

**BOARD OF HIGHER EDUCATION**  
**REQUEST FOR COMMITTEE AND BOARD ACTION**

**COMMITTEE:** Academic Affairs

**NO:** AAC 15-02

**COMMITTEE DATE:** October 14, 2014

**BOARD DATE:** October 21, 2014

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**APPLICATION OF UNIVERSITY OF MASSACHUSETTS BOSTON TO AWARD THE DOCTOR OF PHILOSOPHY IN APPLIED PHYSICS**

**MOVED:** The Board of Higher Education hereby approves the application of **University of Massachusetts Boston** to award the **Doctor of Philosophy in Applied Physics**.

Upon graduating the first class for this program, the University shall submit to the Board a status report addressing its success in reaching program goals as stated in the application and in the areas of enrollment, curriculum, faculty resources, and program effectiveness.

Authority: Massachusetts General Laws Chapter 15A, Section 9(b)

Contact: Winifred M. Hagan, Ed.D., Director for Educator Policy

## **BOARD OF HIGHER EDUCATION**

**October 2014**

### **University of Massachusetts Boston Doctor of Philosophy in Applied Physics**

#### **INTENT AND MISSION**

The University of Massachusetts Boston's (UMB) most recent strategic plan includes honoring its' origins as a teaching institution and its' tradition of public service. It also includes UMB's forward motion as a growing research university. The proposed Ph.D. program in Applied Physics is planned to be fully aligned and congruent with this plan. The purpose of the UMB Ph.D. program in Applied Physics is to produce independent researchers able to apply the skills of the discipline of Physics to questions of scholarship, entrepreneurship, scientific research and development, and basic science. UMB intends to expand the pool of highly trained technical professionals in the state of Massachusetts and to provide a means for non-traditional Physics students to earn a Ph.D.

The proposed program has obtained all necessary governance approvals on campus and was approved by the University of Massachusetts, Board of Trustees on June 18, 2014. The required letter of intent was circulated on April 3, 2014. No comments were received.

#### **NEED AND DEMAND**

##### *National and State Labor Market Outlook*

UMB holds that the need for new Ph.D. physicists in the American economy can be determined by the fact that the unemployment rate for people with a Ph.D. in Physics or Applied Physics, as determined by the American Institute of Physics, is about 2%. According to the Bureau of Labor Statistics, in May 2011 there were 16,220 people in the United States working as physicists. In the state of Massachusetts there are 1050 individuals working as physicists with about a 60/40 split between academic and industrial positions. UMB surveyed large corporate employers in MA for job postings for which a Ph.D. in physics and applied physics is a qualification and found that MA presents a large number of employment opportunities for a Ph.D. physicist. UMB conducted a simple survey of larger technology companies indicating open jobs for physicists by going to the human resources web sites and found potential employers to include 16 major corporations.

##### *Student Demand*

UMB surveyed a small sample of recent graduates and potential candidates, who expressed an interest in applying to the existing Master's degree, regarding their interest in the proposed program. Eleven out of the thirteen responses received indicated interest in the proposed Ph.D. in Applied Physics program. Of the two respondents who were not interested, one was presently enrolled in the Physics Ph.D. program at UMass Lowell and the second individual was not interested in getting a Ph.D. The proposed program is structured to promote students from the UMB master's program into doctoral study. On average seven to ten students complete the

master's program each year. Currently, of the completers for the UMB master's degree program, four or five students proceed to doctoral study elsewhere.

## OVERVIEW OF PROPOSED PROGRAM

The proposed program is designed to require no new faculty, assistantships, administrative resources, classroom resources, or laboratories. It is planned as a logical extension of UMB's existing Applied Physics Master's degree, and to provide students with the opportunity to continue their research at the doctoral level. Combined with direct admission of doctoral students, the program is planned to add to the expanding research needs of the department. The classes needed for this program are expected to be taught with existing faculty.

### *Duplication*

Harvard University, University of Massachusetts Lowell, Worcester Polytechnic Institute, and Clarke University currently offer competitive degrees to the proposed Ph.D. in Applied Physics. At this time, UMB found that Harvard is the only institution actively graduating Ph.D.s in Applied Physics on a regular basis.

## ACADEMIC AND RELATED MATTERS

### *Admission*

It is anticipated that direct admission to the proposed program will be considered for applicants with advanced credentials on a case-by-case basis. UMB expects most doctoral students in the proposed program to advance from their master's program. This reflects UMB's motivation to provide access to applicants from diverse academic backgrounds. The structures in place to support possible remediation are consistent with a M.S./Ph.D. route rather than direct admission. It is also expected that this strategy will preserve the strength and value of the existing M.S. degree. Transfer applicants will receive transfer credit for their previous learning through subject comprehensive exams or credit for any class for which the applicant passed the comprehensive exam. UMB plans that transfer credit is accepted when a topical course is demonstrably equivalent to one in the UMB program.

