B.A. in Physics Education

A. Relationship to UMBC's Mission

UMBC aspires to be one of the nation's best public research universities of its size as it combines the traditions of the liberal arts academy, the creative intensity of the research university, and the social responsibility of the public university. This honors university in Maryland is dedicated to enriching the lives of citizens of the region and State through its links to K-12 education, its outreach to community organizations, its lectures and artistic exhibitions, and its cultural activities. UMBC has been among the K-16 leaders in Maryland working with public and private universities to produce more teachers for Maryland public schools, especially those identified as high-need, and is committed to continuing that leadership into the future by way of instruction, research, and service activities. This new Bachelor of Arts (B.A.) Program in Physics Education will allow UMBC to expand this mission while building upon the strengths of its research and teaching faculty in Physics to respond to the critical shortage of high school physics teachers in Maryland. As stated by UMBC President, Dr. Freeman A. Hrabowski, III,

"*Our mission is to produce outstanding teachers and offer resources and opportunities that will assist educators in enriching the lives of students from early childhood education through college.*"

The B.A. Program in Physics Education will allow UMBC to produce outstanding teachers who are highly qualified to teach high school physics. This new cohort of high school physics educators who receive their teaching certification from UMBC will help generations of high school students reach their full potential in understanding and mastering concepts in physics.

B. Characteristics of the Program

1. Need for program:

The state of Maryland suffers from a chronic shortage of secondary school science teachers. The shortage of physics-trained teachers is particularly acute, as can be seen from data contained the *Maryland Teacher Staffing Report 2005-2007*[1]. Table 2 of the report shows that, for the year 2005-2006, the number of available positions for physics teachers ("Projected New Hires") exceeds the number of candidates ("Projected Staffing Pool") by 48%. In other words, only 68% of the available physics teaching positions can be filled from the pool of new instructors available. The projections for 2006-2007 are even worse: only 56% of the available positions can be filled from the available pool of new teachers.

The report also includes data on the total number of physics education graduates from all of the 23 Maryland institutions that have approved Certification programs. The numbers are dismally low: 11 certified physics graduates in 2004-2005 and 14 in 2005-2006.

[1] Maryland State Department of Education, August 2005

2. Educational Objectives of the Program

The goal of UMBC's B.A. in Physics Education is to provide a curriculum that gives students a solid foundation in physics, complemented by the courses necessary for certification to teach physics at the secondary level, and to provide this in a structure that permits the student to complete the program in four years. In developing the curriculum, we adhered to one inflexible criterion: The selection of required science courses must be such that a person receiving the degree must be a fully-trained physicist, capable of working in a range of technical positions. The incorporation of education courses into this curriculum simply expands the career opportunities available for graduates of the program.

3. Curriculum Design and Learning Outcomes

In the past, the only route that students at UMBC had for becoming certified to teach physics at the secondary school level was to take a B.S. in physics (72 or 73 required credits), the Secondary Education Program offered by the Education Department (46 credits, including specified GFR courses), plus the remaining UMBC requirements for graduation (ENGL100, and several other General Foundation Requirement (GFR) courses not part of the Secondary Education Program, approximately 15 credits). The total number of credits required was 133-136. In addition, the required education internship conflicted with some of the physics course offerings, so a student interested in the program needed more than four years to complete the program.

The UMBC physics undergraduate curriculum committee, with input from the Education Department, and strong encouragement from the Dean and Provost's offices, has developed a Bachelor of Arts (B.A.) degree in physics, suitable for students interested in becoming secondary school teachers.

The B.A. program in Physics Education at UMBC possesses two features: a reduction in the number of credits required (both in physics and in totals needed for graduation), compared to our B.S. program, and one semester with minimum coursework, suitable for a teaching internship.

Our program is summarized in the table below, in which a four-year sequence of courses is laid out that provides a solid technical background for prospective high school teachers and also condenses the program into a four-year sequence that includes room for an education internship, while reducing the total number of credits required for graduation to about 125 credits.

Courses shown in red are those required to satisfy the physics component of the program; course in blue satisfy education and general University requirements.

