from those that are not scientific.	Students will explicitly identify attributes of science as compared to non-science, and will identify attributes of scientific practice in their own work.	Quiz 1: "Practices of Science", direct question on how explanations are tested. "Hot Chocolate" lab on developing tests.	"Proficient" understanding rated as 4/5 on rubric scale. Students should demonstrate 4 tests in response to laboratory outcomes	17/18 students were proficient in each measure.	Students are meeting this learning outcome.	No action plan.
Integration of Science All natural phenomena are interrelated and share basic organizational principles. Scientific explanations obtained from different disciplines should be cohesive and integrated.	Students will identify and describe the nature of facts, laws, and theories in scientific work across disciplines. Students will identify attributes of "scientific method" across multiple laboratories that describe scientific work.	Quiz 1: "Practices of Science", direct question on fact, law, and theory. Various lab investigations, especially including "Matter and Energy" investigation that analyzed conservation principles in parallel phenomena.	"Proficient" understanding rated as 4/5 on rubric scale on quiz. "Proficient" understanding at 8/10 on lab report.	17/18 students were proficient in the quiz measure. 15/18 students were proficient in the lab measure.	Students are meeting this learning outcome.	No action plan.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
Science and Society The study of science provides explanations that have significant impact on society, including technological advancements, improvement of human life, and better understanding of human and other influences on the earth's environment.	Students will evaluate and describe relevance of core scientific ideas to their (future) classroom instruction. Students will investigate sources and uses of energy and evaluate the long term implications.	Multiple lab and quiz questions, especially Final Exam essay question to describe "learningful" science. Energy exam question to design electric plant.	"Proficient" understanding rated as 4/5 on rubric scale on quiz/exam.	17/18 students were proficient.	Students are meeting this learning outcome.	No action plan.
Problem Solving & Data Analysis Science relies on empirical data, and such data must be analyzed, interpreted, and generalized in a rigorous manner.	Students will design investigations, analyze data, and create arguments based on evidence.	All labs and lab reports; most notably final lab and presentation of independent research.	"Proficient" understanding rated as 20/25 on project evaluation.	17/18 students were proficient in the project measure.	Students are meeting this learning outcome.	No action plan.
Organization of systems The universe is scientifically understandable in terms of interconnected systems. The systems evolve over time	Students will create predictions of physical outcomes based on physical system's conditions and principles.	Multiple laboratory investigations, especially: Newton's laws lab predictions. Astronomy lab predictions and analysis.	"Proficient" understanding at 8/10 on lab report.	18/18 students were proficient in Newton's Laws measure. 15/18 students were proficient in Astronomy measure. (2 lab reports missing.)	Students are meeting this outcome.	No action plan.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
according to basic physical laws.						
Matter Matter comprises an important component of the universe, and has physical properties that can be described over a range of scales.	Students must identify and describe basic properties of matter, such as mass, density, charge, etc.	Analysis in Physical Properties of Matter investigation, among others.	"Proficient" understanding at 8/10 on lab report.	18/18 students were proficient in Physical Properties Lab measure.	Students are meeting this outcome.	No action plan.
Energy Interactions within the universe can be described in terms of energy exchange and conservation.	Students must determine sources of energy involved in cycling of matter and create designs or make predictions based on conservation of energy.	Energy lab investigation and analysis. Design a power plant exam question.	"Proficient" understanding at 8/10 on lab report. "Proficient" understanding rated as 4/5 on rubric scale on quiz/exam.	15/18 students were proficient in Energy lab measure. 17/18 students were proficient in Energy question measure.	Students are meeting this outcome.	No action plan.
Forces Equilibrium and change are determined by forces acting at all organizational levels.	Students will identify forces creating equilibrium or changes in motion; and they will predict outcome of such forces.	Newton's motion lab analysis. Newton's Laws quiz question on centripetal force and circular motion of marble.	"Proficient" understanding at 8/10 on lab report. "Proficient" understanding rated as 4/5 on rubric scale on quiz/exam.	18/18 students were proficient in lab measure. 15/18 students were proficient in force question measure.	Students are meeting this outcome.	No action plan.

