Learning Outcomes for Classical Mechanics (PHY 501)

Students who have completed this course should

- Have a deep understanding of Newton's laws,
- Be able to solve the Newton equations for simple configurations using various methods,
- Understand the foundations of chaotic motion.

Learning Outcomes for Methods of Mathematical Physics (PHY 503)

Students who have completed this course should

- Be familiar with the main mathematical methods used in physics.

Learning Outcomes for Electrodynamics (PHY 505)

Students who completed this course should

- Have a deep understanding of the theoretical foundations of electromagnetic phenomena,
- Be able to solve the Maxwell equations for simple configurations,
- Have a working knowledge of special relativity.

Learning Outcomes for Quantum Mechanics I (PHY 511)

Students who completed this course should

- Have a deep understanding of the mathematical foundations of quantum mechanics,
- Be able to solve the Schrödinger equation for simple configurations,
- Understand the effect of symmetries in quantum mechanics.

Learning Outcomes for Quantum Mechanics II (PHY 512)

Students who completed this course should

- Have a deep understanding of the mathematical foundations of quantum mechanics,

- Be able to solve the Schrödinger equation using various approximation methods,
- Have a basic understanding of relativistic effects in quantum mechanics.

Learning Outcomes Research Instruments (PHY 514)

Students who have completed this course should

- Have a basic understanding of research instruments used by faculty in the department,
- be able to explain research instruments in the style of a scientific paper.

Learning Outcomes for Methods of Experimental Research (PHY 515)

Students who have completed this course should

- Be able to perform basic experiments in physics,
- Be able to perform a statistical and systematic analysis of experimental data,
- Be able to write the results of an experiment in the style of a scientific paper.

Learning Outcomes for Astronomical Techniques (PHY 517)

Students who have completed this course should

- Be able to perform basic experiments in astronomy,
- Be able perform a statistical analysis of observed data,
- Be able to write a proposal to request observation time,
- be able to write down the results of an experiment in the style of a scientific paper.

Learning Outcomes for Applications of Synchrotron Radiation (PHY 518)

Students who have completed this course should

- Be familiar with the physics of synchrotron radiation,
- Be familiar with techniques used in applications of synchrotron radiation,

- Be able to write a proposal to request time on the Synchrotron Light Source.

Learning Outcomes for Stars (PHY 521)

Students who have completed this course should

- Understand the formation, evolution, death and classification of stars,
- Understand the physics of stars,including nuclear and neutrino processes, the emission, absorption and transport of radiation, and stellar atmospheres,
- Have an ability to interpret observations of stars including spectra and binary phenomena,
- Be able to make quantitative estimates of phenomena occurring in stars.

Learning Outcomes for Interstellar Medium (PHY 522)

Students who have completed this course should

- Understand radiative processes of the interstellar medium,
- Understand compositions, phases, dynamics, and evolution of the interstellar medium,
- Be able to make quantitative estimates of phenomena occurring in the interstellar medium.

Learning Outcomes for Galaxies (PHY 523)

Students who have completed this course should

- Understand the formation, evolution and classification of galaxies,
- Understand the physics of galaxies,
- Have a quantitative understanding of galaxies.

Learning Outcomes for Cosmology (PHY 524)

Students who completed this course should

- Have a deep understanding of the physics and evolution of the smooth, homogeneous Universe starting from the Big Bang,
- Understand the physics of perturbations about a smooth Universe, including their evolution with the Einstein and Boltzmann equations,

- Understand the observational consequences of these perturbations, including CMB anisotropies and the matter power spectrum.

Learning Outcomes for Statistical Mechanics (PHY 540)

Students who have completed this course should

- Have a deep understanding of physical statistics and its relation to information theory,
- Be able to solve statistical mechanics problems for simple non-interacting systems,
- Have a basic understanding of the phase transitions,
- Be able to use linear response theory and kinetic equation approach.

Learning Outcomes of Advanced Statistical Mechanics (PHY541)

Students who have completed this course should

- Have a deep understanding of universality in second order phase transitions,
- Be able to perform Monte-Carlo simulations of simple systems,
- Be familiar with exactly solvable models.

Learning Outcomes of Superconducting RF for High-Energy Accelerators (PHY543)

Students who have completed this course should

- Understand the physics underlying RF superconductivity and its application to accelerators,
- Understand the advantages and limitations of SRF technology.
- Should be able evaluate and solve problems related to application of superconducting cavities to accelerators, as well actively participate in engineering of SRF systems for various accelerators.

Learning Outcomes for Nuclear Physics I (PHY552)

Students who have completed this course should

- Understand the relation between the standard model and QCD,

- Understand the importance of models in describing the properties of nuclei and nuclear collisions,
- Be able to make quantitative estimates of phenomena involving nuclei.

Learning Outcomes for Nuclear Physics II (PHY552)

Students who have completed this course should

- Have a phenomenological understanding of strong interactions starting from QCD,
- Be familiar with many-body physics,
- Be able to make quantitative estimates for nuclear phenomena in relation to the underlying microscopic theory.