Detailed descriptions of all courses listed, taken from the current UMBC catalog, are contained in Appendix I

Fall, First Year	Spring, First Year
MATH 151 **Calculus and Analytic Geometry I (MS). [4]**	**MATH 152** **Calculus and Analytic Geometry II. [4]**
CMSC 104 **Problem-Solving and Computer Programming. [3]**	**PHYS 121 Introductory Physics I (MS). [4]**
PHYS 105 **Ideas in Astronomy (MS). [3]** **or** **PHYS 106** **Introduction to Astrobiology (MS). [3]**	*Arts & Humanities Elective I [3]*
Language/Culture Elective I [3 or 4]	Language/Culture Elective II [3 or 4]
ENGL 100 Composition. [3]	*PSYC 100** *Introduction to Psychology (SS). [4]*
16 or 17 credits	**18 or 19 credits**
Fall, Second year	**Spring, Second year**
MATH 251 **Multivariable Calculus. [4]**	**MATH 221** **Introduction to Linear Algebra. [3]** **or** **MATH 225** **Introduction to Differential Equations. [3]**
PHYS 122 **Introductory Physics II (MS). [4]**	**PHYS 224** **Introductory Physics III. [3]**
PHYS 122L Introductory Physics Laboratory. [2]	**PHYS 324 Modern Physics. [3]**
Social Sciences Elective [3]	**BIOL 100** **Concepts of Biology. (MS) [4]**
Arts & Humanities Elective II [3]	*EDUC 310 Inquiry into Education. [3]*
16 credits	**16 credits**

* PSYC 100 also fulfills one Social Science (SS) GFR.

Fall, Third year	Spring, Third year
MATH 221 or MATH 225 (Whichever one NOT taken previously)	**PHYS 220 Introduction To Computational Physics [3]**
CHEM 101 Principles of Chemistry I. (MS) [4]	**PHYS 321 Intermediate Mechanics. [3]**
PHYS 330L Optics Laboratory. [3]	HIST 445** History of Science to 1700 (SS). [3] or HIST 446 ** History of Science Since 1700 (SS). [3]
EDUC 311 Psychological Foundations of Education. [3]	Language/Culture Elective III [3 or 4]
EDUC 412 Analysis of Teaching and Learning. [3]	*EDUC 410 Secondary Reading in the Content Areas: The Teaching of Reading in Secondary Schools. [3]*
16 credits	**15 or 16 credits**
Fall, Fourth year	**Spring, Fourth year**
PHYS 303 Thermal and Statistical Physics. [3]	*EDUC 456 Internship in Secondary Education. [10]*
Arts & Humanities Elective III [3]	*EDUC 457 Internship Seminar in Secondary Education [2]*
EDUC 427 Teaching Science in the Secondary School. [3]	
EDUC 388 Inclusion and Instruction. [3]	
EDUC 411 Secondary Reading in the Content Area – Part II. [3]	
15 credits	**12 credits**

** HIST 445 or 446 course also fulfills one Social Science (SS) GFR.
Two Physical Education courses are also required for all majors.

Synopsis of the Program

Overall number of credits required to complete the program: 124-127, depending on choice of Language/Culture electives

Required for Physics portion of the major: 60 credits (18 courses).

Required for Education portion of the major: 33 EDUC credits (9 courses) + PSYC 100 + HIST 445 or 446 (Histories of Science) + 2 AH courses (in fine arts/literature)

Required for any UMBC degree:

ENGL 100
Three Language and Culture GFRs (LC)
Three Arts and Humanities GFRs (AH)
Three Social Sciences GFRs (SS)

The program includes one semester each of chemistry, biology, astronomy, and a history of science (HIST 445 or 446), all of which are required by the National Science Teachers Association (NSTA) for secondary school certification. In addition, it has more than the minimum number of required credits (30) in the parent department in which the degree is to be awarded.

4. Student Audience Served by the Program

It is hoped that the availability of a B.A. program in Physics Education at UMBC will result in a production of approximately six graduates per year (about 24 program majors at any one time). While this number may seem small, it should be compared to the total state-wide production of 11-14 per year. An effort will be made to connect students in the proposed program to current or future financial support opportunities, especially those targeting future STEM educators. The Sherman Teacher Training Program and the Noyce Scholarship Program are two examples.

This simplified program may also make it easier for transfer students to enroll.

If you are interested in obtaining a B.A. in Physics Education, you should declare yourself as a major in this program (PHSE) as early in your UMBC experience as possible. This will allow us to offer you the best guidance on how to satisfy the requirements if you are "out of phase" with the standard course sequence. To declare a major, see Dr. Terrance Worchesky (worchesk@umbc.edu) in Room 217 of the Physics Building.