### Program Enrollment Projection

	# of Students Year 1	# of Students Year 2	# of Students Year 3	# of Students Year 4*
New Full-time	3	3	3	3
Continuing Full-time		2	4	6
New Part-time	1	1	1	1
Continuing Part-time		1	2	2
Totals	4	7	10	12

### *Curriculum (Attachment A)*

The proposed doctorate program is designed to build upon the existing master's program. Course work is planned to encompass the requirements for the master's degree plus additional required classes. Mechanics, electricity and magnetism, quantum mechanics, and statistical mechanics, combined with mathematical methods, applied numerical methods and methods for estimation will be included within the overall curriculum. In addition, elective courses are planned to broaden and deepen the students' understanding of specific areas of research interest.

### *Internships or Field Studies*

Two elective courses will provide opportunities for students outside of the classroom. *Projects in Physics*, is planned to be a project based study program where the student pursues a specific research or technology development project that is outside of the normal curriculum. *Thesis and Internship* supervised research resulting in a thesis or internship presentation. It is expected that internships will include working with a research-active member of the faculty, or a pair of mentors including one at the candidate's place of work and another in the department. It is also expected that students may complete their theses via projects or internships at places like the RLE (MIT), Lincoln Labs (MIT), Photonics Lab (BU), Novartis, Raytheon, and the Proton Beam Facility at MGH to name a few. UMB also has an existing MOU with Universite Paris-Nord (Paris 13) where elements of a Ph.D. thesis may be completed in a project mode.

## **RESOURCES AND BUDGET**

### *Fiscal (Attachment B)*

After several years of attrition, the Physics Department has been rebuilding with eight current faculty members and two more in the engineering program embedded in the Physics Department. The proposed program has been designed not to require any new resources. It is planned that course additions will be taught by existing faculty. The laboratory space allocated to Physics in the new Integrated Sciences Complex is adequate to support expected research. It is planned that the ten faculty members will mentor Ph.D. students and supervise projects. UMB expects to accept Ph.D. candidates at a rate of about two per year while building the program. Given an average expected residence time of three or four years for students who will be entering the program with master's level credentials this would result in one or two Ph.D. students per faculty member on average. This number of students is easily supportable with the existing research faculty. It is also anticipated that new engineering faculty will serve as additional mentor options for students.

UMB expects to redirect the assistantships currently allocated to the M.S. program in Applied Physics to the Ph.D. program and to adjust the graduate stipend to the doctoral level. Increased training resources from external research grants will ensure that UMB can meet the support needs of the program.

### *Faculty and Administration (Attachment C)*

It is expected that currently nine faculty from the Physics Department, two from the engineering program, one from education, and a research faculty member from the Massachusetts General Hospital who teaches *Physics of Medical Imaging* and mentors master's candidates, will be part of the proposed program. The Physics Department is presently staffed by two administrative personnel, one full time and one part time. There are two technical personnel including a full time professional director of technical operations and a half time technical assistant. No new positions are expected at the outset to the proposed program.

### *Facilities, Library and Information Technologies*

UMB deems that no new library resources are necessary to support this program citing the fact that Physics as a field has gone a primarily online literature base. The Healey Library's existing online resources and hard copy holdings are seen as sufficient to provide the historical reference base needed for the proposed program. It is expected that there will be an increase in the use of interlibrary loan for references needed for dissertation writing. UMB plans that Physics courses will not require any additional library resources to support them.

It is reported that a significant fraction of UMB technical support staff's time is spent maintaining computer infrastructure for the Physics Department. The addition of ten students to the proposed program is not expected to have a significant impact on the existing infrastructure. In addition, the Physics Department is scheduled to move to the new Integrated Sciences Complex before the proposed program would begin. The information technology infrastructure in the spaces allocated for the Physics Department, are viewed by UMB as completely adequate to support the needs of the program.

### *Affiliations and Partnerships*

UMB plans to constitute an advisory board for the proposed program following its approval. It is planned that affiliations and partnerships will overlap with the research programs being pursued in the department. UMB has discussed broad aspects of the program proposal with individuals at Micatu Inc., Raytheon, and the Schlumberger and Wellman Center for Photomedicine at the Harvard Medical School.