Fundamentals of Accelerator Physics (PHY554)

Students who have completed this course should

- Understand how various types of accelerators work and understand differences between them,
- Have a general understanding of transverse and longitudinal beam dynamics in accelerators,
- Have a general understanding of accelerating structures,
- Understand major applications of accelerators and the recent new concepts.

Learning Outcomes for Solid State I (PHY555)

Students who have completed this course should

- Be familiar with the basic phenomena in solid state physics,
- Understand the models that describe these phenomena,
- Be able to make quantitative estimates for phenomena in solid state physics.

Learning Outcomes for Solid State II (PHY556)

Students who have completed this course

- Have a working knowledge of diagrammatic methods and Green's functions in many body physics,

- Understand the renormalization group in the context of condensed matter theory,
- Understand the universal features of Fermi liquids,
- Know why topological field theories arise as effective descriptions of some condensed matter systems.

Learning Outcomes for Elementary Particles (PHY557)

Students who completed this course should

- Have a basic understanding of the Standard Model and of

  theoretical methods employed in particle physics,
- Be familiar with main theoretical concepts and experimental techniques used in

  elementary particle physics,
- Be able to make quantitative estimates of phenomena in elementary particle

Learning Outcomes for Physical Biology (PHY558)

Students who completed this course should

- Have a deep understanding of the physics of biological phenomena,
- Be able to explain the models that describe these phenomena,
- Be able to make quantitative estimates for these phenomena.

Learning Outcomes for Biological Dynamics and Networks (PHY559)

Students who completed this course should

- Have a deep understanding of non-equilibrium phenomena in physical biology,
- Be able to work with models that describe these phenomena,
- Be able to make quantitative estimates for these phenomena.

Learning Outcomes for Biology for Physical Scientists (PHY561)

Students who completed this course should

- Be familiar with the basic chemical mechanisms in biology,
- Be familiar with the biology of diseases.

Learning Outcomes for Quantum Electronics I (PHY565)

Students who completed this course should

- Have a deep understanding of phenomena in atomic and molecular physics,
- Be able to describe these phenomena based on quantum mechanics and electrodynamics,
- Be able to make quantitative estimates for these phenomena.

Learning Outcomes for Quantum Electronics II (PHY566)

Students who completed this course should

- Have a deep understanding of phenomena in atomic and molecular physics of current interest,
- Be able to numerically solve the Schrödinger equation that describes these phenomena,
- Be able explain the basic scales that occur in these phenomena.

Learning Outcomes for Special Research Projects (PHY580)

Students who completed this course should

- Have a taste of what it means to do independent research.

Learning Outcomes for Optics Rotation (PHY582)

Students who completed this course should

- Be familiar with the research that takes place in several areas atomic and molecular physics.
- Be able to perform the basics tasks for research in these areas.

Learning Outcomes for Lab Rotation in Physical Biology (PHY584)

Students who completed this course should

- Be familiar with the research that takes place in several areas of physical biology,
- Be able to perform the basics tasks for research in these areas.

Learning Outcomes for Special Study (PHY585)

Students who completed this course should

- Understand a topic in physics chosen in agreement with the advisor.

Learning Outcomes for Master's Degree Thesis Research (PHY595)

Students who completed this course should

- Have made progress with research leading to a Master thesis.

Learning Outcomes for Optics Rotation (PHY582)

Students who completed this course should

- Be familiar with the research that takes place in several areas atomic and molecular physics.
- Be able to perform the basics tasks for research in these areas.

Learning Outcomes for Graduate Seminar (PHY598)

Students who completed this course should

- Be able to give a talk on phenomena in atomic and solid state physics without understanding the background material,
- Be able compose slides for this talk,
- Be able to critique the talks of other students.

Learning Outcomes for Graduate Seminar (PHY599)

Students who completed this course should

- Be able to give a talk on phenomena in Astronomy, Particle Physics and Nuclear Physics without understanding the background material,
- Be able compose slides for this talk,

- Be able to critique the talks of other students.

Learning Outcomes for Practicum in Teaching (PHY600)

Students who completed this course should

- Be able to teach a laboratory class for introductory physics,
- Be able for grade homework and exams of physics courses.

Learning Outcomes for Quantum Field Theory I (PHY610)

Students who completed this course should

- Understand the theoretical developments that led to and underly the contemporary Standard Model of fundamental particles and forces,
- Have passed the threshold of advanced study and research in areas that use quantum field theory, including particle physics, condensed matter physics and string theory.

Learning Outcomes for Quantum Field Theory II (PHY611)

Students who completed this course should

- Understand the theoretical developments that led to and underly the contemporary Standard Model of fundamental particles and forces,
- Have passed the threshold of advanced study and research in areas that use quantum field theory, including particle physics, condensed matter physics and string theory.

Learning Outcomes for Theoretical Particle Physics (PHY612)

Students who completed this course

- Should gain a comprehensive working knowledge of the Standard Model of particle properties and interactions at an advanced level,
- Should understand quantitatively the extensions of the original Standard Model to explain nonzero neutrino masses and lepton mixing, including experimental results and theoretical implications,

- Should know about the questions that the Standard Model does not answer or explain, current ideas on possible physics beyond the Standard Model, and current constraints from searches for new physics.

