Academic Program Assessment Report

Academic Year(s) Assessed: 2024-2025
College: Letters and Science
Department: Physics
Department Head: John Neumeier
Submitted by: John Neumeier

Program(s) Assessed

List all majors (including each option), minors, and certificates that are included in this assessment – add or subtract rows as needed – please use official titles:

Majors	Minors, Options, etc.
Physics, B.S.	Professional Option
Physics, B.S.	Interdisciplinary Option
Physics, B.S.	Astronomy/Astrophysics Option
Physics, B.S.	Teaching Option
Physics	Minor

Section 1. Past Assessment Summary.

Response: We were commended on improvements to our assessment process. The reviewers found our use of town halls with our students exemplary. The committee appreciated our aims to use assessment to strengthen the program and that the report illustrated our desire to improve the program. Recommendations included the addition of more robust assessment rubrics, more direct evidence (actual student work), indirect evidence to support curricular and program changes, better utilization of campus partnerships, better alignment to map PLOs to various majors, options, and minors. Note was made for our planning as to how assessment results will be used to support the 7-year program review.

Section 2. Institutional Assessment Data Request.

Based on the rationale on the Instructions page, please review your program learning outcomes (PLOs) and identify whether you have PLOs that address the Core Qualities. **There are no right or wrong answers.**

Our Physics Professional Option B.S. Program has the following PLO's:

1. Discipline-Specific Knowledge: Students demonstrate option-appropriate knowledge of critical areas of physics.
2. Problem-solving skills: Students formulate and solve physics problems analytically, numerically, and experimentally.
3. Research and Communication Skills: Students apply knowledge to a contemporary problem in physics research. They discuss and describe the results of their work in oral and written form.

Note that our Interdisciplinary option PLO's are similar, but add one PLO for minor-specific knowledge, since this option requires that student's complete a minor in another program of study.

Our Physics Astronomy/Astrophysics Option has the following PLO's:

1. Effectively communicate scientific concepts related to the field of astronomy and/or astrophysics.

2. Analyze problems in physics and mathematical concepts as they pertain to the field of astronomy and astrophysics.
3. Develop strategies and solutions to solve those problems as they pertain to the field of astronomy and astrophysics.
4. Demonstrate critical thinking by applying appropriate mathematical tools and computational methods to physics, astronomy, and astrophysics problems.

Identify 1-2 major-required courses that might have student assignments designed to meet these objectives at least at a surface level. If you cannot identify a course in your program that aligns with this request, please check the appropriate box. At this juncture, this is for information gathering as we plan future institutional assessment endeavors.

Core Quality LOs are Institutional Learning Outcome (ILO)	**PLO overlaps with MSU Core Quality** Mark X if program has at least one PLO that overlaps with an ILO	**Beginning Level** e.g. CORE Courses (US, W, Q, IN, CS, IA, IH, IS, D)	**Developing Level** e.g. list one 200- or 300-level course	**Proficient Level** e.g. list one 300- or 400-level courses, Capstone, Research (R) Core courses	**Not Applicable (N/A)** No course exists in our program that addresses this Core Quality / ILO
Thinkers & Problem Solvers	x	Core classes are designed to address an introductory, foundational level of Core Qualities. Some may overlap into the developing level, but most intermediate-to-developing or proficient/mastery level courses will exist within the majors.	PHSX240 PHSX242 ASTR373	PHSX461 PHSX423 ASTR476	
Effective Communicators	x		PHSX224 PHSX301	PHSX490R PHSX499R	
Local & Global Citizen					x

Section 3. Actionable Research Question for Your Assessment.

Evaluate student knowledge and problem-solving skills through their responses to Essential Knowledge Questions (EKQs) in 6-8 courses each academic year. Evaluate student research experiences and their communication skills using the Capstone class PHSX 499R.