## PROGRAM EFFECTIVENESS

Goal	Measurable Objective	Strategy for Achievement	Timetable
Faculty Productivity	Number of Papers produced by the department	Show increase with success of PhD program by summer 2017	Started Summer 2012
Faculty Productivity	Grants submitted	Show increase with success of PhD program by summer 2017	Started Summer 2012
Improve Curriculum	Ongoing evaluation and improvement	Recruit Advisory Board	Started Spring 2013
Begin Offering candidacy tests		Develop appropriate tests for all core areas	Summer 2015
First Students advanced to candidacy	2 to 4 students having fulfilled all candidacy requirements		Fall 2015
Graduate First Students	2-4 students obtain PhD		Summer 2017
Start Tracking Post graduation success	Graduates placed in appropriate post docs and first jobs	Develop Annual on-line graduate survey to track student outcomes	Summer 2017
	Evaluate Program success	Make evaluation of Ph.D. metrics part of AQUAD Review	2018

## EXTERNAL REVIEW AND INSTITUTIONAL RESPONSE

The proposed program was reviewed by Mara Prentiss, Ph.D., Professor in Physics, at Harvard University, and Shyamsunder Erramilli, Ph.D., Professor in Physics at Boston University. The team conducted a site visit on January 13, 2014 in addition to reviewing documents for the proposed program.

The review team endorsed the proposed Ph.D. program in Applied Physics, suggesting that the program satisfies an unmet need in the state of Massachusetts. The reviewers also found the program curriculum and goals to be more than sufficiently rigorous and the faculty to be conducting world-class research. It was recommended that the stated milestones for senior students be made more specific and concrete, and that student mentoring be more formalized. The reviewers also suggested that the program increase collaboration with outside institutions including corporate as well as other universities, and increase alumni outreach.

UMB agreed with the suggestion to make milestones specific and concrete, and responded to the student mentoring recommendation by having the student examining committee be composed of faculty who will serve on the dissertation advisory group and as final examiners. UMB agreed to increase collaborations and plans an annual industry seminar to include members of an industrial advisory board. UMB underscored existing alumni relationships where

graduates return as speakers in the Masters program and agreed that an increase in activities and events, and a periodic newsletter will serve to strengthen the network.

#### **STAFF ANALYSIS AND RECOMMENDATION**

Staff thoroughly reviewed all documentation submitted by the **University of Massachusetts Boston** and external reviewers. Staff recommendation is for approval of the proposed **Doctor of Philosophy in Applied Physics**.

## ATTACHMENT A: CURRICULUM

<b>Major Required (Core) Courses (Total # of courses required = 4)</b>		
<i>Course Number</i>	<i>Course Title</i>	<i>Credit Hours</i>
611	Theory of Classical Mechanics and Fluid Mechanics	4
612	Electromagnetic Theory	4
613	Quantum Mechanics, Atomic, and Molecular Physics	4
614	Thermodynamics and Statistical Physics	4
	SubTotal # Core Credits Required	16
<b>Elective Course Choices (Total courses required =8) (attach list of choices if needed)</b>		
600	Electronic Instrumentation I: Analog	4
601	Electronic Instrumentation II: Digital	4
602	Laser Optics Laboratory	4
609	Physics of Medical Imaging	4
610	Topics in Medical Imaging	4
616	Mathematical Methods for Physicists	4
623	Quantum Mechanics II	4
630	Solid State Physics	4
631	Physics of Semiconductor Materials	4
632	Advanced Laser Optics	4
635	Back of the Envelope	4
636	Nanophotonics	4
637	Stochastic Processes	4
638	Quantum Measurement Theory	4
640	Computation and Visualization	4
645	Cancer Biophysics	4
	SubTotal # Elective Credits Required	32
799	Dissertation Research	24
<b>Curriculum Summary</b>		
Total number of courses required for the degree		12
Total credit hours required for degree		72
<b>Prerequisite, Concentration or Other Requirements:</b>		
Scientific Communication - Seminar Based Course		



# ATTACHMENT B: BUDGET

## Expenditures

UMass New Program Approval Budget

Ph.D. Applied Physics, UMB

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EXPENDITURE ESTIMATES										
	Year 1		Year 2		Year 3		Year 4		Year 5	
	2015		2016		2017		2018		2019	
	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources	New Expenditures required for Program	Expenditures from current resources
Personnel Services										
Faculty	\$0	\$64,000	\$0	\$65,920	\$0	\$67,898	\$0	\$69,935	\$0	\$72,033
Administrators	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Support Staff	\$0	\$6,500	\$0	\$6,695	\$0	\$6,896	\$0	\$7,103	\$0	\$7,316
Others	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Fringe Benefits __ 34 __ %	\$0	\$23,970	\$0	\$24,689	\$0	\$25,430	\$0	\$26,193	\$0	\$26,978
<b>Total Personnel</b>	<b>\$0</b>	<b>\$94,470</b>	<b>\$0</b>	<b>\$97,304</b>	<b>\$0</b>	<b>\$100,223</b>	<b>\$0</b>	<b>\$103,230</b>	<b>\$0</b>	<b>\$106,327</b>

