**Stage 1: Establish student learning goals.**

Program Learning Objectives (PLOs)

1. Physical Principles: Students will be able to apply basic physical principles—including classical mechanics, electricity and magnetism, quantum mechanics, and thermal physics—to explain, analyze, and predict a variety of natural phenomena.

2. Mathematical Expertise: Students will be able to translate physical concepts into mathematical language. Furthermore, students will be able to apply advanced mathematical techniques (e.g., calculus, linear algebra, probability, and statistics) in their explanations, analyses, and predictions of physical phenomena.

3. Experimental Techniques: Students will be able to perform physical measurements in an experimental laboratory setting and analyze these results to draw conclusions about the physical system under investigation, including whether their data supports or refutes a given physical model.

4. Communication and Teamwork Skills: Students will be able to clearly explain their mathematical and physical reasoning, both orally and in writing, and will be able to communicate and work effectively in groups on a common project.

5. Research Proficiency: Students will be able to formulate research questions that expand their knowledge of physics. Students will be able to apply sound scientific research methods to address these questions, either by researching the current literature or developing independent results.

**Stage 2: Determine the evidence: student work.**

**Stage 3: Design curriculum & pedagogy.**

Curriculum Matrix: Maps skills development for core major courses. Signature assignments allow for consistency of assessment evidence and flexibility for various faculty teaching styles. Campus support is utilized for indirect evidence.

<table>
<thead>
<tr>
<th>Year</th>
<th>Course Title</th>
<th>Physical Principles</th>
<th>Mathematical Expertise</th>
<th>Experimental Techniques</th>
<th>Communication &amp; Teamwork</th>
<th>Research Proficiency</th>
<th>Signature Assignment or Rubric Evidence Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introductory I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>R</td>
<td>A</td>
<td>R</td>
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<tr>
<td>1</td>
<td>Introductory II</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>R</td>
<td>A</td>
<td>A</td>
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<td>2</td>
<td>Classical Mechanics</td>
<td>R, A</td>
<td>R</td>
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<tr>
<td>3–4</td>
<td>Thermodynamics</td>
<td>R, A</td>
<td>R</td>
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<td>A</td>
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<tr>
<td>3–4</td>
<td>Electrodynamics</td>
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<tr>
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<tr>
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<td>Quantum Mechanics</td>
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<td>A</td>
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<tr>
<td>4</td>
<td>Senior Research</td>
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<tr>
<td>4</td>
<td>Senior Thesis</td>
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<tr>
<td>5</td>
<td>Capstone Project</td>
<td>A, A, A, A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

**Stage 4: Gather & review evidence.**

Indirect Evidence: Adds students' opinions about their achievements of the PLOs, what aspects of the program helped them achieve the PLOs (and why), what actions the program may take to improve their learning. (Walvoord)

Senior Exit Survey questions:

- Rate yourself on the skills and knowledge in the following statements. Please give yourself a different score, one for when you started studying at UC Merced, and a second score for today.

- You can analyze experimental results to draw conclusions about the physical system under investigation, including whether the data supports or refutes a given physical model.

Highly proficient
Moderately proficient
 Barely proficient
Not proficient

**References**


**Stage 5: Draw conclusions in the aggregate.**

**Stage 6: Act on the results to improve.**

**Physic Program**

- Mathematics for Physics Course: New elective supported by direct evidence and student focus group (PLO 2).
- Quantitative vs. Qualitative: Mathematically-focused questions often dissuaded students' challenges with conceptual material. Increased faculty awareness leads to richer assignments and exams (PLO 1 and 2).
- Introductory Physic I Labs: Increased emphasis on data reduction & analysis (PLO 3).
- Quantum Video Project: Video must be correct, engaging, and suitable for freshman seminar students (PLO 4). Students work in teams (PLO 4).

**Literature Review in Introductory Courses:** and writing assignments in upper-division courses increases students' ability to work with literature and communicate in written form (PLOs 4 and 5).

**Senior Thesis Presentations:** Sharing rubrics with students results in higher quality presentations (PLOs 4 and 5).

**Assessment Practices**

- **Stage 1: Learning goals**
  - Unspecified context for research proficiency (PLO 5) and varied lengths of students' research experiences led to difficulties in using senior research performance for PLO assessment.
  - Each course syllabus specifies relationship between course learning objectives (CLOs) to PLOs.

- **Stage 2: Determine evidence**
  - The Curriculum Matrix
  - The curriculum matrix identified gaps in developing experimental techniques.
  - Evidence is consistently collected and spread out over all required semester-long courses.

- **Stage 3: Design curriculum & pedagogy**
  - Faculty choose the final exam problem pertinent to their own course, which accommodates various teaching styles.

- **Stage 4: Gather & review evidence**
  - Descriptive rubrics lead to better inter-rater reliability.
  - Rubrics are applicable to course- and program-level assessment. Overall score for course,rubric details for program.

- **Stage 5: Draw conclusions in the aggregate**
  - The curriculum matrix identified gaps in developing experimental techniques.