College Physics I, PHYS 2010 (Johnston, Spring 2016)

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
Nature of Science. Scientific knowledge is based on evidence that is repeatedly examined, and can change with new information. Scientific explanations differ fundamentally from those that are not scientific.	Students will propose hypotheses, obtain and analyze data, and draw conclusions.	Throughout the course in all its aspects, but directly through laboratory reports and laboratory exam.	"Proficient" demonstration of laboratory tasks, skills, and understandings is at 70%.	46/46 students show proficiency on laboratory reports; 36/46 show proficiency on lab exam.	Students are meeting this learning outcome, although there is an interesting contrast between reports and practical exam.	No urgent action plan, though we are always analyzing the lab program, its exam, and its coherence.

Integration of Science All natural phenomena are interrelated and share basic organizational principles. Scientific explanations obtained from different disciplines should be cohesive and integrated.	Students will explain and predict motion resulting from balanced and unbalanced forces in varied physical situations.	Quiz 3 and Exam 1: Explicit focus of problems on force problems that demonstrate conceptual understanding and problem solving.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	35/46 students show proficiency on quiz; 37/46 show proficiency on exam.	Students are meeting this learning outcome.	No action plan.

Science and Society The study of science provides explanations that have significant impact on society, including technological advancements, improvement of human life, and better understanding of human and other influences on the earth's environment.	Students will solve physics problems that have practical, societal impact.	Regular homework problems and in-class exercises. For example, students calculate their own "wattage" and consider the source of their own energy in class.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	Students are proficient at homework problem solving overall. On individual tasks like the "wattage" problem, over 90% of students demonstrate proficiency.	Students are meeting this outcome.	But: We need to code more specific exercises to this outcome. Ironically, students are taking this course to further them along towards medical fields, etc. So there's practical import, but we haven't documented all of it.
Problem Solving & Data Analysis Science relies on empirical data, and such data must be analyzed, interpreted, and generalized in a rigorous manner.	In Students will collect and analyze data and create arguments based on evidence.	Presentation and analysis of data in lab reports.	"Proficient" demonstration of laboratory tasks, skills, and understandings is at 70%.	46/46 students show proficiency on laboratory reports; 36/46 show proficiency on lab exam.	Students are meeting this learning outcome.	No action plan.
Organization of systems The universe is scientifically understandable in terms of interconnected systems. The systems evolve over time according to basic physical laws.	Students will create predictions of physical outcomes based on physical system's conditions and principles.	Full-page final exam problem solving that incorporates a sequence of interconnected systems that must be conceptualized together to successfully solve	"Proficient" demonstration of conceptual understanding and problem is at 70%.	33 of 46 students demonstrate full proficiency on this task.	Students are likely meeting this outcome.	We could connect this problem solving to other laboratory tasks or other activities to better understand how students connect these systems.

Matter Matter comprises an important component of the universe, and has physical properties that can be described over a range of scales.	Students must identify and describe basic properties of matter and its effect on measures including density, potential energy, momentum, etc.	Explored throughout the course, but explicitly and holistically assessed in conceptual and problem solving problems on Exam 3.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	33 of 46 students demonstrate full proficiency on this task.	Students are meeting this outcome.	No action plan.
Energy Interactions within the universe can be described in terms of energy exchange and conservation.	Students must use conservation of energy principles to solve problems, make predictions, and explain phenomena.	Exam 2 holistically and explicitly evaluates students conceptual understanding and problem solving skills in conservation principles.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	28 of 46 students demonstrate full proficiency on this task.	Students are mostly meeting this outcome.	No action plan.
Forces Equilibrium and change are determined by forces acting at all organizational levels.	Students must use analysis of forces to solve problems, make predictions, and explain phenomena.	Explored throughout the course, but explicitly in Exam 1 in which students must explicitly apply Newton's Laws to determine accelerations resulting from forces.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	37 of 46 students demonstrate full proficiency on this task.	Students are meeting this outcome.	No action plan.