Appendix I
B.A. Program in Physics Education (PHSE)
Catalog Listings of Required Courses

PHYS 105
Ideas in Astronomy (MS). [3]
A general-interest course that covers observations, models and theories of the solar system, the stars and the galaxies. Students also will become acquainted with the history of astronomy. Prerequisite: Mathematical ability at the level of high school algebra, geometry and trigonometry.

PHYS 106
Introduction to Astrobiology (MS). [3]
The prospect of extraterrestrial life is considered in the context of the evolution of the Universe and of life on Earth. Course material is taken largely from astronomy, planetology, and biology although the multidisciplinary nature of this topic also requires basic information in chemistry, geology, and physics. While a broad overview is stressed, some topics will be treated in depth. While no formal experience in physics or astronomy is required, some familiarity with basic concepts in astronomy is helpful.

PHYS 121
Introductory Physics I (MS). [4]
This course emphasizes classical mechanics. Topics include force, particle kinematics and dynamics, equilibrium, Newton's laws of motion and gravitation, rotational motion, collisions, momentum, energy and conservation laws. Pre- or corequisite: MATH 151.

PHYS 122
Introductory Physics II (MS). [4]
This course emphasizes electricity, magnetism, heat and thermodynamics. Topics include Coulomb's law, Gauss's law, electric fields and electric potential, currents, simple circuits and Kirchhoff's laws, generation of magnetic fields by charges in motion, electromagnetic induction, magnetic materials, oscillatory circuits, temperature, heat and the laws of thermodynamics. Prerequisite: PHYS 121. Corequisite: MATH 152.

PHYS 122L
Introductory Physics Laboratory. [2]
Four hours of laboratory work a week. This is the laboratory course associated with the PHYS 121-122 sequence. Corequisite: PHYS 121.

PHYS 220
Introduction To Computational Physics [3]
An introduction to the computational software packages MATLAB and Mathematica, with particular emphasis on their use in solving physics problems and analyzing experiemental data taken in physics laboratory experiments. Applications to problems in mechanics, electromagnetics and wave propagation will be stressed. The course will end with a comparison of the strengths and limitations of these languages and a compiled language such as C.. Prerequisite: PHYS 122, MATH 152 and CMSC104 or CMSC201.

PHYS 224
Introductory Physics III. [3]
This course emphasizes vibrations, wave motion and optics. Topics include mathematical characterization of vibrations and waves, sound, superposition of standing waves, geometrical and physical optics, diffraction, interference and polarization of light. Prerequisite: PHYS 122. Corequisite: MATH 251.

PHYS 303
Thermal and Statistical Physics. [3]
Thermodynamic description of systems and statistical interpretation of thermo-dynamic quantities. The first and second laws of physics, temperature, entropy and thermodynamics, and their relationship to a statistical description of many-particle systems. Applications to magnetic systems, gases and liquids, and radiation

are discussed. Prerequisite: PHYS 224 and MATH 251.

PHYS 321
Intermediate Mechanics. [3]
An intermediate course in classical mechanics, including linear and nonlinear oscillations, dynamics of a system of particles, rigid body motion, planetary dynamics, accelerated reference frames. Lagrange's equations, normal coordinates and vibrating strings. Prerequisite: PHYS 224 , MATH 225 and MATH221.

PHYS 324
Modern Physics. [3]
The breakdown of classical physics, special relativity, quantum mechanics and atomic structure, solid-state, nuclear and elementary-particle physics. Co-requisite: PHYS 224.

PHYS 330L
Optics Laboratory. [3]
A laboratory course in optics and spectroscopy,
which includes experiments on reflection, refraction, diffraction, interference, polarization, atomic spectra, interferometers and the properties of lasers. Important physical constants such as the Rydberg constant and the speed of light are measured. Prerequisite: PHYS 224 and PHYS324. Corequisite: PHYS220

MATH 151
Calculus and Analytic Geometry I (MS). [4]
Topics of this course include limits, continuity, the rate of change, derivatives, differentiation formulas for algebraic and trigonometric functions, maxima and minima, integration and computation of areas. Areas and volumes of solids of revolution, applications. Note: Non-science-oriented students interested in calculus should consider MATH 155. Credit will not be given for both MATH151 and MATH 155. Prerequisite: MATH 150 or a qualifying score on the LRC calculus readiness placement test.

