UR Undergraduate Physics and Astronomy Program Learning Objectives and Assessment Plan

A. BS Physics undergraduate program learning objectives (variations can be written for other Physics and Astronomy degrees)

Students will:

1. Demonstrate understanding of the core foundations of physics including classical mechanics, electrodynamics, quantum mechanics, thermodynamics and statistical physics, and astronomy.
    a) Demonstrate comprehension of terms, concepts and models involving the foundations of physics and astronomy.
    b) Be able to use knowledge of how physicists build models to take a realistic system and simplify it to essential physical properties.
    c) Analyze and solve problems on homework and tests by being able to draw on physics and astronomy knowledge.
    d) Analyze results of lab experiments by being able to use physics and astronomy knowledge to draw valid conclusions.
    e) Critically evaluate conclusions in research articles which are based on physics and astronomy knowledge.
2. Understand mathematics fundamentals used in the modeling of physics systems and solving physics and astronomy problems.
    a) Use ordinary and partial differential equations, Fourier analysis and other pertinent math methods In analysis and solution of physics and astronomy problems.
    b) Be able to use statistical methods for analysis of experimental data.
3. Understand the scientific method, including formulation of hypotheses, experimental design, and analysis and interpretation of results.
    a) Demonstrate comprehension of the terms and concepts for scientific method, hypothesis formulation, experimental design, and analysis and interpretation of results.
    b) Be able to formulate an original hypothesis and design an experiment to test the hypothesis.
    c) Be able to analyze and interpret the results of an experiment using statistical methods.
    d) Be able to critically evaluate a research paper's hypothesis, experimental design, analysis and conclusions.
4. Develop basic practical experimental skills used in physics and astronomy research, including laboratory procedures and computational methods.
    a) Be able to carry out an experimental protocol using a variety of experimental methods for the investigation of physics phenomena.
    b) Be able to identify the range of research questions and types of data produced by each of the experimental methods commonly used in the investigation of physics and astronomy phenomena.
    c) Be able to analyze and interpret experimental results arising from each of the experimental methods commonly used in the investigation of physics and astronomy phenomena.
    d) Be able to use basic computational methods to analyze experimental data using shared physics and astronomy datasets or new experimental lab data.

    e) Be able to use basic computational methods, or write a computer program, to develop models or simulations of physical systems.

5. Read and comprehend original scientific literature.
    a) Be able to summarize a research paper including its theoretical approach, hypothesis, experimental design, and interpretation of results.
    b) Be able to use science literature databases to effectively search for pertinent articles related to a research lab or project.
6. The ability to effectively communicate scientific knowledge, experimental results, and analyses in both oral and written formats.
    a) Be able to write a lab report that clearly presents hypothesis, methods, experimental results, and conclusions.
    b) Be able to write a research paper that clearly presents ideas in prose, tabular, and graphical formats, and correctly uses technical terminology.
    c) Be able to make a well-organized oral presentation on topics in physics and astronomy.

UR Physics and Astronomy Core and Restricted Elective Courses by UG Degree

Table 1. Physics Department BS and BA Degrees: Courses (Required Courses = X)

Degree / Course #	BS PHYSICS	BS PHYSICS AND ASTRONOMY	BA PHYSICS	BA PHYSICS AND ASTRONOMY
PHY 217 E&M I	X	X	X	
PHY 218 E&M II	X	X	Optional	
PHY 227 Thermo & Statistical Mech	X	X	Optional	
PHY 235W Classical Mech	X	X	X	
PHY 237 Quantum Mech	X	X	X	
PHY 246 Quantum Theory	X	X	Optional	
PHY 243W Adv. Exp. Techniques I OR PHY 244W OR PHY 245W	X	X	Optional	
MTH 281 Fourier Series	X	X		
COMPUTATION COURSE (PHY 256 OR OTHER)	X	X		
ASTRONOMY OR NAT. SCI. COURSE	X			
PHY RESTRICTED ELECTIVES ??	X		1 200-300 PHY course	
AST 231 Relativity & Gravitation		X		Optional
AST 232 Milky Way Galaxy		X		Optional
AST 241 Stellar Astrophysics		X		Optional
AST 242 Galaxies & Cosmology		X		Optional
AST 393 Senior Project		X		
AST RESTRICTED ELECTIVES		X		3 200-300 AST courses; 2 200 PHY, MTH, science or eng courses