Observational Astronomy, PHYS/ASTR 2040 (Palen, Spring 2016)

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
Nature of Science. Scientific knowledge is based on evidence that is repeatedly examined, and can change with new information. Scientific explanations differ fundamentally from those that are not scientific.	Students will understand how scientists propose hypotheses, obtain and analyze data, and draw conclusions.	"Astronomical Literature Review" assignment: students read and analyze the work of scientists in the academic literature.	On assignments/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	The average score on this assignment was 87.5%, with a majority of students scoring above 80%.	Students are meeting this learning outcome.	No action plan.
Integration of Science All natural phenomena are interrelated and share basic organizational principles. Scientific explanations obtained from different disciplines should be cohesive and integrated.	Students will apply the physics that they have learned for Earth-bound systems to astronomical systems	"Mass of Jupiter" hands-on assignment requires students to apply Newton's Universal Law of Gravitation to observations of the moons of Jupiter, thus deriving the mass of Jupiter from the gravitational acceleration of the moons.	On assignments/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	The average score on this assignment was 78.5%, with one student scoring an exceptional 110%, for extending the work beyond that which was required.	Students are meeting this learning outcome.	No action plan.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
Science and Society The study of science provides explanations that have significant impact on society, including technological advancements, improvement of human life, and better understanding of human and other influences on the earth's environment.	Students will make observations and analysis of the night sky and the effect of light pollution on astronomical observations and on the human body.	Light pollution analysis assignment.	On assignments/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	The average score on the assignment was 80%.	Students are meeting this learning outcome through this exercise as well as repeated other analyses.	No action plan.
Problem Solving & Data Analysis Science relies on empirical data, and such data must be analyzed, interpreted, and generalized in a rigorous manner.	Students will collect, analyze, and interpret astronomical data.	Multiple, ongoing laboratories and assignments, especially "Curve Fitting" lab where students understand of fit, chi-square, and P-value is measured.	On assignments/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Students achieved an average score of 85% on this assignment, and an 84% on all similar tasks.	Students are meeting this learning outcome.	No action plan.
Organization of systems The universe is scientifically understandable in terms of interconnected systems. The systems evolve over	Students will create predictions of physical outcomes based on physical system's conditions and principles.	Multiple laboratory investigations, especially: Hubble Law" lab, where data are interpreted to describe the universe in a hot, dense beginning known as the Big	On assignments/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Students obtained an average of 87.5% on the Hubble Law portion of these paired labs. Due to technical difficulties, the Cosmic	Students are meeting this outcome. We've sorted out technical issues with the second portion of the lab and await further data.	No action plan.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
time according to basic physical laws.		Bang. They then further test this theory in another lab in which they examine the Cosmic Microwave Background Radiation.		Microwave Background portion was incomplete.		
Matter Matter comprises an important component of the universe, and has physical properties that can be described over a range of scales.	Students will characterize basic properties of matter, such as mass, density, velocity, and angular momentum and a wide range of astronomical scales.	Asteroid Rotation lab: students find the rotation speed of an asteroid from observations of its changing reflectance. Then they calculate out how large the asteroid would have to be in order for this rotation rate to provide sufficient artificial gravity for Earthlings to be comfortable.	On assignments/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Students were very interested in this activity, and the lowest score was an 80%. Other similar lab assignments showed varied but still mostly proficient scores.	Students are meeting this outcome.	No action plan.
Energy Interactions within the universe can be described in terms of energy exchange and conservation.	Students will predict and explain the conversion of energy from light to electrical current in astronomical research applications.	Analysis of light energy conversion in "CCD Cameras" assignment and in the Cepheid Variable lab.	On assignments/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Students produced a bimodal distribution on the CCD Camera assignment, with ¾ of students earning more than 90%, and ¼ of students earning less than 40%. Discussions	Students are meeting this outcome.	No action plan.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
				with individual students revealed that students who performed poorly were also taking a quantum mechanics final that week. Students performed significantly better on the Cepheid Variable lab, earning an average of 85%.		
Forces Equilibrium and change are determined by forces acting at all organizational levels.	Students will analyze gravitational forces and orbital motions to describe physical properties of an astronomical system (e.g., mass).	Mass of Jupiter lab and the Rotation of Asteroids lab address force concepts most directly by having students analyze motion data to determine force and mass within a system.	On assignments/exams, 60% correlates to a "mostly proficient" understanding of the learning outcome; 75% correlates to a "proficient" understanding.	Students demonstrate proficiency on both labs, as described above.	Students are meeting this outcome.	No action plan.

