Program: Bachelor of Science

Mission Statement
The primary functions of the Department of Physics and Astrophysics are teaching, research, and service. In accordance with the mission of the University, the department provides courses for physics majors and minors, and service courses to students in other programs in the College of Arts & Sciences and other units of the University.

Student Learning Goals
Goal 1: Students should know the laws of physics. These include, but are not limited to: Newton’s Laws, Maxwell’s equations, basic concepts of modern physics, basic laws of thermodynamics, circuit theory, Lagrangian and Hamiltonian mechanics, and quantum mechanics.

Goal 2: Students should possess practical skills in physics.
Objective 2.1: Students should possess analytical skills.
Objective 2.2: Students should possess computer skills and computational skills.
Objective 2.3: Students should possess experimental physics skills.

Goal 3: Students should be skilled in scientific communication.
Objective 3.1: Students should be skilled in technical writing.
Objective 3.2: Students should be skilled in oral communication.
Objective 3.3: Students should be skilled in scientific visual communication.

Goal 4: Students should be able to demonstrate critical thinking.

Learning goals will be assessed according to the table below.

<table>
<thead>
<tr>
<th>Student Learning Goals or Objectives</th>
<th>Educational Experiences</th>
<th>Assessment Methods</th>
<th>Responsibility</th>
<th>Use of Results and Process of Documentation and Decision Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will know the laws of physics</td>
<td>All physics courses taken by majors</td>
<td>Average exam scores, samples of student work, student interviews</td>
<td>Instructors, Undergrad Committee</td>
<td>Annual recommendations to the Department, Departmental records, annual evaluations</td>
</tr>
<tr>
<td>Analytical skills</td>
<td>All physics courses taken by majors</td>
<td>Average exam scores, samples of student work, student interviews</td>
<td>Instructors, Undergrad Committee</td>
<td>Annual recommendations to the Department, Departmental records, annual evaluations</td>
</tr>
<tr>
<td>Computational skills</td>
<td>PHYS 402 and many upper division courses (esp. Schwalm’s)</td>
<td>Samples of student work</td>
<td>Faculty advisors in relevant courses</td>
<td>Students referred to writing center as appropriate</td>
</tr>
<tr>
<td>Experimental skills</td>
<td>PHYS 251, 252, 253, 325, and 428 (and maybe 415)</td>
<td>Lab reports, examination questions</td>
<td>Main course instructors, Graduate Teaching Assistants, Lab Supervisor</td>
<td>Upgrading equipment, editing manuals</td>
</tr>
<tr>
<td>Students will be skilled in scientific communication</td>
<td>Courses requiring lab reports, homework, and formal papers</td>
<td>Sample and evaluate papers and reports</td>
<td>Course instructors</td>
<td>Students referred to writing center as appropriate</td>
</tr>
<tr>
<td>Students will demonstrate critical thinking</td>
<td>All physics courses</td>
<td>Average exam scores, samples of student work, annual exit interviews</td>
<td>Instructors; interviews by Assessment Committee</td>
<td>Adjust pedagogy; modify curriculum</td>
</tr>
<tr>
<td>Conducting research with guidance of mentor</td>
<td>PHYS 415 and 492</td>
<td>Reports and informal papers</td>
<td>Faculty research advisors</td>
<td>Modify student research topics and expectations</td>
</tr>
</tbody>
</table>
Elaborations
The way that physics learning and research is done evolves with time. Certain software and hardware can become obsolete and be replaced by new things. With this understanding, we are nevertheless going to list examples of how the learning goals might be interpreted, as of 2015. Learning goals are classified below according to the revised Bloom’s taxonomy:

- Bloom 1: Remember
- Bloom 2: Understand
- Bloom 3: Apply
- Bloom 4: Analyze
- Bloom 5: Evaluate
- Bloom 6: Create

Goal 1: Students should know the laws of physics.
Students should be able write down and explain terms in the following:
- Newton’s three laws and the basic equations of Lagrangian and Hamiltonian mechanics [Bloom 1]
- Maxwell’s four equations and Kirchhoff’s laws
- The zeroth, first, second, and third laws of thermodynamics
- The postulates of quantum mechanics
- Basic concepts of modern physics.

Goal 2: Students should possess practical skills in physics.
Objective 2.1: Students will possess analytical skills. They should be able to:
- give qualitative answers based on intuition [Bloom 2]
- give quantitative solutions to “textbook problems” (i.e., do the math) [Bloom 3,4]
- analyze real-life problems [Bloom 4]
- formulate them as physics problems [Bloom 6]
- identify relevant quantities (c.f. Schwalm’s lab assessments) [Bloom 5]
- identify tacit assumptions, make simplifying approximations, etc.