B. Alignment of Program Learning Objectives and Core Course Curriculum

Table 2. Physics and Astronomy Degrees: Program Learning Objectives (LO) Addressed in Each Course (P=LO is a primary focus of student assessments in course)

Learning Objective / Course #	1 apply core knowledge	2 apply math	3 scientific method	4 experimental skills and computation	5 comprehend scientific literature	6 communication
PHY 217 E&M I	P	P				
PHY 218 E&M II	P	P				
PHY 227 Thermo & Stats Mech	P	P				
PHY 235W Classical Mech	P	P				P
PHY 237 Quantum Mech	P	P				
PHY 246 Quantum Theory	P	P				
PHY 243W Adv. Exp. Techniques I OR PHY 244W OR PHY 245W	P	P	P	P	P	P
COMPUTATION COURSE (PHY 256 OR OTHER)				P		
ASTRONOMY OR NAT. SCI. COURSE						
MTH 282 Intro. Complex Var. OR OPT 287		P				
PHY RESTRICTED						

ELECTIVES						
AST 231 Relativity & Gravitation	P	P				
AST 232 Milky Way Galaxy	P	P				
AST 241 Stellar Astrophysics	P	P				
AST 242 Galaxies & Cosmology	P	P				
AST 393 Senior Project	P	P	P	P	P	P
AST RESTRICTED ELECTIVES						

C. Physics and Physics and Astronomy Program Assessment Plan (frequency, responsible for implementation)

Direct methods

- Post-graduation placement in physics or related discipline graduate school programs. (annual)
- -Student scores on Physics GRE (annual, undergraduate program faculty and staff)
- Student scores on General GRE – (annual)
- Awards and Scholarships received by students (annual, undergraduate program faculty and staff)

Indirect methods

- High level of ability self-assessment for program learning outcomes in senior survey (annual) and alumni surveys (every 4 years)

Sample Lab Course Syllabi- Physics Labs 243, 244, 245

Course Name: PHY 243W

Advanced Experimental Techniques I
Course Semester: Fall
Course Credit Hours: 4
Course Prerequisite:
PHY 217, PHY 237 and MTH 164 (may be taken concurrently)
Course Description:

Students work in pairs and each team is expected to perform three or four experiments from a variety of available setups such as Berry's phase with light, Universal chaos, lifetime of cosmic ray muons, optical pumping, electron diffraction's, etc. This is a hands-on laboratory with most experiments under computer control. This course can be used towards satisfying part of the upper-level writing requirement.

Course Homepage:
http://www.pas.rochester.edu/~advlab/

Course Name: PHY 244W
Advanced Experimental Techniques II
Course Semester: Fall
Course Credit Hours: 4
Course Prerequisite:
PHY 217, PHY 237 and MTH 164 (may be taken concurrently).
Course Description:

This course is a continuation of PHY 243W with greater emphasis on independent research and construction of more complicated instrumentation. Students work in pairs and each team is expected to do three or four experiments from a variety of available setups. This course can be used to satisfying part of the upper-level writing requirement.

Course Name:PHY245W

Advanced Experimental Techniques II
Course Semester: Fall
Course Credit Hours: 4
Course Prerequisite:
PHY 217, PHY 237 and MTH 164 (may be taken concurrently).
Course Description:

This course is a continuation of PHY 243W with greater emphasis on independent research and construction of more complicated instrumentation. Students work in pairs and each team is expected to do three or four experiments from a variety of available setups. This course can be used to satisfying part of the upper-level writing requirement.