Sonoma State University
Department of Physics and Astronomy
Learning Objectives

All Physics and Astronomy courses are expected to incorporate critical thinking abilities, quantitative skills and communication skills as core objectives in their course material and course work. They will also be required to demonstrate knowledge, understanding and use of the principles of physics and/or astronomy. In addition, there are objectives specific to Physics and Astronomy discipline courses. Both our overall and course-specific learning objectives are listed below.

Overall Learning Objectives

Objectives Specific to Physics and Astronomy discipline courses

Students are required to demonstrate:

1) Knowledge, understanding and use of the principles of physics and/or astronomy
2) Ability to use reasoning and logic to define a problem in terms of principles of physics
3) Ability to use mathematics and computer applications to solve physics and/or astronomy problems
4) Ability to design and/or conduct experiments and/or observations using principles of physics and/or astronomy and physics or astronomical instrumentation
5) Ability to properly analyze and interpret data and experimental uncertainty in order to make meaningful comparisons between experimental measurements or observation and theory

General Skills for all Physics and Astronomy courses

Students are expected to acquire:

6) Critical Thinking Abilities
7) Quantitative Skills
8) Communication Skills

Since all courses are expected to incorporate these learning objectives, they are not indicated in the matrix below.

Aligning Physics Courses with Learning Objectives

Major Courses

Courses/ Objectives	P114	P116	P210A/B	P209A/B	P214	P216	P313	P313L	P314
1	X	X	X	X	X	X	X	X	X
2	X		X		X		X		X
3	X		X		X		X	X	X
4		X		X		X		X	
5		X		X		X		X	

Courses/ Objectives	P 320	P325	P340	P366	P381	P430
1	X	X	X	X	X	X
2	X	X	X		X	X
3	X	X	X		X	X
4				X		
5				X		

Courses/ Objectives	P445	P450	P460	P466	P475	P492	P493
1	X	X	X	X	X	X	X
2	X	X	X		X	X	X
3	X	X	X	X	X	X	X
4				X		X	X
5	X			X		X	X

Courses/ Objectives	P497	A331	A380	A482	A492	A497
1	X	X	X	X	X	X
2	X		X		X	X
3	X		X		X	X
4	X	X		X	X	X
5	X	X		X	X	X

General Education Courses:x

Courses/ Objectives	P100	P102	P300	P342	A100	A231	A303	A305	A350
1	X	X	X	X	X	X	X	X	X
2		X	X	X		X	X	X	X
3		X				X			
4		X				X			
5									

1) Knowledge, understanding and use of the principles of physics and/or astronomy
2) Ability to use reasoning and logic to define a problem in terms of principles of physics
3) Ability to use mathematics and computer applications to solve physics and/or astronomy problems
4) Ability to design and/or conduct experiments and/or observations using principles of physics and/or astronomy and physics or astronomical instrumentation
5) Ability to properly analyze and interpret data and experimental uncertainty in order to make meaningful comparisons between experimental measurements or observation and theory
6) Critical Thinking Abilities – *All courses*
7) Quantitative Skills – *All courses*
8) Communication Skills – *All courses*

Individual Course Learning Objectives

Astronomy Courses

Astronomy 100:

- Students will learn the composition and nature of the universe, from our own solar system, to stars and stellar evolution, interstellar matter, galaxies, and clusters of galaxies. Students will explore historic astronomy, some fundamental physics such as Newton's laws and the nature of light, and discuss how astronomers discover the nature of the universe.

Astronomy 150:

- Describe the primary constituents of the Universe on scales from the solar system to observational frontiers, and place these constituents in context with the appropriate measures of space and time.
- Understand the fundamental methodology of science, including scientific inquiry, data gathering, analysis, generating hypotheses, and testing predictions.
- Connect observations of the Universe with the fundamental laws and principles that govern the behavior of the physical world.
- Learn the history of modern observational astronomy, with a key focus on how the interpretation of results from experimentation and observation guided the deployment of astronomy.
- Understand how the interactions between matter and energy give rise to observational data that allows us to learn about the distant universe without direct interaction.
- See how technological developments in both telescope and detector technology have opened new regions of the electromagnetic spectrum to inquiry.
- Explore the objects that comprise the solar system, with focus on chemical and atmospheric composition and how these interact to determine the changing nature of planetary environments.
- Understand the physics governing the life-cycle of stars, from initial gravitational collapse, through main-sequence nuclear fusion, and eventually to end-products such as black holes and neutron stars.
- Describe the types of galaxies that comprise the universe on large-scales, and how they develop and interact through known physical processes.
- Understand how we have made observations of the early universe that allow us to understand the evolutionary history of the universe, from big-bang to present day.

Astronomy 231:

- Students will learn introductory astronomical concepts by engaging in hands-on laboratories.

