LEARNING OUTCOMES ASSESSMENT PLAN

UMBC Department of Physics, Bachelors program (revised February 2015)

I. Desired Learning Outcomes

The UMBC Department of Physics aspires to instill in our undergraduate students the knowledge, skills, values and vision to prepare them for graduate school and successful careers in physics and related fields and for a lifetime of continued learning.

Specific Learning Outcomes for bachelor's degree graduates of the Department of Physics:

1. A thorough knowledge of the basic fields of physics, such as mechanics, electricity and magnetism, thermal and statistical physics, and quantum mechanics.

2. The ability to formulate physical problems in the language of mathematics and to use both mathematical and computational skills to solve physical problems.

3. The ability to communicate scientific information effectively, both verbally and in writing.

4. Demonstrated ability to design and carry out experiments using modern equipment and analyze and interpret experimental data.

II. Direct Learning Outcome Assessment Actions

1. Key Course Assessments. In order to facilitate the assessment of each of the desired learning outcomes of Section I, we focus on learning assessments in the following key Physics Department courses. These courses, together with their corresponding learning outcomes, are listed below.

<u>PHYS 220 Introduction to Computational Physics</u>

This course will be used to assess learning outcome 2 using the methods described below. By the end of the course, students should be able to:

1. Use a software package (e.g., Mathematica or Matlab) or high-level programming langrage (e.g., Python or IDL) to write modularized programs and plot simple figures, such as scatter plots, time series, histograms, and 2D contours.

2. Use Monte Carlo methods to simulate and understand random walk problems, such as photon transport in isotropic-scattering medium.

3. Write programs to solve physics problems involving ordinary differential equations, such as projectile motion with drag and nonlinear oscillations.

4. Write programs to solve physics problems involving partial differential equations, such as finding the electrostatic potential and simulating heat diffusion.

5. Demonstrate a good mastery of basic data analysis methods, such as linear regression, uncertainty analysis, null hypothesis testing, and Fourier analysis.

PHYS 303 Thermal and Statistical Physics

This course will be used to assess learning outcomes 1 and 2 using the methods described below. By the end of the course, students should be able to:

1. Derive the thermodynamics properties of a model system (e.g., two-state paramagnet, ideal gas) by determining its multiplicity

2. Derive the thermodynamics properties of a model system (e.g., paramagnet, ideal gas) using Boltzmann factors and the partition function

3. Calculate the entropy change during a thermodynamic process (e.g., heating under constant pressure or constant volume, phase change).

4. Determine relationships between state variables for a thermodynamic process (e.g. adiabatic or isothermal compression, Joule-Thomson expansion).

5. Determine the efficiency of a heat engine (e.g., Carnot cycle).

6. Apply the Fermi distribution and Bose-Einstein distributions to model problems (e.g., electrons in solids, heat capacity of solids, blackbody radiation).

PHYS 321 Intermediate Mechanics

This course will be used to assess learning outcomes 1 and 2 using the methods described below. By the end of the course, students should be able to:

1. Use Newton's laws to set up and solve a range of physical problems.

2. Exhibit an understanding of energy conservation, potential energy, conservative and central forces, conservation of momentum and angular momentum, and use it to solve a range of physical problems.

3. Set-up and solve problems related to driven and damped oscillations, along with coupled oscillators and normal modes of oscillation.

4. Use the Lagrange formalism to find and solve the equations of motion for mechanical systems.

5. Develop an understanding of rigid body rotational motion and use it to solve related problems.

6. Understand and solve problems related to the two-body central force problem.

7. Show an understanding of mechanics in non-inertial reference frames and use it to solve related problems

PHYS 330L Optics Laboratory.

This course will be used to assess learning outcomes 3 and 4 using the methods described below. By the end of the course, students should be able to:

1. Follow a general laboratory guide and develop specific strategies for accomplishing prescribed measurement goals using available lab materials and equipment.

2. Write a mature laboratory report which includes the most common elements and organization of scientific papers published in journals today.

3. Replicate the key experiments demonstrating the nature of light and optical systems, such as: measuring the speed of light, measuring the wavelength of a laser using a Michelson interferometer, measuring the thickness of an object using thin-film interference, characterizing single and double slits using a laser, and measuring Brewster's angle.