Operating Expenses										
Supplies	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Library Resources	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Marketing/Promotional Expenses	\$5,000	\$0	\$5,000	\$0	\$5,000	\$0	\$5,000	\$0	\$5,000	\$0
Laboratory Expenses	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
General Administrative Overhead	\$450	\$0	\$450	\$0	\$450	\$0	\$450	\$0	\$450	\$0
Other	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Operating Expenses	\$5,450	\$0	\$5,450	\$0	\$5,450	\$0	\$5,450	\$0	\$5,450	\$0
Net Student Assistance										
Assistantships	\$70,852	\$0	\$145,955	\$0	\$225,501	\$0	\$232,266	\$0	\$239,234	\$0
Fellowships	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Stipends/Scholarships	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Student Assistance	\$70,852	\$0	\$145,955	\$0	\$225,501	\$0	\$232,266	\$0	\$239,234	\$0
Capital										
Facilities / Campus recharges	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Equipment	\$16,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

Other	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Capital	\$16,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Expenditures	\$92,302	\$94,470	\$151,405	\$97,304	\$230,951	\$100,223	\$237,716	\$103,230	\$244,684	\$106,327

<b>BUDGET SUMMARY OF NEW PROGRAM ONLY</b>					
	Year 1 2015	Year 2 2016	Year 3 2017	Year 4 2018	Year 5 2019
Total of newly generated revenue	\$92,302	\$151,405	\$230,951	\$237,716	\$244,684
Total of additional resources required for program	\$92,302	\$151,405	\$230,951	\$237,716	\$244,684
Excess/ (Deficiency)	\$0	\$0	\$0	\$0	\$0

## ATTACHMENT C: FACULTY

Summary of Faculty Who Will Teach in Proposed Program							
Please list full-time faculty first, alphabetically by last name. Add additional rows as necessary.							
Name of faculty member (Name, Degree and Field, Title)	Check if Tenured	Courses Taught Put (F) to indicate Foundational course. Put (OL) next to any course currently taught online.	Number of sections	Division of College of Employment	Full- or Part-time in Program	Full- or part-time in other department or program (Please specify)	Sites where individual will teach program courses
Arnason, Stephen Ph.D. in Physics Associate Professor	<input checked="" type="checkbox"/>	<ul style="list-style-type: none"> <li>• Electronic Instrumentation I: Analog</li> <li>• Solid State Physics</li> </ul>	1	Physics	Full-time	No	• Main Campus
Buchwald, Walter Ph.D. in E.E. Associate Professor	<input checked="" type="checkbox"/>	<ul style="list-style-type: none"> <li>• Nano-photonics</li> </ul>	1	Engineering	Full-time	No	• Main Campus
Celli, Jonathan Ph.D. in Physics Assistant Professor		<ul style="list-style-type: none"> <li>• Cancer Biophysics</li> </ul>	1	Physics	Full-time	No	• Main Campus
Jacobs, Kurt Ph.D. in Physics Associate Professor	<input checked="" type="checkbox"/>	<ul style="list-style-type: none"> <li>• Stochastic processes</li> <li>• Quantum Measurement Theory</li> </ul>	1	Physics	Full-time	No	• Main Campus
Kulkarni, Rahul Ph.D. in Physics Associate Professor		<ul style="list-style-type: none"> <li>• Thermodynamics and Statistical Mechanics (F)</li> </ul>	1	Physics	Full-time	No	• Main Campus
Mollow, Benjamin Ph.D. in Physics Professor	<input checked="" type="checkbox"/>	<ul style="list-style-type: none"> <li>• Electromagnetic Theory (F)</li> </ul>	1	Physics	Full-time	No	• Main Campus
Olchanyi, Maxim Ph.D. in Physics	<input checked="" type="checkbox"/>	<ul style="list-style-type: none"> <li>• Quantum Mechanics, Atomic and Molecular</li> </ul>	1	Physics	Full-time	No	• Main Campus

Professor		Physics(F) • Mathematical Methods for Physicists					
Rao, Gopal Ph.D. in Physics Professor	<input checked="" type="checkbox"/>	• Laser Optics Laboratory • Advanced Laser Optics	1	Physics	Full-time	No	• Main Campus
Sun, Greg Ph.D. in E.E. Professor	<input checked="" type="checkbox"/>	• Physics Of Semiconductors	1	Engineering	Full-time	No	• Main Campus
Sundaram, Bala Ph.D. in Physics Professor	<input checked="" type="checkbox"/>	• Theory of Classical Mechanics and Fluid Mechanics (F)	1	Physics	Full-time	No	• Main Campus
Yelleswarapu, Chandra Ph.D. in Physics Assistant Professor		• Electronic Instrumentation II: Digital	1	Physics	Full-time	No	• Main Campus
Seco, Joao Ph.D. in Applied Physics Assistant Professor (MGH) Faculty Affiliate (UMB)		• Topics in Medical Imaging	1	Physics	Full-time	No	• MGH – Proton Beam Facility