- Students will practice data-taking skills such as making measurements with specialized equipment and computer applications.
- Students will gain experience interpreting data through the use of mathematical tools such as tables, graphs, and equations.
- Students will practice communicating scientific results in the form of written lab reports.
- Students will gain experience working collaboratively as they share the responsibility of conducting experiments and writing up their results

Astronomy 303:

- Students will understand that science is a creative process of discovery -- with new knowledge built on observations, evidence, and logical reasoning – and will be able to describe evidence that supports major scientific understandings as well as lack of evidence for ideas that are not founded in science.
- Students will be able to describe the major factors that contribute to the long-term habitability of Earth, and characteristics and needs of life (including some examples of life in extreme environments and artificial life).
- Students will be able to describe evidence of the potential for life on other worlds in our solar system, as well as how the potential for life on Earth and other worlds has evolved and will continue to evolve.
- Students will understand and be able to describe the methods we use for learning about the potential habitability of worlds and the possibility of intelligent life in the Universe. These methods include different methods of space travel, and different ways of observing and gathering information about other worlds.

Astronomy 305:

- Students will be able to describe the major research questions and methodologies of the most recent developments in the field of astronomy
- Students will be able to describe the nature of high-energy phenomena in the universe.
- Students will be able to read, understand and analyze scientific ideas communicated in a variety of formats with a variety of intended audiences.
- Students will be able to communicate scientific ideas in a variety of formats.

Astronomy 331:

- Students will learn the methods and techniques of astronomical imaging. The course will offer a practical approach to using charged- coupled device (CCD) detectors and computer-controlled telescopes to obtain images of the moon, planets, stars, and nebulae. Topics include telescope control, planning observing programs, identifying astronomical objects, determining image sizes and exposure times, and image processing techniques.

Astronomy 380:

- Students will learn the structure and evolution of stars, including stellar interiors and atmospheres, nucleosynthesis and late stages of stellar evolution.

Astronomy 482:

Students will understand/be able to … (Skills course, so concepts are mostly actually things students will "do")

- How to operate telescopes, learning the interface software, the coordinate systems, and the major object catalogs.
- How to control imaging cameras, including selecting appropriate parameters to maximize signal to noise, understanding gain, linearity, saturation etc..
- How to operate a spectrograph and obtain well sampled, high quality spectra of stars.
- How to process astronomical data to recover important physical quantities: luminosity, astrometry, color, distance, spectral energy distribution, age, etc.
- Prepare and curate a system of electronic logging to document work before, at, and after the telescope.
- How to read and comprehend the existing literature in the discipline.
- Present scientific results through written and verbal presentations, adhering to the standards of the field.

Physics Courses

Physics 100:

- Students will reexamine and redefine common science concepts related with mechanics.
- Students will apply the defined physics concepts and principles to their daily life examples.
- Students will practice thinking in a logical process, which is essential in science.
- Students will develop cognitive understanding of science concepts through in-class demonstrations and exercises.
- Students will discuss in pier groups to develop their cooperative skills and reinforce understanding of concepts.
- Physics 102:
- Upon completion of the course, the student should be able to:
- gain an understanding of some of the fundamental laws and principles governing the behavior of the physical world
- become familiar with the scientific method and how it can be applied to the solution of problems
- associate terms with the corresponding definitions and identify significant physical variables in given situations
- generalize the given application of physical principles to similar but novel situations
- describe physical relationships in the environment and identify appropriate applications
- discuss physical theories and their implications for humans and the Universe
- operate standard laboratory equipment, make measurements and analyze data
- write simple laboratory reports

Physics 114/ 116**:**

- Develop knowledge of scientific theories, concepts, and data about living and non-living systems.

- Understand how the scientific method is used to develop scientific principles and interpret evidence.
- Appreciate the value systems and ethics associated with scientific inquiry, and the potential limits of scientific endeavors.
- Demonstrate understanding of the scientific method through laboratory exercises.
- Read and understand mathematical arguments and data, and use mathematics effectively to analyze and solve problems that arise in ordinary and professional life.
- Gain an understanding of the fundamental laws and principles governing the behavior of the physical world.
- Understand the physical world through interpretation of results from experimentation and/or observation.
- Learn that there are interactions between matter and energy and use this knowledge to understand physical, chemical, or geological phenomena.
- Develop a basic understanding of physical matter and the scientific method so that they can apply this understanding to more complex systems.
- Operate standard laboratory equipment;
- Analyze laboratory data;
- Write comprehensive laboratory reports.

