The University Senate of Michigan Technological University

Proposal 17-16

(Voting Units: Academic)

Proposal for Ph.D. in Applied Physics

Department of Physics
Michigan Technological University
Houghton, MI 49931

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1. Date: February 23, 2016

2. Contacts:

Yoke Khin Yap, Director of Graduate Studies – Engineering Physics
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3. Approval for interdisciplinary programs

Not Applicable.

4. General description and characteristics of program including learning goals

The Department of Physics proposes a spin-off of its current Ph.D. in Engineering Physics to create a new, broadened program: Ph.D. in Applied Physics. The current Ph.D. in Engineering Physics program engages students to solve engineering-related problems by using the tools and principles of physics. The Ph.D. in Applied Physics will further broaden the scope of this program to help meet the needs of students seeking training in broader interdisciplinary areas of engineering and science, including nanotechnology, photonics, plasmonics, and biophysics. This degree will also provide a logical path for students who compete the M.S. in Applied Physics to continue toward a Ph.D., should they decide to further their studies and pursue research. The department is simultaneously proposing that the Ph.D. in Engineering Physics program be shelved, contingent upon this proposal being approved.

The study of physics has generally been focused on the foundational disciplinary areas, including high-energy physics, atomic and molecular physics, astrophysics, and nuclear physics. During the past two decades, new branches of physics have gained increasing attention, particularly in those interface areas where traditional physics intersects with other applied disciplines. These include biophysics, physics at the nanoscale condensed matters, materials physics, optics/photonics, plasmonics, optoelectronics, etc. In order to fill such a void in the interdisciplinary program in physics at the Ph.D. level, we propose to spin off our current Ph.D. in Engineering Physics into a new program, Ph.D. in Applied Physics. This will broaden the scope of the current engineering physics program to include new emerging physics areas.

Learning Goals:

Learning Goal 1: Students will demonstrate a mastery of the advanced coursework appropriate for their graduate program. This goal will primarily be demonstrated by passing the required coursework and the Qualifying Examination, as described below.

Learning Goal 2: Students will develop the capacity for both critical and independent thought in their chosen area (technical specialty) of applied physics research. This goal will primarily be demonstrated through annual research presentations, annual progress reports submitted to the graduate studies committee that include lists of presentations and publications, and through written and oral presentations for the Preliminary Exam, Dissertation, and Thesis Defense.

Learning Goal 3: Students will have the ability to communicate orally and in writing to demonstrate clear, logical, critical thinking. This goal will be demonstrated using the same measures as for Learning Goal 2.

5. Rationale

Much exciting research is now being done in new interdisciplinary branches of physics, including biophysics, physics at the nanoscale condensed matters, materials physics, optics/photonics, plasmonics, optoelectronics, etc. Most of the faculty members of the department have established research programs in these "frontier" areas of applied physics. The current Ph.D. in Physics at Michigan Tech focuses more on "traditional" branches of physics such as astrophysics, atomic & molecular physics, and condensed matter physics. Our Ph.D. in Engineering Physics enables students to solve engineering-related problems by applying the tools and principles of physics. The proposed spin-off program will broaden the focus of "engineering-related problems" to more interdisciplinary "application topics" that may involve engineering, as well as other branches of science (chemistry, biology, etc.).

The proposed spin-off program will offer the following advantages:

- Enables faculty in appropriate application areas where physics borders related engineering and science fields to more effectively recruit graduate students
- Prepares a framework for future implementation of a more flexible and appropriate coursework requirement to meet the needs of students depending on their individual area of research
- Enables graduates from our new M.S. in Applied Physics (started in Fall 2015) to continue their study in Ph.D. in Applied Physics, should they wish to do so

6. Discussion of related programs within the institution and at other institutions

6.1. Related programs within the institution

Michigan Tech offers a M.S. in Physics, a relatively new M.S. in Applied Physics, a Ph.D. in Physics, and a Ph.D. in Engineering Physics. All of these programs are designed with their own unique yet related and overlapping curricula. As may be evident from the curriculum requirements described below, the new program is clearly a spin-off of the Ph.D. in Engineering Physics, maintaining the same curricular structure, but broadening the research areas from engineering-related to broader applications. The curriculum requirements of the spin-off program are also a seamless extension of the M.S. in Applied Physics (started in Fall 2015), making transition from the M.S. program to the new Ph.D. program a logical one for those students who wish to continue on toward a Ph.D. in Applied Physics.

The spin off program from Ph.D. in Engineering Physics to Ph.D. in Applied Physics will consolidate our M.S. and Ph.D. programs into two main streams: 1) Physics, and 2) Applied Physics.

