TO: Kathy Pollock, Chair, Senate Executive Committee

FROM: Carol Lawton, Chair, Curriculum Review Subcommittee Carol A. Lawton

DATE: September 12, 2018

SUBJECT: Proposals for Physics Concentration and Minor in Materials Science

Curriculum Review Subcommittee members support the proposal for a B.S. in Physics with a concentration in Materials Science. We find that the proposal requires no Senate review.

Approving	Not Approving	Absent
Swathi Baddam		
Seth Green		
Carol Lawton		
Vincent Maloney		
Sue Skekloff		
Jin Soung Yoo		
Julia Smith		
Kate White		

Curriculum Review Subcommittee members also support the Physics Department proposal for a minor in Materials Science. We find that the proposal requires no Senate review.

Approving	Not Approving	Absent
Swathi Baddam		
Seth Green		
Carol Lawton		
Vincent Maloney		
Sue Skekloff		
Jin Soung Yoo		
Julia Smith		
Kate White		

Proposal for a B.S. in physics with Concentration in Materials Science

Purdue University Fort Wayne
April 18, 2018

Mark F. Masters, Ph.D., Department of Physics

Introduction: Materials Science is the endeavor to understand and develop new materials for specific tasks. This has involved nanotechnology, biomaterials, metallurgy, polymers, ceramics, etc. It is a multidisciplinary/interdisciplinary field encompassing several disciplines of science and technology.

The intention of this proposal is to create a preliminary program that will evolve as more departments create courses that can be fit into the concentration. At present the courses selected for contribution to the concentration are from Chemistry, Geology (EAPS – Earth Atmospheric and Planetary Science), Mechanical Engineering Technology, and Physics.

A part of physics is the study of the structure and properties of matter. Physics includes the examination of energy and energy transport mechanisms. Physics involves the understanding of the tools used to study matter. Physics includes learning the fundamental principles and developing skills to study and model materials. In many ways physics lies at the heart of understanding materials.

As a model program we examined the University of Missouri's Department of Physics' "Physics with an Emphasis in Material Science." https://physics.missouri.edu/undergrad/major-physics. There is another program at University of New Hampshire. Florida State University has just started a Materials Physics Major. The point is that there is a strong coupling of physics and material science.

1. **Name of proposed new program**

Bachelor of Science in Physics with a concentration in Material Science

2. **Title of degree to be conferred**

Bachelor of Science

3. **Field of study, department, and school involved**

Material Science/Physics, Department of Physics, College of Arts and Sciences

4. **Objectives of the proposed concentration**

There are several objectives for this concentration:

a. First, there is a regional demand for graduates with Materials Science background. Materials Science is very interdisciplinary involving Physics, Chemistry, Biology, Geology and Engineering. Many of our graduates work in industry and are classified as "engineers." We believe that this concentration will help the students transition more smoothly into industrial

careers, expanding opportunities available to them. This concentration should also open new graduate school opportunities for them as well.

Quoting directly from the University of New Hampshire about their concentration in Material Science "This option combines courses from the Physics and other Departments to provide training in physics and materials science, an area that has proven industrial demand."

c. Within physics, it is critical to provide students with more options than just simply physics as is recommended by the SPIN-UP report and our last program review. SPIN-UP was a National Science Foundation sponsored project that investigated qualities that make a successful, thriving physics department. (http://www.aps.org/programs/education/undergrad/faculty/spinup/upload/SPIN-UP-Report.pdf) In this project, it was found that having one or more concentrations is extremely beneficial to the physics program, helping to attract more majors.

5. **Proposed date of initiation of the new program**

Fall 2019

6. **A statement describing the relationship of the proposed program to the mission and scope of the campus**

Department Mission: The relevant part of the Department of Physics Mission Statement is "producing well prepared graduates who are confident in their abilities and understanding of physics," and "Physics Majors will gain a strong working knowledge of basic science and physics."

The proposed concentration is clearly within this mission. Materials Science and engineering was an outgrowth of chemistry and physics. It is not unheard of for physics programs to have a materials science concentration or the equivalent. The American Chemical Society talks about material science as part of chemistry. At its heart, material science is interdisciplinary.

College Mission: "...the college provides students with a breadth of knowledge about the global environment and fosters an appreciation and respect for diversity. The College of Arts and Sciences equips students to think critically, communicate effectively, and develop creative solutions to future challenges."

This proposed concentration is directly related to the college mission statement, particularly breadth of knowledge and creative solutions to future challenges. It does so by providing a concentration that is of growing importance.