Physics for Scientists & Engineers, PHYS 2210 (Armstrong, Spring 2016)

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
Nature of Science. Scientific knowledge is based on evidence that is repeatedly examined, and can change with new information. Scientific explanations differ fundamentally from those that are not scientific.	Students will propose hypotheses, obtain and analyze data, and draw conclusions.	Throughout the course in all its aspects, but directly through laboratory reports and laboratory exam.	"Proficient" demonstration of laboratory tasks, skills, and understandings is at 70%.	Lab reports and exams average 80%.	Students are meeting this learning outcome.	No action plan.
Integration of Science All natural phenomena are interrelated and share basic organizational principles. Scientific explanations obtained from different disciplines should be cohesive and integrated.	Students will explain and predict motion resulting from balanced and unbalanced forces in varied physical situations.	Exam 1: Explicit focus of problems on force problems that demonstrate conceptual understanding and problem solving.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	Exam score average 78%	Students are meeting this learning outcome.	No action plan.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
Science and Society The study of science provides explanations that have significant impact on society, including technological advancements, improvement of human life, and better understanding of human and other influences on the earth's environment.	Students will solve physics problems that have practical, societal impact.	Regular homework problems.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	Students are proficient at homework problem solving overall; but we do not have data parsed out to demonstrate their understandings for these specific problems.	Students are likely meeting this outcome, but …	We need to tabulate and code these specific questions, also possibly adding them to our laboratory assessments.
Problem Solving & Data Analysis Science relies on empirical data, and such data must be analyzed, interpreted, and generalized in a rigorous manner.	In Students will collect and analyze data and create arguments based on evidence.	Presentation and analysis of data in lab reports.	"Proficient" demonstration of laboratory tasks, skills, and understandings is at 70%.	Lab reports and exams average 80%.	Students are meeting this learning outcome.	No action plan.
Organization of systems The universe is scientifically understandable in terms of interconnected systems. The systems evolve over time	Students will create predictions of physical outcomes based on physical system's conditions and principles.	Regular homework problems.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	Students are proficient at homework problem solving overall; but we do not have data parsed out to demonstrate their understandings for these specific problems.	Students are likely meeting this outcome, but …	We need to tabulate and code these specific questions, also possibly adding them to our laboratory assessments.

Gen Ed Learning Goal	Measurable Learning Outcome	Method of Measurement	Threshold	Findings Linked to Learning Outcomes	Interpretation of Findings	Action Plan/Use of Results
according to basic physical laws.						
Matter Matter comprises an important component of the universe, and has physical properties that can be described over a range of scales.	Students must identify and describe basic properties of matter and its affect on measures including density, potential energy, momentum, etc.	Explored throughout the course, but explicitly and holistically assessed in conceptual and problem solving problems on Exam 3 and Exam 4.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	Exam score averages were 78%	Students are meeting this outcome.	No action plan.
Energy Interactions within the universe can be described in terms of energy exchange and conservation.	Students must use conservation of energy principles to solve problems, make predictions, and explain phenomena.	Exam 3 holistically and explicitly evaluates students conceptual understanding and problem solving skills in conservation principles.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	Exam score averages were 76%	Students are meeting this outcome.	No action plan.
Forces Equilibrium and change are determined by forces acting at all organizational levels.	Students must use analysis of forces to solve problems, make predictions, and explain phenomena.	Explored throughout the course, but explicitly in Exam 1 in which students focus on applying Newton's Laws to determine accelerations resulting from forces.	"Proficient" demonstration of conceptual understanding and problem is at 70%.	Exam score average was 78%.	Students are meeting this outcome.	No action plan.