6.2. Related programs at other institutions

There are several universities offering M.S. and Ph.D. level graduate programs in applied physics including:

University of Michigan (http://www-applied.physics.lsa.umich.edu/)
Columbia University (http://apam.columbia.edu/applied-physics#Programs),
Caltech (http://www.aph.caltech.edu/),
Stanford University (http://www.stanford.edu/dept/app-physics/cgi-bin/), and
Cornell University (http://www.aep.cornell.edu/).

All these universities emphasize new emerging areas of study, including:

- nanoscience/condensed matter/solid-state physics
- laser/photonics/plasma physics
- biophysics/medical physics

7. Projections:

The number of students expected in the new program is expected to be six to seven students in the short term, which is the same as the number of students in our Engineering Physics Ph.D. program in recent years. Slightly higher enrollment may be possible, depending primarily on the number of faculty in the department and their fields of specialization. Some students are likely to change from the Ph.D. in Physics to the new Ph.D. in Applied Physics as may be appropriate to their research areas.

8. Scheduling plans (Extension, Evening, Regular)

Regular only.

9. Curriculum design

The framework for the curriculum of the new degree program is shown in the table below. For comparison, the curriculum requirements of the current Ph.D. in Engineering Physics and the M.S. in Applied Physics programs are also shown below. The new curriculum is the same as that of the Engineering Physics Ph.D. program with the following two changes:

1. This "Engineering" component of the Qualifying Exam will be changed to an "Application" component, as follows:

   For the current "Engineering" component qualifying examination:
   "The engineering member(s) of the student's Advisory Committee shall formulate the engineering component of the Qualifying Examination that is two to three hours in length and appropriate to the student's chosen area of engineering physics interest, focusing on fundamentals related to but not on the student's current research. The format of the engineering component of the Qualifying Examination shall be determined by the student's Advisory Committee."

For the new "Application" component of the qualifying examination:
"The student's Advisory Committee shall formulate the application component of the Qualifying Examination that is two to three hours in length and appropriate to the student's chosen area of applied physics interest, focusing on fundamentals related to but not on the student's current research. The format of the application component of the Qualifying Examination shall be determined by the student's Advisory Committee."

2. Whereas the Engineering Physics Ph.D. program requires that a faculty member in engineering be a member of the student's qualifying examination and advisory committee, there is no such specific requirement for the Applied Physics Ph.D. program. The qualifying examination and research advisory committee will be formed under the advice of the research advisor and the Applied Physics Graduate Studies committee, following the regulations of the Graduate School, and as deemed most appropriate for the student and the chosen area of research.

The spin-off program's curriculum requirements are summarized here, along with those of the related Ph.D. in Engineering Physics and the new M.S. in Applied Physics:

Degree	**Course Requirements Beyond Those of the Graduate School**
Ph.D. in Applied Physics	Core Courses: (*The same as those in the current Ph.D. in Engineering Physics program.*) PH5010 Journal Club (1 credit) PH5110 Classical Mechanics (2 credits) PH5210 Electrodynamics I (3 credits) PH5310 Statistical Mechanics (3 credits) PH5320 Mathematical Physics (3 credits) PH5410 Quantum Mechanics I (3 credits) Disciplinary Electives: (*The same as those in the current Ph.D. in Engineering Physics program, which already offer sufficient flexibility to cover the fundamental courses needed for applied physics research.*) Three courses at the 4000-level and higher, including a minimum of one course at the 5000-level or higher, in the student's chosen area of specialization, and as approved by the student's advisory committee. Additional courses may be required by the student's advisory committee. Research: PH6999 Doctoral Research as required to complete doctoral research and credit requirements. Qualifying Examination: (*The **physics component** is the same as for the Ph.D. in Engineering Physics. The **engineering component** of the Qualifying Exam will be changed into the **application component** as described earlier in this section.)* The Qualifying Exam will include both a **physics component**, and an **application component** as described above.

Comparison to related Michigan Tech graduate degrees in Physics:

Ph.D. in Engineering Physics	Core Courses: PH5010 Journal Club (1 credit) PH5110 Classical Mechanics (2 credits) PH5210 Electrodynamics I (3 credits) PH5310 Statistical Mechanics (3 credits) PH5320 Mathematical Physics (3 credits) PH5410 Quantum Mechanics I (3 credits) Disciplinary Electives: Three courses at the 4000-level and higher, including a minimum of one course at the 5000-level or higher, in the student's chosen area of specialization, and as approved by the student's advisory committee. Additional courses may be required by the student's advisory committee. Research: PH6999 Doctoral Research as required to complete doctoral research and credit requirements. Qualifying Examination: The **physics component** of the Qualifying Exam will cover three of the four following areas, to be chosen in advance**,** by the student: classical mechanics (including special relativity), electricity and magnetism, quantum mechanics, and general physics. The **engineering component** of the Qualifying Exam is described earlier in this section.