We revised program assessment to improve and simplify it while also closing the loop by providing feedback to faculty. Our new approach began with the creation of new Program Learning Outcomes (PLOs). The new PLOs are reduced in number, more broadly defined, and provide more latitude to assess our programs. For Fall 2024, we developed Essential Knowledge Questions for 3 courses (ASTR373, PHSX224, and PHSX320). Note the ASTR course which enables assessment of the ASTRO option. For Spring 2025, we requested input from three courses (PHSX 242, PHSX262, and ASTR 372). Only one instructor responded, unfortunately. Essential Knowledge Questions for 1 course (PHSX242) were developed and allowed assessment of that course. The EKQs were integrated into tests and quizzes. We requested that each EKQ require less than a 3-minute response time from students. The results were communicated back to the Undergraduate Curriculum Committee, which reported the results at a faculty meeting. Our catalog of Essential Knowledge Questions is developing. They are posted on our webpage (https://physics.montana.edu/ugrad/assessments.html).

Section 4. Assessment Plan, Schedule, and Data Sources.

a) Did you change the previously established Assessment Plan Schedule. If yes, how was it changed? No. The only change is that we assess different courses each year to allow us to screen all courses in the curriculum, eventually.

b) Please provide a multi-year assessment schedule that will show when all program learning outcomes will be assessed, and by what criteria (data). List your PLOs in full for reference. Add rows as necessary.

	ASSESSMENT PLANNING SCHEDULE CHART					
PLO#	PROGRAM LEARNING OUTCOME (Professional and Interdisciplinary Options)	2023-2024	2024-2025	2025-2026	2026-2027	Data Source*
1	Discipline-Specific Knowledge: Students demonstrate option-appropriate knowledge of critical areas of physics.	x	x	x	x	EKQs
2	Problem-solving skills: Students formulate and solve physics problems analytically, numerically, and experimentally.	x	x	x	x	EKQs
3	Research and Communication Skills: Students apply knowledge to a contemporary problem in physics research. They discuss and describe the results of their work in oral and written form.	x	x	x	x	PHSX499R Capstone Class

	ASSESSMENT PLANNING SCHEDULE CHART					
PLO#	PROGRAM LEARNING OUTCOME (Astronomy/Astrophysics Option)	2023-2024	2024-2025	2025-2026	2026-2027	Data Source*
1	Effectively communicate scientific concepts related to the field of astronomy and/or astrophysics.		x	x	x	PHSX499R Capstone Class
2	Analyze problems in physics and mathematical concepts as they pertain to the field of astronomy and astrophysics.		x	x	x	EKQs
3	Develop strategies and solutions to solve those problems as they pertain to the field of astronomy and astrophysics.		x	x	x	EKQs
4	Demonstrate critical thinking by applying appropriate mathematical tools and computational methods to physics, astronomy, and astrophysics problems.		x	x	x	EKQs

c) What are the threshold values for which your program demonstrates student achievement? Provide a rationale for your threshold values.

Threshold Values		
PROGRAM LEARNING OUTCOME (Professional and Interdisciplinary Options)	Threshold Value	Data Source
Example: 6) Communicate in written form about fundamental and modern microbiological concepts.	The threshold value for this outcome is for 75% of assessed students to score above 2 on a 1-4 scoring rubric.	Randomly selected student essays
Discipline-Specific Knowledge: Students demonstrate option-appropriate knowledge of critical areas of physics.	Grading: Accomplished=4, Competent=3, Developing=2, Beginning=1, Inadequate=0. Threshold value = 3.	EKQs
Problem-solving skills: Students formulate and solve physics problems analytically, numerically, and experimentally.	Grading: Accomplished=4, Competent=3, Developing=2, Beginning=1, Inadequate=0. Threshold value = 3.	EKQs
Research and Communication Skills: Students apply knowledge to a contemporary problem in physics research. They discuss and describe the results of their work in oral and written form.	Performance on classroom discussions, presentation, and final paper.	Capstone (PHSX499R) performance