Objective 2.2: Students will possess computer skills and computational skills. They should be able to:
- use computers (Mathematica, C, Fortran, etc.) for symbolic computation, numerical computation, and visualization [Bloom 1,2,3]

Objective 2.3: Students will possess experimental physics skills. They should be able to:
- use voltmeters, oscilloscopes; build circuits; take measurements [Bloom 1,2,3]
- design, conduct, and interpret basic experiments, e.g., design a circuit to measure capacitance, or a pendulum to measure the acceleration due to gravity [Bloom 4,5,6]

Goal 3: Students will be skilled in scientific communication.
Objective 3.1: Students will be skilled in technical writing. They should be able to:
- use appropriate physics notation, e.g., vectors, units, measurement uncertainties [Bloom 1,2,3]
- use appropriate physics terminology, e.g., distinguishing between force/power/energy [Bloom 1,2,3]
- write scientific papers with Abstract/Model/Methods/Results/Discussion/References [Bloom 1,2,3]

Objective 3.2: Students will be skilled in oral communication. They should be able to:
- give presentations (e.g., for PHYS 415) [Bloom 1–6]

Objective 3.3: Students will be skilled in visual communication. They should be able to:
- produce plots, graphs, sketches, schematics, free-body diagrams, etc. [Bloom 1–6]

Implementation
Assessment methods vary from course to course, and between course sections, due to different pedagogies (e.g., lecture vs SCALE-UP). Typically, questions that test a particular goal (e.g., analytical skills) are embedded into tests or assignments, in order to allow that particular learning goal to be assessed. Students who are taking PHYS 415 as a Capstone course are assessed according to a rubric that addresses students’ knowledge, comprehension, analysis, synthesis, evaluation ability, oral communication, and written communication.
Program: Master of Science

Mission Statement
The primary functions of the Department of Physics and Astrophysics are teaching, research, and service. In accordance with the mission of the University, the department provides courses for physics majors and minors, and service courses to students in other programs in the College of Arts & Sciences and other units of the University.

Student Learning Goals
Goal 1: Students should acquire competency in graduate-level physics, including mechanics, electromagnetism, quantum mechanics, and theoretical methods.

Goal 2: Students should possess analytical, computational, and/or experimental skills in physics, depending on specialization, at the level of a professional physicist.

Goal 3: Students should be skilled in scientific communication (including giving oral presentations and writing research papers).

Goal 4: Students should be able to conduct research under the guidance of a mentor.

<table>
<thead>
<tr>
<th>Student Learning Goals and Program Objectives</th>
<th>Educational Experiences</th>
<th>Assessment Methods</th>
<th>Responsibility</th>
<th>Use of Results and Process of Documentation and Decision Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competency in graduate-level physics including mechanics, electromagnetism, quantum mechanics, and theoretical methods</td>
<td>Physics graduate courses, 509, 539, 541, 545; 535 &amp; 536 if applicable; two out of three of 510, 540, 542.</td>
<td>Pre-post examination scores, samples of student work, best, worst and typical, and student interviews</td>
<td>Instructors, Graduate Committee</td>
<td>Make adjustments to course content and instructional methods</td>
</tr>
<tr>
<td>Analytical, computational, and experimental skills</td>
<td>Graduate courses, 550, 590, M.S. research project</td>
<td>Exams, homework, interaction with advisor</td>
<td>Instructors, thesis advisor</td>
<td>Adjustments to level and type of examinations, homework, etc.</td>
</tr>
<tr>
<td>Scientific communication</td>
<td>Presentations in classes, meetings, conferences; M.S. thesis</td>
<td>Accepted papers; manuscripts prepared; sample of oral presentations</td>
<td>Thesis advisor</td>
<td>Provide opportunities for practice and provide feedback</td>
</tr>
<tr>
<td>Ability to conduct research</td>
<td>Physics 590, 550; M.S. thesis</td>
<td>Review of research project and thesis; Annual Progress Reports</td>
<td>Thesis committee</td>
<td>Feedback to student</td>
</tr>
</tbody>
</table>
Elaborations
The way that physics learning and research is done evolves with time. Certain software and hardware can become obsolete and be replaced by new things. With this understanding, we are nevertheless going to list examples of how the learning goals might be interpreted, as of 2015.

Goal 1: Competency in graduate-level physics
This goal refers to content knowledge: students should be able to state theorems and formulas, and explain their meanings.