Degree	Course Requirements Beyond Those of the Graduate School
M.S. in Applied Physics Thesis option A Report option B Coursework option D	Core Courses: Minimum of 10 PH credits at the 4000-level or higher including a minimum of 6 credits from the following list: PH5010 Journal Club (1 credit; required) PH5110 Classical Mechanics (2 credits) PH5210 Electrodynamics I (3 credits) PH5310 Statistical Mechanics (3 credits) PH5320 Mathematical Physics (3 credits) PH5410 Quantum Mechanics I (3 credits) Application Electives Minimum 10 credits at the 4000-level and higher (including at least one course at the 5000-level or higher) from an Application Elective list; with approval of advisor. Additional courses may be required by the student's advisory committee under plans A and B. Research *PH5999 Master's Research* Minimum 6 credits for thesis degree (Thesis option) Minimum 3 credits for report degree (Report option) No research for coursework degree (Coursework option)

10. New course descriptions

No new courses are necessary and none are proposed.

11. Model schedule demonstrating completion time:

Year 1 (assuming Fall matriculation)

- September: Qualifying Examination (Free Shot)
- 2-3 Physics courses each semester (9 credits)
- Funding via a Teaching Assistantship. 20 hours of work/week, typically in introductory Physics Labs
- January: Qualifying Examination (First Shot)
- Spring of Year 1- Select a research Advisor
- Summer of Year 1- Begin research

Year 2 1-2 courses/semester

- Divide remaining time between research and, if still on GTA, teaching
- September- retake un-passed Qualifying Examination sections if necessary
- Annual progress report and oral presentation

Year 3

- Elective coursework
- Emphasis on research and, if still on GTA, teaching
- Take Preliminary Exam in the fall or winter
- Annual progress report and oral presentation

Years 4 & 5

- Research
- Submit co-authored manuscripts for publication in refereed journals, in collaboration with your research advisor
- Attend and present talks and/or posters at national meetings and at Michigan Tech graduate research events
- Annual progress reports and oral presentation
- Write and defend thesis

12. Library and other learning resources

No additional library or learning resources are required.

13. Faculty Resumes

All graduate faculty in physics may participate in this program. Names of individual faculty and links to their resumes may be found at the following link:
http://www.mtu.edu/gradschool/administration/dean/locator/?raw=true&search_type=department&departments=SA-PH&linked=yes

14. Description of available/needed equipment.

A wide variety of equipment is available in the department and across campus for the diversity of applied research that is currently being conducted in Engineering Physics Ph.D. areas.
Facilities available in physics are highlighted here:
http://www.mtu.edu/physics/facilities/research/
Core facilities available campus-wide are highlighted here:
http://www.mtu.edu/research/administration/vpr-office/core-facilities/
No additional equipment is required for the purpose of this proposal.

15. Program costs, years 1, 2, and 3.

Since this is a spin-off proposal with anticipated shelving of the current program that it will replace, there are no additional program costs beyond our existing Engineering Physics Ph.D. program.

16. Space

No additional space is required to accommodate the new graduate degree program.

17. Policies, regulations and rules

None besides curricular requirements outlined above and those of the Graduate School.

18. Accreditation requirements

Not applicable.

19. Planned implementation date

Fall semester of 2016.

Appendix: Criteria for Financial Evaluation of Proposed Academic Program

I. Relation to University Strategic Plan

a. Relation of program to the university's educational and research goals.

As does the current program Ph.D. in Engineering Physics, which this spin off proposal is intended to replace, the Ph.D. in Applied Physics supports the university's strategic plan's GOAL 2 to provide a "distinctive and rigorous action-based learning experience grounded in science, engineering, technology, sustainability, business, and an understanding of the social and cultural contexts of our contemporary world," and, in particular, to further support the second and third criteria under subgoal 2.1:

- promote mutual appreciation and collaborative opportunities across academic disciplines
- continually review and update existing programs and develop new offerings in emerging disciplinary and interdisciplinary areas

The new program also supports subgoal 2.3 criteria

- expand Ph.D. and master's enrollments, degrees awarded, and scholarly productivity

The program will also further support the following criteria of GOAL 3: Research, scholarship, entrepreneurship, innovation, and creative work that promotes a sustainable, just, and prosperous world.