Threshold Values		
PROGRAM LEARNING OUTCOME (Astronomy/Astrophysics Option)	Threshold Value	Data Source
Example: 6) Communicate in written form about fundamental and modern microbiological concepts.	The threshold value for this outcome is for 75% of assessed students to score above 2 on a 1-4 scoring rubric.	Randomly selected student essays
Effectively communicate scientific concepts related to the field of astronomy and/or astrophysics.	Performance on classroom discussions, presentation, and final paper.	Capstone (PHSX499R) performance
Analyze problems in physics and mathematical concepts as they pertain to the field of astronomy and astrophysics.	Grading: Accomplished=4, Competent=3, Developing=2, Beginning=1, Inadequate=0. Threshold value = 3.	EKQs
Develop strategies and solutions to solve those problems as they pertain to the field of astronomy and astrophysics.	Grading: Accomplished=4, Competent=3, Developing=2, Beginning=1, Inadequate=0. Threshold value = 3.	EKQs
Demonstrate critical thinking by applying appropriate mathematical tools and computational methods to physics, astronomy, and astrophysics problems.	Grading: Accomplished=4, Competent=3, Developing=2, Beginning=1, Inadequate=0. Threshold value = 3.	EKQs

Section 5. What Was Done?

a) Self-reporting Metric (required answer): Was the completed assessment consistent with the program's assessment plan? If not, please explain the adjustments that were made.

Yes **No**

How was the data collected and analyzed and by whom? Please include method of collection and sample size.

For Fall 2024, we developed Essential Knowledge Questions for 3 courses (ASTR373, PHSX224, and PHSX320). Note the ASTR course which enables assessment of the ASTRO option. For Spring 2025, we requested input from three courses (PHSX 242, PHSX262, and ASTR 372). Only one instructor responded, unfortunately. Essential Knowledge Questions for 1 course (PHSX242) were developed and allowed assessment of that course. The EKQs were integrated into tests and quizzes. We requested that each EKQ require less than a 3-minute response time from students. The results were communicated back to the Undergraduate Curriculum Committee, which reported the results at a faculty meeting. Our catalog of Essential Knowledge Questions is developing. They are posted on our webpage (https://physics.montana.edu/ugrad/assessments.html).

The instructors determined the numerical scores that were used. The results were communicated back to the Undergraduate Curriculum Committee, which then reported the results at a faculty meeting. The Undergraduate Curriculum Committee used those scores to determine thresholds and identify common failure modes from student written responses.

We assessed the communication PLO (3 for Professional and Interdisciplinary, 1 for Astro) through instructor interaction with students in PHSX 499R. Students were required to produce a resume, discuss it with classmates, and revise. They contacted a past graduate of our program to learn about that person’s career path. This was presented in class and in a one-page writing assignment. They engaged in classroom discussions and were required to present the results of their research in oral and poster presentations. They were also required to write a paper about their research project. All students performed above threshold.

c) Please provide a rubric that demonstrates how your data was evaluated. (Delete example below and replace with program's assessment-specific rubric.)

Indicators	Beginning - 1	Developing- 2	Competent- 3	Accomplished- 4
Analysis of Information, Ideas, or Concepts	Identifies problem types	Focuses on difficult problems with persistence	Understands complexity of a problem	Provides logical interpretations of data
Application of Information, Ideas, or Concepts	Uses standard solution methods	Provides a logical interpretation of the data	Employs creativity in search of a solution	Achieves clear, unambiguous conclusions from the data
Synthesis	Identifies intermediate steps required that connects previous material	Recognizes and values alternative problem-solving methods	Connects ideas or develops solutions in a clear coherent order	Develops multiple solutions, positions, or perspectives
Evaluation	Check the solutions against the issue	Identifies what the final solution should determine	Recognizes hidden assumptions and implied premises	Evaluates premises, relevance to a conclusion and adequacy of support for conclusion.

Section 6. What Was Learned.

a) Based on the analysis of the data, and compared to the threshold values established, what was learned from the assessment?

For Fall 2024, PHSX224, which is our Physics III course (sophomore level), we found that on the two EKQs, 25% and 12% of the students reached the threshold level of 3 or above. The majority of students scored Developing (score of 2). There are some common difficulties exhibited. These included connecting variables to physical quantities. *Note that we ask the instructors to assess only Physics majors.*

For the junior-level course PHSX320 (F24), a course populated solely by physics majors, the outcomes were stronger. Out of 26 students for the four EKQs, on one 77% of the students were above threshold while for two others, 61% were above and for the last only 23% were above. Breaking this down further, about 16-20 students scored Competent or above on all but one EKQ. About 6-10 scored beginning or developing and none scored 0 (inadequate).

