Learning outcomes - Undergraduate Core courses

All outcomes start with the phrase: "**At the end of this course, students will be able to:**". And then there are bulleted points after that. So you should copy that format into your syllabus.

Phys 102

- write qualitatively correct sentences that indicate an understanding of kinematics, forces, energies, momenta, torque, simple harmonic motion, buoyancy, etc.
- draw qualitatively correct free body diagrams and then apply Newton's Law to those situations.
- determine which conservation principle(s) apply in a particular problem and then correctly apply them to determine the final solution.
- compare and contrast traveling waves and standing waves.
- use the laws of thermodynamics to determine the efficiency of an engine.

PHYS 103

- use electric forces and electric potentials to determine the motion of electric charges.
- calculate magnetic forces on moving charges due to various distributions of electric current.
- qualitatively and quantitatively determine what happens in DC circuits containing resistors, capacitors and inductors.
- determine image locations for mirrors and lenses using both ray diagrams and calculations.
- describe experiments that illustrate the particle/wave duality of light.

PHYS 105A

- use correct syntax for variables, loops, arrays, strings, etc. in python and/or C/C++.
- debug code to find their mistakes.
- write working code for basic statistical analysis.
- produce plots that effectively illustrate the results of their work.
- write working code that performs a mathematical function such as integration or solving a first order differential equation.

PHYS 139

• write lab reports which document the goals, procedures, and outcomes of the experiment in sufficient detail for the reader to understand and reproduce their results.
• create a linear plot for data naturally described by a power law or an exponential function and be able to extract physical information from the slope and intercept of that plot.
• measure the speed of a moving object (such as a car) just by using their cell phone.
• measure lengths less than 1 mm using a Vernier caliper.
• design lab experiments to measure various physical quantities.
• use Microsoft Excel to analyze data.

PHYS 140/141

• write qualitatively correct sentences that indicate an understanding of kinematics, forces, energies, momenta, torque, simple harmonic motion, buoyancy, etc.
• draw qualitatively correct free body diagrams and then correctly apply Newton's Laws for translation and rotation in various physical situations.
• determine which conservation principle(s) apply in a particular problem and then correctly apply them.
• calculate the time evolution of systems undergoing simple harmonic motion.
• determine the orbital periods, energies and angular momenta for orbiting objects.
• 141 only: write lab reports which document the goals, procedures, and outcomes of the experiment in sufficient detail for the reader to understand and reproduce their results.

PHYS 142/143

• compare and contrast traveling waves and standing waves and be able to mathematically describe them.
• use the laws of thermodynamics to determine the efficiency of an engine.
• determine image locations for mirrors and lenses using both ray diagrams and calculations.
• describe qualitatively what leads to double slit interference and single slit diffraction and be able to perform the corresponding calculations to determine minima/maxima locations.

• 142 only: measure the focal length of both concave and convex lenses.

PHYS 161H

• write qualitatively correct sentences that indicate an understanding of kinematics, forces, energies, momenta, torque, simple harmonic motion, buoyancy, etc.
• draw qualitatively correct free body diagrams and then correctly apply Newton's Laws for translation and rotation in various physical situations.
• determine which conservation principle(s) apply in a particular problem and then correctly apply them.
• calculate the time evolution of systems undergoing simple harmonic motion.
• determine the orbital periods, energies and angular momenta of orbiting objects.
• design lab experiments to measure various physical quantities.

PHYS 162H

• compare and contrast traveling waves and standing waves and be able to mathematically describe them.
• use the laws of thermodynamics to determine the efficiency of an engine.
• determine entropy changes for various processes.
• determine image locations for mirrors and lenses using both ray diagrams and calculations.
• describe qualitatively what leads to double slit interference and single slit diffraction and be able to perform the corresponding calculations to determine minima/maxima locations.
• measure the focal length of both concave and convex lenses.

PHYS 181

• write lab reports which document the goals, procedures, and outcomes of the experiment in sufficient detail for the reader to understand and reproduce their results.
• create a linear plot for data naturally described by a power law or an exponential function and be able to extract physical information from the slope and intercept of that plot.
• determine the acceleration due to gravity using a cell phone and a string.
• measure lengths less than 1 mm using a Vernier caliper.

• use Microsoft Excel to analyze data.

PHYS 182

• use a multimeter to measure voltage, current, and resistance.
• build an electric motor using household items such as wires, a small magnet, some paper and a flashlight battery.
• analyze time-dependent electrical signals using an oscilloscope.
• measure the focal length of convex and concave lenses.
• build a refracting telescope.

PHYS 204

• calculate basic probabilities and be able to determine averages and standard deviations from probability distributions.
• determine the eigenvalues and eigenvectors of a matrix and physically interpret the results.
• calculate Fourier series and Fourier transforms for time-dependent signals and/or spatially-dependent distributions.
• calculate gradients, curls and divergences in Cartesian and non-Cartesian coordinate systems and interpret what they mean.
• use separation of variables to solve partial differential equations.