Physics 209A :

- We hope to engage you in experiments chosen specifically so that can clarify and reinforce the concepts you will encounter in lecture. Through working and observing hands-on, these abstractions will gain in relevance to your daily lives.
- Basic experimentation skills are encouraged in using multiple tools for data acquisition. Analytic software takes the process one step further. Exposure to these unfamiliar tools will enhance your flexibility in unfamiliar work environments.
- Basic statistical theory will be used to analyze results. We hope that you will see that there is a difference between ideal concepts in physics that result in exact solutions, and the lab environment that will introduce inevitable errors. All experimental results contain different levels of precision and accuracy; you will learn how to express them statistically.
- Not least of the goals is the hope that you will develop collaborative skills in a lab environment. To succeed you will adapt and grow in ability with unfamiliar people. Together you must work out the best ways to approach experiments and find ways to contribute equally. Together you will design alternative approaches to new tasks. This will easily translate and enhance your skills into a working environment later in life.

Physics 209B:

- Reinforce physics concepts learned from lectures with hand-on experiments.
- Develop an ability to design and perform physics experiments and use scientific instrumentation.
- Practice analyzing and interpreting experimental data within the context of theory.
- Your goal is not to blindly following lab procedures, generate preliminary results, and leave.

- You are the main operator in this lab. You need to know what you are doing during each step of your action.
- Always try to obtain the best results. Don't be satisfied with a proper/expected result. Think about how you can make your measurements better.
- The group with the best results (in an acceptable time frame) will be rewarded bonus points.
- When you obtain data from your measurement, think about what the results imply and what could have been errors in your measurements. How could you fix the possible source of error? If you can obtain logical scientific reasoning for your errors/and results, you will be also rewarded bonus points.
- Your laboratory manual and instructor are only for your guidance. The given procedure in the manual is only an outline and you are encouraged to upgrade/ modify.

Physics 210A:

- Perform calculations of kinematics problems in 1 and multiple dimensions.
- Understand and work with vectors
- Apply Newton's Laws of motion to mathematically solve physical situations in both linear and rotational environments.
- Work with Newton's law of gravitation.
- Understand and use mathematically the conservation laws of energy, momentum and angular momentum.
- Learn the fundamentals of temperature, pressure, and fluid flow.

Physics 210 B

- Perform calculations using Coulomb's Law in 1 and 2 dimensions.
- Use vector arithmetic in doing electric force, electric field, magnetic force and magnetic field calculations.
- Perform elementary DC and AC electric circuit calculations with series and parallel resistors and capacitors.
- Perform calculations of magnetic field induction and use Lenz's law correctly.
- Perform calculations and understand image properties with plane, concave and convex mirrors.
- Perform calculations with light refraction and Snell's law.
- Do problems with light interference and the double-slit experiment.

Physics 214/216:

- Students will have an opportunity to think like a physicist, including: how to identify problems, how to examine the identified problems using mathematical descriptions and experiments, how to propose possible solutions, and how to 2. predict the outcome of their proposed solutions.
- Students will practice thinking in a logical process, which is essential in science.
- Students will develop a cognitive understanding of science concepts through in-class demonstrations and exercises.

- Students will discuss in peer groups to develop their cooperative skills and reinforce their understanding of concepts.
- Students will practice problem-solving skills and be able to apply mathematical methods using appropriate technology.
- Operate standard laboratory equipment;
- Analyze laboratory data;
- Write comprehensive laboratory reports.

Physics 300:

- Students demonstrate a thorough understanding of both the science of sound and the relationship to the aesthetics of music.
- Students demonstrate an in depth understanding of the science and historical evolution of a particular musical instrument or similar topic within the scope of the syllabus
- Students will continue to develop their writing and presentation skills. The professor and the student will mutually agree upon a topic as discussed in goal #2. The student will prepare a written paper and subsequently share their research work with the class through an oral presentation.
- Students will continue to build a mathematical competency to allow them to better cope with the sophisticated technology driven world in which they live.
- The professor has a personal goal to demystify science to the non-science oriented student and allow the student to better appreciate the both the science and artistry of music.

Physics 340:

- Students will learn the properties of light from geometric and physical optics perspectives. Topics include ray optics, refraction, diffraction, coherence, interference, and polarization. Students will learn and use Fermat's principle, Huygens' principle and Fourier optics.

Physics 342:

- Students will be introduced to familiar optical phenomena and technology.
- Students should realize that physics is not a subject for the math or science oriented people but a subject of nature.
- Students should understand and be able to demonstrate their understanding of basic principles and ideas introduced.
- Students will practice thinking in a logical process, which is essential in science.
- Students will discuss in pier groups to develop their cooperative skills and reinforce their understanding of concepts.

Physics 450:

- Students will learn the following topics: ideal gases, heat capacities, entropy, enthalpy, the laws of thermodynamics: Boltzmann, Bose and Fermi statistics; applications such as engines, refrigerators and blackbody radiation.

Physics 494:

- Students will learn about active research topics in physics and astronomy through public lectures presented by professional scientists.
- Students will learn important research and critical thinking skills by preparing for the talks through web-based research and reporting.