For the junior level class Extragalactic Astronomy ASTR373, there were 7 students who were given 3 EKQs. On two EKQs, 71% of the students reached the threshold value. On the third EKQ 57% did.

For freshmen level Honors Physics PHSX242, three EKQs were utilized. On one 83% scored threshold or above while on the other two 65% did.

In PHSX499R the focus was on communication due to the course format. 100% of the students were above threshold level.

b) What areas of strength in the program were identified from this assessment process?
We find that the research experience, as indicated in PHSX499R, is a very formative activity. Students synthesize their knowledge of physics into reports and presentations about the research. They also do an outstanding job in oral and written presentation.

c) What areas were identified that either need improvement or could be improved in a different way from this assessment process?

Although the EKQs identify that more of our students should be reaching threshold levels of knowledge, more data is needed to inform our path forward. We believe that a deeper analysis using more EKQs would be beneficial. We are also piloting an approach that uses a nation-wide test of physics knowledge, the LASSO platform. This is currently being used to assess PHSX261 and PHSX343.

Section 7. How We Responded.

a) Describe how "What Was Learned" was communicated to the department, or program faculty. How did faculty discussions re-imagine new ways program assessment might contribute to program growth/improvement/innovation beyond the bare minimum of achieving program learning objectives through assessment activities conducted at the course level?

The results were communicated at a faculty meeting. We are currently investigating improving this assessment approach or developing another. A deeper analysis using more EKQs could be beneficial. We are also piloting an approach that uses a nation-wide test of physics knowledge, the LASSO platform. This is currently being applied to assess PHSX261 and PHSX343. We are also planning to assess the communication PLO using PHSX 200, where a paper is a requirement, and PHSX 261, where a lab book is maintained.

b) How are the results of this assessment informing changes to enhance student learning in the program?

We believe that more and better data collection is needed to make a proper assessment.

c) If information outside of this assessment is informing programmatic changes, please describe that.

See section 8 (a).

d) What support and resources (e.g., workshops, training, etc.) might you need to make these adjustments?

None identified.

Section 8. Closing the Loop(s).
Reflect on the program learning outcomes, how they were assessed in the previous cycle (refer to #1 of the report), and what was learned in this cycle about any actions stemming from the previous cycle.

a) Self-Reporting Metric (required answer): Based on the findings and/or faculty input, will there be any changes made (such as plans for measurable improvements, realignment of learning outcomes, curricular changes, etc.) in preparation for upcoming assessments?

Yes ■ **No** ☐

We have Undergraduate Town Hall meetings at the end of each semester. The Undergraduate Curriculum Committee and the department head attend the Town Halls. Afterwards, the faculty discuss and implement changes where possible. Changes that were made were communicated to the undergraduates by the department head.

Throughout AY 24-25 we have critically assessed our programs with the goal of streamlining and improving pedagogy, retention, and recruitment where possible. This led to moving PHSX 200 Research Programs in Physics to Spring semester to allow students more time to learn Physics prior to being informed as to which research programs are available for their future research involvement. We revamped the Physics Minor to provide more flexibility to students and to recommend areas in physics on which to focus. We moved the timing of some courses in the ASTRO option to streamline the program and adjusted some content accordingly. We added a new course PHSX256 which uses the programming language Python to solve physics problems. This is offered in the second semester. It has removed the requirement for PHSX 331 (Computational Physics) for the ASTRO option students, streamlining that program. The curriculum for PHSX 331 (Computational Physics) was improved, allowing coverage of more advanced mathematics, since elementary computer coding will be covered in PHSX 256. PHSX 301 and PHSX261 (Electronics) are being moved to coincide in Spring Semester so that Fourier transforms, used in 261, can be covered in PHSX 301. We have eliminated PHSX 262 (Electronics II) as a requirement (for Professional and Interdisciplinary Options), turning it into an elective. It may only be offered every other year, thereby reducing costs. In this process, 1 credit was added to PHSX261 to assure adequate coverage.