PHYS 239

• build circuits whose circuit elements are in series and/or parallel.
• use a digital multimeter to measure voltage, current, and resistance.
• build a radio that can receive AM signals.
• build an electric motor using household items such as wires, a small magnet, some paper and a flashlight battery.
• analyze time-dependent electrical signals using an oscilloscope.

PHYS 240/241

• analyze the motion of electric charges under the influence of electric and magnetic fields.
• use Faraday's Law to determine the magnitude and direction of any "induced" currents.

• qualitatively and quantitatively determine what happens in AC and DC circuits containing resistors, capacitors and inductors.
• use Maxwell's equations to determine electric and magnetic fields from a variety of charge and current distributions.
• 241 only: perform measurements on circuits with the most common measurement instruments.

PHYS 261H

• calculate electric fields and electric potentials due to continuous charge distributions.
• use Faraday's Law to determine the magnitude and direction of any "induced" currents.
• qualitatively and quantitatively determine what happens in AC and DC circuits containing resistors, capacitors and inductors.
• use Maxwell's equations to determine electric and magnetic fields from a variety of charge and current distributions.
• design and perform measurements on circuits with the most common measurement instruments.

PHYS 263H

• use the Lorentz transformation to transform frames and correctly calculate positions, times, velocities, energy, momenta, etc. in the new frame.
• qualitatively describe the historical experiments that led to the development of quantum theory.
• explain the consequences of the Heisenberg uncertainty principle and be able to estimate minimum uncertainties in various physical situations.
• solve the Schrödinger equation for "simple" one-dimensional potentials.
• describe the basic features of the quantum mechanical solutions for the hydrogen atom.

PHYS 305

• write working code in C++ and/or Python.
• write code to solve systems of linear equations.
• write code to perform numerical differentiation and integration.
• write code to solve ODEs and PDEs.

• write code to perform statistical analyses.

PHYS 321

• solve problems requiring Newton's 2nd Law where the force depends upon time, position or velocity.
• determine the equation(s) of motion using a Lagrangian and be able to explain what all the terms in the equation(s) represent physically.
• solve for the trajectory of a particle's "orbit" in a spherically symmetric potential.
• solve for and describe the motion of a body under the influence of ficticious forces.
• determine the Hamiltonian and be able to explain why it is/is not constant and whether or not it is equal to the particle's energy.
• determine and interpret the inertia tensor.

PHYS 331

• determine electric fields using a variety of methods and be able to explain why a particular method is preferred in a particular situation.
• determine magnetic fields using a variety of methods and be able to explain why a particular method is preferred in a particular situation.
• solve Maxwell equations in a vacuum and in linear, homogeneous and isotropic materials.
• solve Laplace's equation using the method of images and using separation of variables.

PHYS 332

• calculate reflection and transmission probabilities for electromagnetic waves incident upon a boundary.
• use transformation laws to determine the electromagnetic fields in different reference frames.
• perform calculations connected to conservation of energy, linear momentum and angular momentum for electromagnetic fields and matter.
• use the scalar potential and the vector potential in different gauges.

PHYS 371

• solve the Schrödinger Equation for a variety of one-dimensional potentials.
• use the wavefunction for any potential to determine measureable properties.
• evaluate the commutator of two operators and be able to explain the observational consequences of the result.
• represent operators as matrices and solve corresponding eigenvalue problems.
• solve the Schrödinger equation for central potentials.
• use ladder operators to solve the harmonic oscillator and the angular momentum problem.

PHYS 381

• record accurate data from their experimental work.
• analyze and interpret their data and reach appropriate conclusions.
• write lab reports which document the goals, procedures, and outcomes of the experiment in sufficient detail for the reader to understand and reproduce their results.
• give a verbal presentation that effectively summarizes their procedure and results.

PHYS 382

• conduct experiments using sophisticated equipment and accurately record their data.
• critically analyze their experimental errors and how they impact their conclusions.
• design their own experiment(s) to address real-world questions.
• give an effective verbal presentation summarizing the experiment they designed.

PHYS 426

• use the enthalpy, the Gibbs free energy and the Helmholtz free energy (when appropriate) to analyze various physical systems.
• calculate and qualitatively explain the temperature variation of the heat capacity and the entropy in a 2-state system.
• distinguish the statistical ensembles (micro-canonical, canonical, and grand canonical) and explain the experimental conditions for which each one applies.

• use the partition function to determine macroscopic thermodynamic properties for various systems.
• calculate various thermodynamic quantities for Fermi, Bose and photon gases.

PHYS 472

• perform calculations using Dirac notation.
• correctly perform the summation of angular momenta.
• use time-independent and time-dependent perturbation theory to solve appropriate problems with small interaction terms in the Hamiltonian.
• write wavefunctions with correct symmetry properties for fermions and bosons in ground states and excited states.
• use variational and/or WKB methods to approximate eigenvalues.
• use the adiabatic approximation to calculate the time evolution of a state