Goal 2: Analytical, computational, and/or experimental skills
Analytical skills include algebra, calculus, geometrical methods, and approximation methods. Computational skills may include symbolic calculations, numerical calculations, and programming in Mathematica, C++, and/or Fortran. Experimental skills may include electronic circuit design and construction, metalworking, using research equipment, data-taking, LabView programming, or even handling of hazardous materials. The skill set depends strongly on the student’s research specialization.

Goal 3: Scientific communication
Written communication includes technical writing, using symbols, notation, and terminology appropriately, and typesetting mathematical equations using LaTeX. Oral communication includes having discussions and giving presentations. Visual communication may include producing sketches, plots, figures, or animations, using hand drawing, computers, photography, or other methods.

Goal 4: Ability to conduct research
Ability to conduct research at the M.S. level.
Program: Doctor of Philosophy (Physics)

Mission Statement
The primary functions of the Department of Physics and Astrophysics are teaching, research, and service. In accordance with the mission of the University, the department provides courses for physics majors and minors, and service courses to students in other programs in the College of Arts & Sciences and other units of the University.

Student Learning Goals
Goal 1: Students should acquire competency in graduate-level physics including mechanics, electromagnetism, quantum mechanics, statistical physics, and theoretical methods.

Goal 2: Students should possess analytical, computational, and/or experimental skills in physics, depending on specialization, at the level of a professional physicist.

Goal 3: Students should be skilled in scientific communication (giving oral presentations and writing research papers).

Goal 4: Students should acquire skills to carry out programs of independent research at a research laboratory or as a university faculty member.

<table>
<thead>
<tr>
<th>Student Learning Goals and Program Objectives</th>
<th>Educational Experiences</th>
<th>Assessment Methods</th>
<th>Responsibility</th>
<th>Use of Results and Process of Documentation and Decision Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competency in graduate-level physics including mechanics, electromagnetism, quantum mechanics, statistical physics, and theoretical methods.</td>
<td>Physics graduate courses, 509, 510, 539, 540, 541, 542, 543, 545; 535 &amp; 536 if applicable.</td>
<td>(a) Average examination scores, samples of student work; (b) Qualifying and Comprehensive Examinations</td>
<td>(a) Instructors, (b) Graduate Committee. Department.</td>
<td>(a) Make adjustments to course content and instructional methods. (b) Decide students’ qualifications</td>
</tr>
<tr>
<td>Analytical, computational, and experimental skills</td>
<td>All graduate classes</td>
<td>Examinations (including Qualifying and Comprehensive Examinations), homework, interaction with advisor</td>
<td>Faculty research advisors, course instructors</td>
<td>Adjustments to pedagogy and level and type of examinations, homework, etc.</td>
</tr>
<tr>
<td>Scientific communication</td>
<td>Presentations in classes, meetings, conferences; doctoral dissertation; writing papers</td>
<td>Accepted papers; manuscripts prepared; sample of oral presentations</td>
<td>Dissertation advisor</td>
<td>Provide opportunities for practice and provide feedback</td>
</tr>
<tr>
<td>Ability to conduct research</td>
<td>Physics 590, 550; doctoral dissertation and associated research</td>
<td>Review of research project and dissertation; Annual Progress Reports</td>
<td>Dissertation committee</td>
<td>Feedback to student</td>
</tr>
</tbody>
</table>
Elaborations
The way that physics learning and research is done evolves with time. Certain software and hardware can become obsolete and be replaced by new things. With this understanding, we are nevertheless going to list examples of how the learning goals might be interpreted, as of 2015.

Goal 1: Competency in graduate-level physics
This goal refers to content knowledge: students should be able to state theorems and formulas, and explain their meanings.

Goal 2: Analytical, computational, and/or experimental skills
Analytical skills include algebra, calculus, geometrical methods, and approximation methods. Computational skills may include symbolic calculations, numerical calculations, and programming in Mathematica, C++, and/or Fortran. Experimental skills may include electronic circuit design and construction, metalworking, using research equipment, data-taking, LabView programming, or even handling of hazardous materials. The skill set depends strongly on the student’s research specialization.

Goal 3: Scientific communication
Written communication includes technical writing, using symbols, notation, and terminology appropriately, and typesetting mathematical equations using LaTeX. Oral communication includes having discussions and giving presentations. Visual communication may include producing sketches, plots, figures, or animations, using hand drawing, computers, photography, or other methods.