PFW Mission: "We offer a broad range of high-quality undergraduate, graduate, and continuing education programs that meet regional needs ..."

The proposed concentration will be of high quality and provide a unique opportunity for students of Northeast Indiana.

7. **A statement describing the relationship of the proposed program to already existing programs at the campus.**

There are no Material Science programs at PFW. There are components of a program distributed across many departments such as Physics and Geology, Chemistry, Mechanical Engineering, Mechanical Engineering Technology. The intention is to bring these together to form a group.

This proposal is simply the first step at creating this group.

8. **A statement describing the relationship of this program to similar programs in other regional and Indiana post-secondary educational institutions.**

There is a materials science engineering program at Purdue West Lafayette and another at Notre Dame. There are no materials science programs in Northeast Indiana.

9. **A statement describing cooperative endeavors explored and/or intended with other institutions particularly those located in the same geographic region.**

PFW Physics with a concentration in Materials Science would be the only program of its nature in Indiana.

10. **A statement indicating need for the concentration in terms of manpower supply and demand.**

This concentration adds courses, specialization and focus to a physics degree which is inherently a general program. Looking at www.hoosierdata.in.gov, there is moderate predicted demand for materials engineers.

There are many companies that hire our graduates, but also need employees with materials science background. These include Steel Dynamics, Fort Wayne Metals, and Regal Beloit. In these cases, the Materials Science would be a significant assistance in getting that first job. Combining the Materials Science skills with the physics skills will yield a significant synergy opening new opportunities to our students.

11. **A statement describing resources over and above present levels required to initiate the program**

The Material Science concentration consists of core physics courses in combination with a variety of specified engineering courses and some free electives. Since engineering programs and the physics program already exist, we do not believe that any additional resources will be required.

12. **Proposed Curriculum**

The proposed curriculum starts with a physics core common to all specializations. There is an interdisciplinary/multidisciplinary core of materials science classes.

COAS Requirements: 11 credit hours.

Second semester writing	(3)
Foreign Language	(8)

General Education: 24 credit hours

Core Physics courses: 20 credit hours

PHYS 15200 – Mechanics	(5)
PHYS 25100 – Heat, Electricity, Magnetism and Optics	(5)
PHYS 34200 – Modern Physics	(3)
PHYS 34300 – Modern Physics Laboratory	(1)
PHYS 44200 – Quantum Mechanics	(3)

PHYS 48001 – Senior Thesis I (2)
PHYS 48002 – Senior Thesis II (1)

Core Supplementary Courses: 16 credit hours
CHM 11500 (4)
MA 16500 (4)
MA 16600 (4)
MA 26100 (4)

Additional Physics Classes: 20 credit hours
PHYS 30500 – Mathematical Methods (3)
PHYS 31000 – Intermediate mechanics (3)
PHYS 31200 – Intermediate Electricity and Magnetism I (3)
PHYS 32200 – Intermediate Optics (3)
PHYS 34500 – Optics Laboratory (1)
PHYS 32500 – Scientific Computing (3)
PHYS 34600 – Advanced laboratory (1)
PHYS 41800 – Statistical mechanics (3)

Additional supporting classes: 4 credit hours
CHM 11600 Chemistry II (4)

Core Materials Science Classes: 23 credit hours

Take 4 credit hours of the following
PHYS 1XX01 - Materials Science: Semiconductors, Conductors and Superconductors (1)
PHYS 1XX02 – Materials Science: Optical and Magnetic Materials (1)
PHYS 1XX03 – Materials Science: Thermal Properties (1)
PHYS 2XX01 – Electron Microscopy (1)
PHYS 2XX02 – X-Ray Analysis (1)
PHYS 2XX03 – Scanning Probe Microscopy (1)

Required
PHYS 1XX04 – Materials Science: Materials Lab (1)
EAPS 22100 – Mineralogy) (3)
ET 20000 - Strength of Materials (3)
MET 18000 – Materials and Processes (3)
EAPS 42500 – Scanning Electron Microscope) (3)

Either CHM 24100 - Inorganic Chemistry or CHM 26100 – Organic Chemistry (3)

PHYS 54500 – Solid State Physics (3)

The laboratories (PHYS 343, 345 and 346 will also have investigations specific for MS students that will provide synthesizing experiences).

