UMBC Department of Physics (revised May 2016) PhD program

I. Desired Learning Outcomes

The UMBC Department of Physics aspires to instill in our PhD students the knowledge, skills, values, and vision to prepare them for successful careers in physics and related fields and for becoming leaders in their fields.

Specific Learning Outcomes for PhD degree recipients of the Department of Physics:

1. An enhanced, graduate level understanding of the basic fields of physics, including mechanics, electromagnetism, statistical mechanics, and quantum mechanics.

2. A mastery of the concepts and the literature of the specific sub-discipline of physics in which their thesis is focused.

3. The ability to conduct original, independent research.

4. Enhanced oral and written communications skills as required for professional presentations and publications.

II. Direct Assessment of the Learning Objectives

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 graduate level Physics Department courses. These courses, together with their corresponding learning outcomes, are listed below.

<u>PHYS 601 Quantum Mechanics 1</u>

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

1. Utilize the postulates of quantum mechanics to describe quantum systems and determine their properties, including the results of measurements.

2. Use operator techniques to solve relevant problems.

3. Analyze the time dependence of quantum systems using the Heisenberg picture.

4. Use the properties of angular momentum and spin to describe quantum systems such as the hydrogen atom and an electron in a magnetic field.

5. Understand the interaction of the electromagnetic field with charged quantum-mechanical particles and solve related problems such as the rate of absorption and emission of light.

6. Use perturbation theory to find approximate solutions to more complex quantum-mechanical systems.

PHYS 602 Statistical Mechanics

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

1. Use the partition function with applications to ideal gas, liquid, and solid, a 2-state system, diatomic molecule, and non-ideal gas.

2. Apply chemical equilibrium considerations between particles in the gas phase, including ionization equilibrium.

3. Solve problems regarding Fermi-Dirac and Bose-Einstein distributions and apply to fully degenerate gases and thermodynamic quantities.

4. Explain phase transitions and phase equilibrium.

5. Analyze problems on paramagnetism and Curie's Law.

6. Solve problems on kinetic theory and transport processes and in particular on Maxwell-Boltzmann distribution, effusion, viscosity, thermal conduction, diffusion, and electrical conductivity.

7. Use photon statistics and blackbody radiation and derive and apply the quantum density of states

8· Connect statistical mechanics and probability theory, and derive thermodynamic quantities (energy, entropy, specific heat, Helmholtz free energy, Gibbs free energy) from statistical physics,
Maxwell's relations, conjugate variables in thermodynamics

9. Apply the equipartition theorem, the laws of thermodynamics, entropy, adiabatic processes, heat capacity, general undergraduate review.

PHYS 607 Electromagnetic Waves & Radiation

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

1. Use elementary concepts of the electric potential, the integral form of Gauss's Law, and electrostatic potential energy to treat electrostatics problems.

2. Solve boundary-value problems in electrostatics using method of images and Green's function techniques.

3. Solve boundary-value problems in electrostatics using separation of variables in cartesian, spherical, and cylindrical coordinates.

4. Use the concept of electric displacement to solve electrostatics problems in macroscopic media.

5. Use elementary concepts of Ampere's law, the vector potential, and magnetic scalar potential to treat magnetostatics problems.

6. Apply Poynting's theorem and conservation of momentum and energy to electromagnetic fields.

<u>PHYS 690 Professional Techniques in Physics.</u>

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

1. Make an oral presentation on a research topic in front of their cohort.

3. Write a thesis proposal.

4. Write a grant proposal.

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.

2. Assessment through the Thesis proposal (Candidacy exam) and PhD defense. The Candidacy exam tests the readiness of the student to perform original physics research, and is based on a paper submitted by the candidate. This paper, essentially a research proposal, is on the student's proposed thesis or a closely related topic. The candidacy examination includes general questions on the physics fundamental to the proposed thesis, in addition to specifics of the topic. The examination also tests the student's familiarity with basic literature in the field. The PhD defense and the submitted PhD dissertation are the last requirements for the Ph.D. These evaluate, beyond the points mentioned above, the autonomy and scientific maturity of the candidate. Both the candidacy exam and PhD defense provide an opportunity for assessment of the graduate level learning outcomes 2, 3, 4. The Candidacy exam and defense, together with candidacy papers and PhD dissertations will be evaluated by the corresponding faculty committees, who will provide feedback evaluating the desired learning outcomes 2, 3, 4 to the graduate committee. A brief form, developed by the PhD graduate committee will be filled out by the thesis advisor at the conclusion of those exams and submitted to the assessment committee for evaluation and potential actions.

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 /teaching/mentoring methods. In anticipation of this meeting, the assessment committee will:

1. Use the instructor's feedback on the learning outcome assessments described above, along with the end of the semester questionnaires to identify weak points in the student learning and produce recommendations in how to overcome these weaknesses.

2. Assimilate the input from the candidacy/final oral exam committees and communicate to the faculty possible weak points identified in the preparation of the PhD students as well as suggestions for overcoming them.

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/mentoring 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.