MATH 152
Calculus and Analytic Geometry II. [4]
Topics of this course include logarithmic and exponential functions, inverse functions, methods of integration, improper integrals, hyperbolic functions, sequences and infinite series, power series, Taylor series, applications, conic sections and polar coordinates. Prerequisites: MATH 151, 141 or 155B.

MATH 221
Introduction to Linear Algebra. [3]
Topics of this course include:linear equations, Gauss-Jordan reduction, matrices and determinants and their properties, vector spaces and subspaces, basis and dimension, linear transformations, kernel and range, eigenvalues and eigenvectors, and matrix diagonalization. Prerequisites: MATH 141, 151, 155 or 380.

MATH 225
Introduction to Differential Equations. [3]
Topics of this course include: solutions of first- and second-order linear differential equations, non-linear exact and separable equations, integrating factors, homogeneous equations, higher-order linear equations, initial and boundary value problems, solutions as functions of the equation parameters, Laplace transforms, power series solutions for Bessel and Legendre equations, difference equations and numerical methoids. Note: Recommended for science majors who need a basic knowledge of differential equations. Recommended: MATH 251. Prerequisite: MATH 142 or 152.

MATH 251
Multivariable Calculus. [4]
Topics of this course include: vectors, lines, planes and surfaces in three dimensions. Vector functions and their derivatives. Partial derivatives, gradients, directional derivatives, maxima, minima and Lagrange multipliers. Multiple integrals, area, volume, surface area, integration in different coordinate systems. Line integral, Green's theorem, Stokes' theorem and divergence theorem. Prerequisite: MATH 142 or 152.

BIOL 100
Concepts of Biology. (MS) [4]
A broad overview of contemporary biological science. Major areas include the biochemistry of energy transformation, cell structure and function, Mendelian molecular and population genetics, plant and animal physiology, evolution and ecology. Note: This course is designed for students who have taken one year of both high school biology and chemistry. BIOL 100 is a prerequisite for all biology courses at the 200-level or higher.

CHEM 101
Principles of Chemistry I. (MS) [4]
An introduction to chemistry for science majors and other students who require a thorough grounding in the principles of chemistry. Topics treated include the atomic-molecular theory of matter, states of matter, chemical nomenclature, energetics of chemical and physical processes, solutions, periodic properties, VSEPR, molecular orbital theory and chemistry of familiar elements. Note: Credit may not be obtained for both CHEM 101 and 123. Highly recommended: MATH 150. Prerequisites: Working knowledge of elementary algebra.

CMSC 104
Problem-Solving and Computer Programming. [3]
This courase is designed to prepare students for CMSC 201 by providing an introduction to computer programming that does not require prior programming experience. Students will be thaught the basic use of a programming environment and the basic elements of the C programming language (including loops, control statements and arrays). This course also introduces general computer science concepts such as operating systems, computer organization, computer architecture, data representation and memory usage. Note: This course does not fulfill any of the computer science major requirements. Students who have taken and received transfer credit for, or are taking concurrently any computer programming course in a high-level programming language will not receive credit for CMSC 104. The list of such programming courses includes, but is not limited to: CMSC 103, CMSC 106, CMSC 109, CMSC 201, CMSC 202 and sections of CMSC 291 that cover programming topics.

ENGL 100
Composition. [3]
Aworkshop in writing. The approaches to this course may vary in individual sections, but the aim is to help students write clearly and effectively. Note: This course, a university graduation requirement, must be passed with a grade of "C" or better. Students should plan to take this course in their first year.

HIST 445
History of Science to 1700 (SS). [3]
The story of the growth of scientific knowledge in the West. Topics include views of nature in traditional societies, Babylonian mathematics and astronomy, Egyptian medicine, the work of the ancient Greeks, medieval European and Arabic science, the Copernican revolution, the relationship between religion and science, and the Scientific Revolution. Prerequisite: HIST 100 and junior/senior status or permission of the instructor.

HIST 446
Historyof Science Since 1700 (SS). [3]
Asurvey of the history of Westernscience since the 18th century, emphasizing the development of various scientific fields within their institutional settings and the professionalization of the role of the scientist. Prerequisite: HIST 100, plus junior/senior status or permission of the instructor.

PSYC 100
Introduction to Psychology (SS). [4]
Introduction to the basic concepts of psychology. Emphases on interpretation of psychological data, biological bases of behavior, perception, learning, individual differences, personality, behavior pathology and social psychology.