The Education Option, not covered in our assessment since there are only about 2 enrollees and many Education courses, was totally revamped in collaboration with the Education Department. This streamlined the option, making it more attractive. Syllabi and learning outcomes were updated in CIM for most courses.

The above changes were entered into CIM through Fall 2025, thanks to our Curriculum Committee Chair.

We rewrote laboratories for 242 over the summer, adding new equipment (using EFAC funds) and a new Gauss's Law laboratory. We rewrote the entire laboratory manual for ASTR 371, made a digital copy that is provided to students free of charge, and added new equipment (also using EFAC funds). For PHSX 205 the entire lab/tutorial manual was rewritten, digitized, and offered to students free of charge. The same is currently being done for PHSX207.

b) In reviewing the last report that assessed the PLO(s) in this assessment cycle, what changes proposed were implemented and will be measured in future assessment reports? What action will be taken to improve student learning objectives going forward?

There were not changes suggested. We have included our EKQs for the committee to see.

c) Have you seen a change in student learning based on other program adjustments made in the past? Please describe the adjustments made and subsequent changes in student learning.

Our response to 8 (a) covers this.

d) If the program sees anything emerging from this assessment cycle that it anticipates would be a factor or an item of discussion in its 7-year program review cycle, please use this space to document that for future reference.

Submit report to programassessment@montana.edu
Update Department program assessment report website.
Update PLO language in CIM if needed (Map PLOs to Course LOs)

Proposed Program Learning Outcomes

- **Discipline-Specific Knowledge**: Students demonstrate option-appropriate knowledge of critical areas of physics.
- **Problem-Solving Skills**: Students formulate and solve physics problems analytically, numerically, and experimentally.
- **Research and Communication Skills**: Students apply knowledge to a contemporary problem in physics research. They discuss and describe the results of their work in oral and written form.

Course Assessment Method

- Asked instructors of four courses to report student performance on several Essential Knowledge Questions, integrated into their regular tests and consistent with Course Learning Outcomes.

- Instructors graded the EKQ responses independently from the test grades: 4=A, 3=B, etc.

- For each grade level, instructors reported numbers of students achieving at that level and provided images of typical student performance.

- The Curriculum Committee reviewed the submissions and generated one significant failure mode for each EKQ.

EKQs from Extragalactic Astronomy ASTR 373 Reines F24

This course will provide an introduction to extragalactic astronomy and astrophysics. Topics to be covered include the nature of galaxies, galactic evolution, the structure of the Universe, active galaxies and supermassive black holes, cosmology, and the early Universe

- Consider a flat, radiation-only universe, which describes the early evolution of our own universe. Starting with the Friedmann equation, find the evolution of the scale factor with time during this radiation-dominated phase of the universe.
  - N=7, mean=2.9, std=0.8 (A:2, B:2, C:3, D:0, F:0)
  - **Failure to connect variables to physical quantities. Trouble with elementary definite integral.**
- How is the data that populates a given a Hubble diagram measured, and what is the distance for a given redshift?
  - N=7, mean=2.9, std=0.5 (A:1, B:4, C:2, D:0, F:0)
  - **Imprecise command of astronomical measurements.**

EKQs from Extragalactic Astronomy ASTR 373 Reines F24

This course will provide an introduction to extragalactic astronomy and astrophysics. Topics to be covered include the nature of galaxies, galactic evolution, the structure of the Universe, active galaxies and supermassive black holes, cosmology, and the early Universe

- Given measured emission spectrum for H_α and rest wavelength, estimate gas velocity and redshift. Explain physical cause of broadening.
  - N=7, mean=3.0, std=0.7 (A:2, B:3, C:2, D:0, F:0)
  - Failure to interpret peak position and width, and connection to broadening.