Learning Outcomes for General Relativity (PHY620)

Students who completed this course should

- Should have a deep understanding of the Einstein equations and their underlying mathematical structure
- Should understand the Lagrangian formulation of General Relativity,
- Should be able to derive testable physical consequences of General Relativity in various solutions of Einstein's equations,
- Should understand phenomena of various black holes and their basic thermodynamic properties,
- Should have an understanding of cosmological solutions of General relativity.

Learning Outcomes for Advanced Quantum Field Theory (PHY621)

Students who completed this course should

- Have a deep understanding of the mathematical foundation nonperturbative structures in field theory,
- Be familiar with the limiting procedure of quantum field theory,
- Be able to perform simple calculations for these phenomena.

Learning Outcomes for String Theory I (PHY622)

Students who completed this course should

- Be familiar with the relativistic description of strings,
- Be familiar with the quantization of strings,
- Be able to perform algebraic manipulations with the underlying mathematical formalism.

Learning Outcomes for String Theory II (PHY623)

Students who completed this course should

- Be familiar with advanced concepts in string theory as well as the underlying mathematical formalism.
- Understand the relation between quantum field theory and string theory.
- be prepared to work on current problems in string theory.

Learning Outcomes for Advanced Graduate Seminar (PHY655)

Students who completed this course should

- Be able to fully grasp all details of a topic of current interest in theoretical physics,
- Be able to give a specialized lecture on current topic in theoretical physics,
- Have an overview of current research in theoretical physics.

Learning Outcomes for Astronomy Journal Club (PHY664)

Students who completed this course should

- Be able to explain an journal article on a topic in astronomy,
- Be able to critique the talk of other students,
- Have an overview of current research in the field.

Learning Outcomes for Journal club in Physical Biology (PHY665)

Students who completed this course should

- Be able to explain an journal article on a topic in physical biology,
- Be able to critique the talk of other students,
- Have an overview of current research in the field.

Learning Outcomes for Cool Stars (PHY666)

Students who completed this course should

- Be familiar with current research on Cool Stars.

Learning Outcomes for Seminar in Astronomy (PHY668)

Students who completed this course should

- Be familiar with current research in Astronomy.

Learning Outcomes for Nuclear Astrophysics Seminar (PHY669)

Students who completed this course should

- Be familiar with current research in Nuclear Astrophysics.

Learning Outcomes for Seminar in Theoretical Physics (PHY670)

Students who completed this course should

- Be familiar with current research in Theoretical Physics.

Learning Outcomes for Seminar in Elementary Particle Physics (PHY672)

Students who completed this course should

- Be familiar with current research in Elementary Particle Physics.

Learning Outcomes for Seminar in Cosmology (PHY673)

Students who completed this course should

- Be familiar with current research in Cosmology.

Learning Outcomes for Seminar in Nuclear Physics (PHY674)

Students who completed this course should

- Be familiar with current research in Nuclear Physics.

Learning Outcomes for Seminar in Solid-State Physics (PHY676)

Students who completed this course should

- Be familiar with current research in Solid-State Physics.

Learning Outcomes for Atomic, Molecular and Optical Physics Seminar (PHY678)

Students who completed this course should

- Be familiar with current research in Atomic, Molecular and Optical Physics.

Learning Outcomes for Special Topics in Theoretical Physics (PHY680)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Theoretical Physics.

Learning Outcomes for Special Topics in Statistical Mechanics (PHY681)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Statistical Mechanics.

Learning Outcomes for Special Topics in Solid-State Physics (PHY682)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Solid-State Physics.

Learning Outcomes for Special Topics in Astronomy (PHY683)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Astronomy.

Learning Outcomes for Special Topics in Nuclear Physics (PHY684)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Nuclear Physics.

Learning Outcomes for Special Topics in Mathematical Physics (PHY685)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Mathematical Physics.

Learning Outcomes for Special Topics in Elementary Particle Physics (PHY686)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Elementary Particle Physics.

Learning Outcomes for Topics in Biological Physics (PHY687)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Biological Physics.

Learning Outcomes for Topics in Astrophysics (PHY688)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Astrophysics.

Learning Outcomes for Topics in Atomic and Optical Physics (PHY690)

Students who completed this course should

- Be familiar with an advanced topic of current interest in Atomic and Optical Physics.

Learning Outcomes for the Colloquium (PHY698)

Students who completed this course should

- Be familiar with topics of current interest in Physics.

Dissertation Research on Campus (PHY699)

Students who completed this course should

- Have made progress on a research project leading to a doctoral dissertation,
- Be familiar with issues related to the ethics of doing research.

Dissertation Research on off Campus - Domestic (PHY700)

Students who completed this course should

- Have made progress on a research project leading to a doctoral dissertation,
- Be familiar with issues related to the ethics of doing research.

Dissertation Research on off Campus - International(PHY701)

Students who completed this course should

- Have made progress on a research project leading to a doctoral dissertation,
- Be familiar with issues related to the ethics of doing research.

Summer Research (PHY800)

Students who completed this course should

- Have made progress on a research project.