EDUC 310
Inquiry into Education. [3]
This course introduces reflective practice as a foundation for the study of teaching and learning. Inquiry as a way of learning about schools, as well as about self as teacher and learner, will be explored through reflection on students' experiences with children and schooling. The macro and micro sociocultural contexts of education across diverse settings will be examined. Students will draw upon anthropological and sociological research methods to study the dynamics of classrooms, schools and communities. An in-school experience of twenty-four hours is required in this course.
Prerequisite: Permission of department.

EDUC 311
Psychological Foundations of Education. [3]
The psychology of school learning will be explored. There will be an overview of theories of teaching, learning and related research, including the philosophical assumptions underlying each within the context of class, culture and gender issues. Included are explorations of ways of knowing and the many ways that learners construct knowledge. Emphasis is placed on empirical findings and their implications for the process of schooling. Topics include instructional models and objectives, conditioning, skill acquisition, verbal learning, memory, problem-solving, creativity and discovery learning.
Prerequisite: Permission of department.

EDUC 388
Inclusion and Instruction. [3]
This course is designed to introduce students to strategies for differentiating instruction within general education classrooms. The course examines the legal, philosophical and programmatic underpinnings of instructional inclusion, broadly defined. Addressed in the course are approaches for adapting the curriculum — especially in the areas of reading, writing and math — to meet the needs of socioculturally, linguistically, cognitively (e.g., dyslexic, dyscalculic) and behaviorally diverse student populations, including students identified traditionally as having special needs (e.g., gifted and talented, physically challenged).
Prerequisite: Permission of department.

EDUC 410
Secondary Reading in the Content Areas: The Teaching of Reading in Secondary Schools. [3]
Major approaches to teaching reading to students in grades 6 to 12. Emphasis on skills in such content areas as English, social studies, etc., which the secondary teacher can apply toward improving high school students' reading ability and their attitude toward reading. Some emphasis on the diagnosis and remediation of certain kinds of reading difficulties is included. A field experience of twelve hours is required.
Prerequisites: Admission to teacher education and permission of the department.

EDUC 411
Secondary Reading in the Content Area – Part II. [3]
This course is designed to develop competency in
the utilization of reading and writing strategies, assessments, vocabulary building, comprehension and special-needs adaptations.The secondary certification candidates should be able to demonstrate competency in their knowledge of contemporary theory,
research, wisdom of practice, modeling and analysis, and protected practice. Field experiences are required in this course.
Prerequisite: EDUC 410 and permission of the department.

EDUC 412
Analysis of Teaching and Learning. [3]
This course is an introduction to a systematic approach to instruction. Special emphasis is placed on developing performance objectives, planning teaching strategies and formulating evaluation instruments to assess learning. The use of technological resources
in instructional planning is emphasized. Students will develop skills to create meaningful learning

experiences for students of diverse cultural, ethnic, linguistic and intellectual backgrounds. These skills are then practiced in peer teaching situations.
Prerequisite: Permission of the department.

EDUC 427
Teaching Science in the Secondary School. [3]
This course develops a holistic, interdisciplinary understanding of science. Develops skills at designing, using and assessing various developmentally appropriate teaching strategies. Focuses on inquiry and action. Active learning strategies/tools, including reflective inquiries, demonstrations, constructions, fieldtrips, observations and authentic teaching experiences. Use of educational technologies to enhance the teaching and learning of science. Emphasis on adapting subject matter to learner diversity. Field experiences are required in this course.
Prerequisites: Admission to teacher education and permission of the department.

EDUC 456
Internship in Secondary Education. [10]
Directed and evaluated teaching experience in selected classrooms. Increased emphasis on independent teaching. Maintaining learning communities that serve the needs of diverse learners. There is an emphasis on discipline-specific planning, implementing and assessing instruction. Focus on
academic and social outcomes. Prerequisite: Completion of all methods courses required for certification and permission
of the department.

EDUC 457
Internship Seminar in Secondary Education [2]
The seminar provides a forum for discussing and processing field experiences and current issues/problems in teaching and learning. Topics that are addressed include classroom management, assessment strategies, the culture of schools, and becoming a professional. The seminar provides a supportive arena to integrate theory, research, and practice while preparing teacher candidates for the responsibilities of classroom instruction.
Prerequisites: Completion of the Phase I internship and permission of the department.