EKQs from Physics III PHSX 224 Rugheimer F24

Covers topics in thermodynamics (such as temperature, heat, laws of thermodynamics, and the kinetic theory of gases) and modern physics (such as relativity; models of the atom; quantum mechanics; and atomic, molecular, solid state, nuclear, and particle physics)

- Identify amplitude, period, speed, etc. for $y(x,t) = A\cos(kx - \omega t + \varphi)$
  - N=16, mean=2.2, std=0.5 (A:1, B:3, C:11,D:1, F:0)
  - **Failure to connect variables to physical quantities.**
- Given diagram depicting geometry, write the $p_{xi} = p_{xf}$, $p_{yi} = p_{yf}$ and $E_i = E_f$ equations necessary to derive the Compton Scattering equation
  - N=16, mean=2.0, std=0.3 (A:0, B:2, C:12,D:2, F:0)
  - **Failure to express conservation of linear momentum in 2D.**

EKQs from Classical Mechanics PHSX 320 Yu F24

Principles of Newtonian and Lagrangian mechanics including single particle motion, systems of particles, rigid body motion, moving coordinate systems, and small oscillations

- Find Lagrangian for 2-mass pendulum, upper mass slides horizontally
  - N=26, mean=2.8, std=0.8 (A:6, B:10, C:8, D:2, F:0)
  - **B: incorrect position vector and sign on potential; C: ignore one of the masses**
- Find CM and moment of inertia tensor for three point masses.
  - N=26, mean=3.1, std=0.9 (A:11, B:9, C:4, D:2, F:0)
  - B: didn’t know how to find elements of tensor; C: failed to understand CM frame; D: didn’t know concept of CM or the difference between vectors and scalars.

EKQs from Classical Mechanics PHSX 320 Yu F24

Principles of Newtonian and Lagrangian mechanics including single particle motion, systems of particles, rigid body motion, moving coordinate systems, and small oscillations

- Find x(t) for arbitrary potential energy and initial conditions, assuming small step
  - N=26, mean=2.1, std=0.9 (A:3, B:3, C:13, D:7, F:0)
  - **B: wrong initial conditions; C: idea to expand potential, but no connection to harmonic oscillations**
- Find angular momentum from Lagrangian for given potential and kinetic energy for binary system.
  - N=26, mean=3.1, std=1.2 (A:13, B:3, C:6, D:2, F:0)
  - B: concept of angular momentum conservation unclear; C: failure to distinguish generalized momentum, momentum vector, and derivatives of Lagrangian.

EKQs from Physics II PHSX 242 Filwett S25

Restricted to Physics majors or Honors students or consent of instructor. The honors section of PHSX 222. The concepts are discussed in more depth and the range of applications is greater

- Describe at least 2 similarities and 2 differences between a capacitor and a battery (you can do this using full sentences, or with a table/diagram).
  - N=18, mean=3.4, std=0.6 (A:10, B:5, C:3, D:0, F:0)
  - Failure to indicate 1 similarity. (No image for C performance.)
- A helium nucleus (2 protons & 2 neutrons) moves into a region with $B=0.05\hat{j} + 0.6\hat{k}$ T, having a velocity of $7 \times 10^5 \hat{j}$ m/s. (a) What force does the particle feel? (b) Draw a sketch and label the particle's velocity, direction of force, and the B field. (mass of a proton and mass of a neutron are both $\sim 1.67 \times 10^{-27}$kg).
  - N=17, mean=2.9, std=1.1 (A:6, B:5, C:4, D:2, F:0)
  - **Numerical errors. Ambiguous axes or failure of cross product.**

EKQs from Physics II PHSX 242 Filwett S25

Restricted to Physics majors or Honors students or consent of instructor. The honors section of PHSX 222. The concepts are discussed in more depth and the range of applications is greater

- Two charged concentric spherical shells have radii 8.24 cm and 16.8 cm. The charge on the inner shell is 5.36×10^{-8} C and that on the outer shell is 2.56×10^{-8} C. Find the electric field at r = 11.2 cm. Explain which charge has a larger contribution to the field you found.
  - N=17, mean=2.9, std=1.2 (A:7, B:4, C:4, D:2, F:0)
  - **Included field due to charges beyond field point. Incorrect field due to charged shell. Used difference of squared radii in denominator.**