Electives (to be developed a later)

PHYS 3XX01	Physics of Electronic devices	(1)
PHYS 3XX02	Surface Science	(1)
PHYS 3XX03	Tribology	(1)
PHYS 3XX04	Thermal Properties of Materials	(1)
PHYS 3XX05	Material Physics and metallurgy	(1)
PHYS 4XX01	Metamaterials	(1)
PHYS 4XX02	Nanotechnology	(1)
PHYS 4XX03	Biomaterials	(1)
PHYS 5XX01	Electric, Magnetic and Optical Properties of materials	(3)

Course on Polymers
Course on Ceramics

Proposal for a new minor in Materials Science

The proposed minor is closely related to the proposed concentration. The proposed minor is intended to be approachable – i.e. the courses are intended to be mostly conceptual and the math pre-requisites are not too high (at least for physics). The minor is also multi-disciplinary drawing on courses from physics, earth atmospheric and planetary science (geology), chemistry, and engineering technology. This minor will change as other courses are introduced from other disciplines; this is a starting point.

The principle physics courses are a series of 1 credit hour, 5-week classes at the 100 level conceptual courses to build fundamental ideas about materials; a series of 1 credit hour, 5 week classes at the 200 level conceptual courses on the tools used in material science; and then some core courses that are in chemistry, geology, physics and engineering technology.

The capstone of the minor can be made of 300 and 400 level courses in a variety of departments.

Comparison of the proposed materials science minor with other programs is a little difficult. All programs we found were offered from department of Materials Science and Engineering. As such, their the programmatic goals were a little different since engineering and physics are not completely parallel philosophies. A direct comparison between the proposed program and one from Texas A&M show that since Texas A&M is largely focused on engineering, they have fewer classes focused on fundamentals, and concentrate more on phenomenon and mechanical behavior. However, examination of the topics indicates broad overlap of topics.

Texas A&M	Proposed
Two of the following:	3 of the following
Structure of materials Polymer Science Mechanical Behavior Electronic, Optical and Magnetic Properties	Semiconductors, conductors and superconductors Optical and magnetic materials Thermal Properties Electron Microscopy X-Ray Analysis Scanning Probe Microscopy
Two of the following	Required
Materials Processing Nanoscience and Nanomaterials Fundamentals of Corrosion Processing and Characterization of Polymers Fundamentals of Ceramics Elements of Composite Materials	Materials Laboratory Strength of Materials Mineralogy Modern Physics Inorganic/Organic Chemistry
	3 of the following
	Physics of electronic devices Surface Science Tribology Thermal Properties of Materials Materials Physics metallurgy Metamaterials Nanotechnology Biomaterials

	Electric, magnetic and Optical Properties
	Scanning Electron Microscope X-ray analysis Polymers Ceramics Analytical Chemistry Quantum Mechanics Physical Chemistry

Minor in Materials Science

A minor in Materials Science is of use to students who are not physics majors but want to learn about materials science. The courses are listed below.

Take at least 3 credits of the following classes

PHYS 1XX01 - Materials Science: Semiconductors, Conductors and Superconductors	(1)
PHYS 1XX02 – Materials Science: Optical and Magnetic Materials	(1)
PHYS 1XX03 – Materials Science: Thermal Properties	(1)
PHYS 2XX01 – Electron Microscopy	(1)
PHYS 2XX02 – X-Ray Analysis	(1)
PHYS 2XX03 – Scanning Probe Microscopy	(1)

Required

PHYS 1XX04 – Materials Science: Materials Lab	(1)
ET 20000 - Strength of Materials	(3)
MET 18000 – Materials and Processes	(3)
EAPS 22100 – Mineralogy	(3)
PHYS 34200 - Modern Physics	(3)

Either CHM 24100 - Inorganic Chemistry or CHM 26100 – Organic Chemistry (3 or 4)

Take at least 3 Credits of the following

PHYS 3XX01 Physics of Electronic devices	(1)
PHYS 3XX02 Surface Science	(1)
PHYS 3XX03 Tribology	(1)
PHYS 3XX04 Thermal Properties of Materials	(1)
PHYS 3XX05 Material Physics and metallurgy	(1)
PHYS 4XX01 Metamaterials	(1)
PHYS 4XX02 Nanotechnology	(1)
PHYS 4XX03 Biomaterials	(1)
PHYS 5XX01 Electric, Magnetic and Optical Properties of materials	(3)
EAPS 42500 – Scanning Electron Microscope	(3)
EAPS 42700 – X-ray analysis	(3)
Course on Polymers (CHM XXXXX)	
Course on Ceramics (EAPS XXXXX)	
CHM 42400 – Analytical Chemistry 2	(4)
PHYS 44200, Quantum Mechanics	(3)
CHM 38300 or 38400 – Physical Chemistry	(4 or 2)