3.1 Growth in research, scholarship, and creativity

- increase external support for research, scholarly, and creative activities;
- encourage and support interdisciplinary activities

b. Consistency with the university's resource allocation criteria

No new resources are being requested for this program.

II. Impact on University Enrollment

a. Projected number of students in the program:

Based on enrollments in the Ph.D. in Engineering Physics enrollments in the past 5 years, we anticipate an average enrollment of 9 students enrolled (out of approximately 40 Ph.D. students advised by physics faculty).

b. Source of new students; in particular, will the students be drawn from existing programs, or will they be students who would otherwise not have come to MTU?

We anticipate that most of the enrollment in this program will come from the existing program in physics, primarily the Ph.D. in Engineering Physics, but also from the Ph.D. in Physics. Current students will be given the option, in consultation with their research advisors, to change to the new program.

c. What is the likely correlation between demand for the new program and existing enrollment patterns at MTU?

With the shelving of the Ph.D. in Engineering Physics, new students will be accepted into the new program likely at the same rate that we have been accepting new students into the old program. With the broadened scope of the new program, some students who are in or would likely enroll in the Ph.D. in Physics may also select the new program. We expect that overall growth of Ph.D. students in the department will remain near current levels, but can grow if/when external funding grows.

III.

a. What is the current enrollment in the unit (2015-2016)?

Undergraduate Majors: 58

B.S. Physics 38
B.A. Physics 7
B.S. Applied Physics 13

Graduate Students: 41

M.S. Physics.....2
M.S. Applied Physics.....3
Ph.D. Physics 24
Ph.D. Engineering Physics.....6
Ph.D. Atmospheric Physics.....6

IV. Impact on Resources Required by Department in Which the Program is housed. This would include, but not be limited to:

a. Faculty lines: As a spin-off program with planned shelving of its parent program, this new program will be supported through existing faculty lines.
b. Faculty and student labs, including ongoing maintenance: None anticipated.
c. Advising: No changes relative to our current programs.
d. Assessment: No changes relative to our current programs.

V. Impact on Resources Required By other Units within the University. This analysis would include, but not necessarily be limited to, the impacts on:

a. Other academic (e.g., Gen Ed) units with regard to faculty, labs and assessment. (NOTE: The current Student to Faculty ratio for the university as a whole is approximately 12:1 per Institutional Analysis.)

No changes.

b. Information Technology, the Library, central administration and career planning with respect to the impact on the need for computing services, library resources, advising, record keeping, development of employer relations etc.

No changes.

VI. Assessment of the ability to obtain the necessary resources assuming requested funds are obtained

a. For high demand fields (e.g., business fields, etc.), will it be possible to fill allocated lines.

No additional resources are requested associated with this program.

VII. Past proposals. Has the department initiated any other new degree programs in the last five years? Yes, M.S. in Applied Physics started in Fall 2015; B.A. in Physics started in Fall 2012.

If so:

a. Describe the extent to which the new program has met the original goals with respect to:

1. Enrollment:
   B.A. Physics- current enrollment is 7.
   M.S. in Physics- This program is brand new, so it is too early to tell.
2. Costs: not applicable- no additional costs were expected
3. New faculty: not applicable- none requested
4. Other resources required for the program: not applicable- none requested

b. How have degree programs added in the past five years affected total enrollment in the department?

B.A. in Physics- This new program helps to stabilize our overall undergraduate enrollment and gives students flexibility, especially for secondary education certification majors. Average enrollment in SPA programs has been 5 to 6 students.

M.S. in Physics- This program is brand new, so it is too early to tell.

VIII. Departmental Budget contribution (From the 2014-15 Compendium)

a. What is the department's total general fund budget?

$2,703,942 + $526,829 (grad student transfer) = $3,230,771

b. How much tuition does the department generate? This information should be provided for both the credit hours taught by the department and the number of credit hours taken by the department's majors.

Undergraduate Credits: 9,101
Graduate Credits: 675

Based on in-state tuition rates, this generates an estimated $4, 931,790.

Estimated tuition revenue from majors:
Undergraduate: 58 majors × 31.5 credits × $478/credit = $873,306
Graduate: 675 credits × $861.5/credit = $581,512.50

IX. How do the benefits from this program compare to other alternatives that are currently under consideration or development. Will approval and allocation of resources to this program preclude the development of other programs?

No other alternatives are being considered as this program is a spin-off that broadens our successful Ph.D. in Engineering Physics, which will be shelved. No new impacts on other programs are expected.