Goal 4: Ability to conduct research
Ability to conduct research at the Ph.D. level.
DEPARTMENTAL PLAN FOR ASSESSMENT OF STUDENT LEARNING
2004-2005 ACADEMIC YEAR

Department: Physics

Program: Bachelor of Science

Mission Statement

The primary functions of the Physics Department are teaching, research and service. In accordance with the mission of the University, the department provides courses for physics majors and minors, and service courses to students in other programs in the College of Arts & Sciences and other units of the University.

Student Learning Goals

Student Learning Goal 1: **Provide student with quality instruction in physics.**

Objective 1.1: Students will acquire a knowledge base in physics, including Newton's Laws and applications, Maxwell's equations, and the basic laws of thermodynamics.

Objective 1.2: Department will provide good quality instruction through traditional lectures, and/or modern instructional technology and methods.

Student Learning Goal 2: **Provide students with the discipline’s tools and practical experience in physics.**

Objective 2.1: Students will be able to use their knowledge base to solve physical problems.

Objective 2.2: Students will gain hands-on laboratory experience.
Student Learning Goal 3: **Contribute to the student’s general education.**

- Objective 3.1: Students will practice analytic and critical thinking.
- Objective 3.2: Students will practice written communication skills.

Student Learning Goal 4: **Preparing students for their career goals.**

- Objective 4.1: The Department will help students realize a broad range of physics-related career goals.
- Objective 4.2: Students will gain research experience in physics.
<table>
<thead>
<tr>
<th>Student Learning Goals and Program Objectives</th>
<th>Educational Experiences</th>
<th>Assessment Methods</th>
<th>Timeline</th>
<th>Responsibility</th>
<th>Use of Results and Process of Documentation and Decision Making</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Students will acquire a knowledge base in physics, including Newton's Laws and applications, Maxwell's equations, and the basic laws of thermodynamics.</td>
<td>Physics 251, 252, 253, and upper division courses</td>
<td>Average examination scores, samples of student work, student interviews.</td>
<td>Test scores and samples each semester, interviews annually.</td>
<td>Instructors, Undergrad Committee.</td>
<td>Annual recommendations to the Department. Departmental records, annual evaluations.</td>
</tr>
<tr>
<td>2. Students will be able to use their knowledge base to solve physical problems.</td>
<td>All physics courses taken by majors</td>
<td></td>
<td></td>
<td></td>
<td>Adjustments to level and type of examinations, homework etc.</td>
</tr>
<tr>
<td>3. Students will gain hands-on laboratory experience</td>
<td>Physics 251, 252, 253, 325, and 428</td>
<td>Lab reports, examination questions</td>
<td>Each semester</td>
<td>Main course instructors</td>
<td>Upgrading equipment, editing manuals</td>
</tr>
<tr>
<td>4. Students will gain research experience in physics</td>
<td>Physics 415 and 492</td>
<td>Reports and informal papers</td>
<td>As students enroll in these courses</td>
<td>Faculty research advisors</td>
<td>Modify student research topics and expectations.</td>
</tr>
<tr>
<td>5. Students will practice written communication skills</td>
<td>Courses requiring lab reports, homework, and formal papers</td>
<td>Sample and evaluate papers and reports</td>
<td>Each semester</td>
<td>Course instructors</td>
<td>Students referred to writing center as appropriate</td>
</tr>
<tr>
<td>6. Department will provide good quality instruction through traditional lectures, and/or modern instructional technology and methods.</td>
<td>All classroom-based physics courses</td>
<td>a) Student evaluation, b) faculty peer evaluations of lectures c) Student survey</td>
<td>Peer evaluations annually, student evaluations per semester</td>
<td>a) Instructors, b) Department Lecture Assessment Committee. c) Undergrad Committee.</td>
<td>Adjustments made to teaching assignments. Feedback used to modify new methods.</td>
</tr>
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<tr>
<td>7. Students will practice analytic and critical thinking.</td>
<td>All physics courses</td>
<td>Average exam scores, samples of student work, annual interviews</td>
<td>Each semester</td>
<td>Instructors Interviews by Undergrad Committee</td>
<td>Adjust pedagogy Modify curriculum</td>
</tr>
<tr>
<td>8. Department will help students realize a broad range of physics related career goals.</td>
<td>Individual tracks in the multi-track program, special advisement</td>
<td>Student exit survey Alumni survey</td>
<td>Each student graduating ~ each ten years or so</td>
<td>Undergrad. Committee Faculty Student Advisors</td>
<td>Adjustments to curriculum and course content, planning for new faculty hires. Revise tracks.</td>
</tr>
</tbody>
</table>