4. Demonstrate an understanding of the concepts behind modern optics technology, such as laser gyros, holographic films, and fiber optic cables.

PHYS 407 Electromagnetic Theory

This course will be used to assess learning outcomes 1 and 2 using the methods described below. By the end of the course, students should be able to:

1. Have a working understanding of vector analysis, of the physical meaning of differential operators such as the div and curl, and of related theorems such as the divergence, Gauss's and Stokes' theorems.

2. Solve problems in electrostatics that manifest an understanding of the divergence of electrostatic fields, the electric potential, and work and energy in electrostatics.

3. Demonstrate an ability to solve problems in electrostatics by solving Laplace's equation, and by using the method of images, or of separation of variables.

4. Understand electric fields in matter, through being able to solve problems involving the field of a polarized object, the electric displacement, and dielectrics.

5. Demonstrate an understanding of magnetostatics, through the ability to solve problems involving the Lorentz force and the Biot-Savart Law, as well as the divergence and curl of the magnetic field and vector potential of the magnetic field.

6. Understand magnetic fields in matter, through solving problems involving magnetization, the field of a magnetized object, the auxiliary field H, magnetic susceptibility and permeability and ferromagnetism.

7. Demonstrate an understanding of the electromotive force, the electromagnetic induction, and Maxwell's equations.

PHYS 424 Introduction to Quantum Mechanics.

This course will be used to assess learning outcomes 1 and 2 using the methods described below.
By the end of this course, the student should be able to:

1. Explain the breakdown of classical mechanics and the development of quantum mechanics.

2. Utilize the concept of the wavefunction (and quantum states and qubits) to describe quantum systems, with emphasis on using the statistical interpretation and predicting the outcomes of measurements.

3. Solve the Schrodinger equation for various 1D potentials.

4. Work with Dirac notation and the formalism of QM including the concepts of Hilbert space, operators, commutators, eigenfunctions and eigenvalues, and the uncertainty principle.

5. Perform 3D calculations in Quantum Mechanics, using the example of the Hydrogen atom, with emphasis on the concepts of angular momentum and spin.

6. Analyze systems of identical particles and the concepts of fermion and boson statistics.

The syllabi of the key courses will include the specific learning outcomes (goals). The assessments will be based on evaluating quantitatively the collective results of specific exam problems as well as homework, in-class observation, and other methods that relate to a particular learning outcome (e.g. by reporting the percentage of the class that showed a satisfactory understanding in an exam problem for a particular learning goal and by comparing, if applicable, to results of previous years). Every year, the instructors of the key courses should evaluate all the specific learning goals and provide to the assessment committee feedback on the learning outcomes, which will be used to suggest possible improvements as discussed in Section IV below.

III. Indirect Learning Outcome Assessment

A questionnaire for each key course will be filled by the students at the end of the semester. The questionnaire will list the learning goals asking the students to evaluate by grading in a scale from 1 to 5, with 5 been the highest grade, the degree to which each learning goal have been achieved. It will also allow students to provide suggestions for changes in the course.

IV. Using the Results of Assessments for Departmental Action

An annual faculty meeting will be devoted to (i) evaluating the data obtained through the learning outcome assessment actions discussed above and (ii) recommending the implementation of necessary changes in the curriculum or teaching methods. In anticipation of this meeting, the self-assessment committee will use the instructor's feedback on the learning outcome assessments described above, along with the end of the semester questionnaires, to determine if any changes in the curriculum or teaching methods would be desirable. These recommendations, along with any trends in the results and the overall learning outcome assessment, will be communicated to the faculty in advance of the faculty meeting.

This information will be reviewed by the entire physics faculty during the annual meeting. The faculty will debate the findings of the self-assessment committee, identify possible issues emerging from them and will suggest possible improvements to the curriculum or teaching methods. After approval by the faculty, the changes will be implemented by the undergraduate curriculum committee.

After the faculty meeting, the self-assessment committee will prepare a report that the Chair of the Department will use to inform the Dean of the College of Natural and Mathematical Sciences.